Scientific Services
for Transport & Industry

4-RAIL Services Ltd

Head Office: Unit 3, Metro Centre,
Britannia Way, London, NW10 7PA
Phone: 020 8955 9680 Fax: 020 8955 9689

Laboratory: Unit 11, Ironbridge Close,
Great Central Way, London, NW10 0UF
Phone: 020 8955 1700 Fax: 020 8830 1003
Email: enquiries@4-rail.com
Web: www.4-rail.com

FINAL

Report No. 4RS-RL-140792-R440676

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

Prepared for: *Ms. Louise Dearman*
Occupational Hygiene Adviser
Tfl – Rail and Underground
1st Floor
Petty France
London
SW1H 0BD

Issue Date: *1st May 2015*

Prepared by: *Ms. R Lopez*
Senior Environmental Technologist

Signature: .....

Certified by: *Dr. I. R. Girling*
Senior Consultant

Signature: .....

VAT Registration No: 691 5975 82
Registered Office: Unit 3, Metro Centre,
Britannia Way, London, NW10 7PA
Registered in England No: 3256863

CONDITIONS OF ISSUE OF REPORTS.

FURTHER INFORMATION.

REQUESTS FOR ADDITIONAL INFORMATION ON THE SUBJECT OF THIS REPORT OR OTHER QUERIES SHOULD BE ADDRESSED TO THE AUTHOR.

CONTENTS

Executive Summary

At the request of Louise Dearman, London Underground Limited, personal dust monitoring for respirable dust exposure was undertaken on Station Staff and Train Operators at various stations and train lines. 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. The samples were collected using respirable dust cyclone heads and cyclone inhalable samplers worn by, Station Staff and Train Operators during their shifts and 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. 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, Paddington, Piccadilly Circus, Tottenham Court Road, Vauxhall and Waterloo. The Train Operator and passenger dust exposure monitoring was carried out on the Bakerloo, Central, Circle and Hammersmith & City, District, Jubilee, Northern, Piccadilly and Victoria lines.

For Train Operators, the highest respirable dust concentration measured was 1.81 mg/m^3 for the Victoria Line, with most levels being below 0.5 mg/m^3. 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 similar to those measured previously. The lowest dust levels were recorded for Train Operators working on the Circle and H&C Lines. For passengers, the results were all below or same as 0.61 mg/m^3. The levels recorded for all lines were significantly less than the Workplace 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, the dust levels measured were all below 1.45 mg/m^3, and therefore well below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour Time Weighted Average). Results for the static samples were also below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour Time Weighted Average). 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. At some stations, platform duties had not been scheduled, however the combined results of personal samples on Station Staff and the static monitoring samples indicate that the respirable dust concentrations at the stations assessed were below the Workplace Exposure Limit of 4 mg/m^3 (long term 8 hour Time Weighted Average).

Selected samples taken from collectors worn by Train Operators were analysed for crystalline silica content by the Institute of Occupational Medicine (IOM). In all cases, the levels found were below the detection limit of <0.01 mg/filter, and were therefore well below the Workplace Exposure Limit of 0.1 mg/m^3 (long term 8 hour Time Weighted Average).

Also, samples taken from PM2.5 collectors worn by Train Operators were analysed for metals. Apart from iron, the levels of metals found were below 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 Louise Dearman, 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.

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 (for comparison with the IOM Report Ref TM/03/02). 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 and numbers of airborne particles within each size range.

1.3 The specific stations and locations where monitoring was requested were:

Stations	Sampling Locations	Sample Type
Aldgate East	Platform and gate line duties	Personal
	District line platforms	Static
Baker Street	Gate line, platform & station checks duties	Personal
	Jubilee line platforms	Static
Elephant and Castle	Gate line and platform duties.	Personal
	Bakerloo line platforms.	Static
Euston Square	Gate line and platform duties.	Personal
	Circle and Hammersmith & City line platforms	Static
Hampstead	Gate line duties	Personal
	Northern line platforms & Ticket office	Static
King's Cross	Gate line and platform duties.	Personal
	Metropolitan line platforms & Ticket office	Static
Oxford Circus	Gate line and platform duties.	Personal
	Bakerloo, Central and Victoria lines platforms	Static
Paddington	Gate line, platform & station checks duties	Personal
	Bakerloo line platforms	Static
Piccadilly Circus	Gate line duties	Personal
	Piccadilly line platforms & Ticket office	Static
Tottenham Court Road	Gate line duties	Personal
	Central line platforms & Station Supervisor Office	Static
Vauxhall	Gate line and platform duties.	Personal
	Victoria line platforms	Static
Waterloo	Gate line and platform duties.	Personal
	Waterloo & City and Bakerloo line platforms	Static

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

1.5 Since the District, Hammersmith and City and Metropolitan Lines are in open air, except in regions where they overlap with the Circle Line, it was considered that these could be covered by monitoring in trains following the Circle Line. The Circle Line represents the covered sections of the District, Hammersmith and City and Metropolitan Lines and hence where the higher levels of airborne dust might be found. Also as new rolling stock has been introduced on the District Line, it was requested that this was monitored separately as well.

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. Actual exposure will be less than this.

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.

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.

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. 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 November 2014 and February 2015.

The respirable dust results obtained were from 0.04 to 0.60 mg/m^3. The lines with highest results were the Jubilee and the Bakerloo lines with levels of 0.55 mg/m^3 and 0.60 mg/m^3 respectively. The District and Circle lines presented the lowest exposure results with a respirable dust level of 0.04 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.

Bakerloo Line

The respirable dust and PM2.5 exposure levels for the Bakerloo Line Train Operators measured on the 13th, 17th and 18th of November 2014, are given in Table 2. The respirable dust results were 0.41 and 0.51 mg/m^3 and the PM2.5 result was 0.26 mg/m^3.

Central Line

The respirable dust and PM2.5 exposure levels for the Central Line Train Operators measured on the 10th, 11th and 12th of November 2014, are given in Table 3. The respirable dust obtained results were 0.23 and 0.45 mg/m^3 with a concentration of 0.23 mg/m^3 for the PM2.5 result.

Circle and Hammersmith & City Lines

The respirable dust and PM2.5 exposure levels for the Circle and H&C Line Train Operators measured on the 10th, 11th and 12th of December 2014, are given in Table 4. The respirable dust results were 0.07 and 0.04 mg/m^3. The measured level of PM2.5 was 0.08 mg/m^3.

District Line

The respirable dust and PM2.5 exposure levels for the District Line Train Operators measured on the 27th of November 2014, 1st and 2nd of December 2014, are given in Table 5. The measured level of PM2.5 was 0.09 mg/m^3. The respirable dust results were 0.15 and 0.28 mg/m^3. This result of 0.28 mg/m^3 has been included for indicative purposes only, as the dust pattern on the filters suggests that the filter has moved within the sampling head meaning a non-even distribution of dust collection on the surface of the filter and probably leading to a loss of dust.

Jubilee Line

The respirable dust and PM2.5 exposure levels for the Jubilee Line Train Operators measured on the 24th, 25th and 26th of November 2014, are given in Table 6. The respirable dust results were 0.14 and 0.11 mg/m^3. The measured level of PM2.5 was 0.14 mg/m^3.

Northern Line

The respirable dust and PM2.5 exposure levels for the Northern Line Train Operators measured on the 15th, 16th and 17th of December 2014, are given in Table 7. The respirable dust results were 0.40 and 0.61 mg/m^3. The measured level of PM2.5 was 0.18 mg/m^3.

Piccadilly Line

The respirable dust and PM2.5 exposure levels for the Piccadilly Line Train Operators measured on the 19th, 20th and 21st of November 2014, are given in Table 8. The respirable dust results were 0.18 and 0.60 mg/m^3. The measured level of PM2.5 was 0.17 mg/m^3.

Victoria Line

The respirable dust and PM2.5 exposure levels for the Victoria Line Train Operators measured on the 3rd, 4th and 8th of December 2014, are given in Table 9. The respirable dust results were 0.46 and 1.81 mg/m^3. The measured level of PM2.5 was 0.16 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 22 and the certificates for the analysis of quartz are included in Appendix 1. For each filter, the level of crystalline silica found was below or same as the detection limit of the analytical method, 0.01mg/filter. The calculated levels of airborne respirable crystalline silica where therefore all <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 23 to 25 and the certificates for the analysis of metals are included in Appendix 2.

For each filter, the levels of analysed metals (apart from Iron) were below the detection limit of the analytical method i.e. < 0.004 mg/filter. The calculated levels of 2.5 µm metals (apart from Iron) were all <0.008 mg/m^3 when the volume of air sampled was accounted for. The iron levels detected were all below 0.05 mg/filter and below 0.08 mg/m^3 when the volume of air sampled was accounted for.

5.2.4 The Grimm results are shown in graphs Figures 1 to 8. The graph of results for the Central Line is given in counts per volume of air (Figure 2) whilst the graphs of results for the rest of the lines are given in concentration/ mass per volume of air (Figures 1 and 3 to 8). The display difference between the Central Line and the other lines is due to a data logging issue which resulted in the Grimm monitor being set at counts per volume of air for the Central Line shift.

Several peaks can be observed on all of the graphs which match with times when opening of cab doors or windows took place and also when changing ends of train at the end of routes. The Grimm monitor was also disconnected during breaks 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.

It can be deduced from the graphs that the Bakerloo, Piccadilly and Northern lines presented higher dust concentration than the rest of the lines. The Circle and Hammersmith & City line had the lowest concentration.

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 in primarily in gate line and platform areas.

Where no platform duties were carried out static samples were taken but these cannot directly replace personal samples. In the following results summary, the focus is on the personal samples where possible.

Aldgate East Station

The results for the monitoring at Aldgate East Station are given in Table 10. The monitoring was carried out on the 18th of December 2014. The results for the personal samples were 0.26, 0.38 and 0.75 mg/m^3. The results for the static samples at the District Line platforms were between 0.53 and 0.75 mg/m^3.

Baker Street Station

The results for the monitoring at Baker Street Station are given in Table 11. The monitoring was carried out on the 19th of December 2014. The results for the personal samples of the staff on platform/station checks/gate line duties were 0.97 and 1.45 mg/m^3. The results for the static samples at the Jubilee Line platforms were between 1.02 and 1.03 mg/m^3.

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 22nd of December 2014. The results for the personal samples were 0.10, 0.84 and 1.76 mg/m^3. The results for the static samples at the Bakerloo Line platforms were between 0.27 and 0.29 mg/m^3.

Euston Square Station

The results for the monitoring at Euston Square Station are given in Table 13. The monitoring was carried out on the 23rd of December 2014. The results for the personal samples were 0.15 and 0.23 mg/m^3. The results for the static samples at the ticket hall and at the H&C Line platforms were 0.39 mg/m^3, 0.61 mg/m^3 and 0.71 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 5th January 2015. The results for the personal samples of the staff on gate line duties were 0.32 and 0.47 mg/m^3. The results for the static samples at the Northern Line platforms and ticket office were between 0.27 and 0.93 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 6th January 2015. The results for the personal samples of the staff on platform/gate line duties and for the static sample at the ticket office were < 0.02 mg/m^3. The results for the static samples at the Metropolitan Line platforms were both 0.05 mg/m^3.

Oxford Circus Station

The results for the monitoring at Oxford Circus Station are given in Table 16. The monitoring was carried out on the 15th January 2015. The results for the personal samples of the staff on platforms/gate line duties were between 0.14 to 0.50 mg/m^3. The results for the static samples at the Central, Victoria and Bakerloo Lines platforms were between 0.31 to 0.87 mg/m^3.

Paddington Station

The results for the monitoring at Paddington Station are given in Table 17. The monitoring was carried out on the 14th January 2015. The results for the personal samples were 0.25, 0.46 and 0.53 mg/m^3. The results for the static samples at the Bakerloo Line platforms were between 1.03 to 1.07 mg/m^3.

Piccadilly Circus Station

The results for the monitoring at Piccadilly Circus Station are given in Table 18. The monitoring was carried out on the 8th January 2015. The result for the personal sample of the staff on gate line duties was 0.16 mg/m^3. The results for the static samples at the Piccadilly Line platforms, at the ticket office and by the travel information centre were between 0.21 to 0.45 mg/m^3.

Tottenham Court Road Station

The results for the monitoring at Tottenham Court Road Station are given in Table 19. The monitoring was carried out on the 7th January 2015. The results for the personal samples of the staff on gate line duties were < 0.02 mg/m^3. The results for the static samples at the Northern Line platforms and SSOs were between 0.14 to 0.52 mg/m^3.

Vauxhall Station

The results for the monitoring at Vauxhall Station are given in Table 20. The monitoring was carried out on the 12th January 2015. The results for the personal samples were between 0.04, 0.09 to 0.14 mg/m^3. The results for the static samples at the Victoria Line platforms were between 0.33 to 0.43 mg/m^3.

Waterloo Station

The results for the monitoring at Waterloo Station are given in Table 21. The monitoring was carried out on the 13th January 2015. The results for the personal samples were between 0.17, 0.32 to 0.83 mg/m^3. The results for the static samples at the W&C Line and Bakerloo Line platforms were between 0.08 to 0.69 mg/m^3.

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: Bakerloo, Central, Circle and Hammersmith & City, District, Jubilee, Northern, Piccadilly and Victoria, and 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 Victoria Line and the lowest results were for the samples of the train operators on the Circle and H&C Lines. As a passenger, the higher levels were found on the Jubilee and the Bakerloo lines. The Grimm laser scatter data showed that the Bakerloo, Piccadilly and Northern lines presented higher dust concentration than for the other lines. The 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, Baker Street, Elephant and Castle, Euston Square, Hampstead, King's Cross, Oxford Circus, Paddington, Piccadilly Circus, Tottenham Court Road, Vauxhall and Waterloo were all below the Workplace exposure limit of 4 mg/m^3 for respirable dust (long-term 8 hour time weighted average).

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). The higher results were for the Jubilee, Northern and Bakerloo platforms at Baker Street, Hampstead and Paddington Stations respectively.

6.6 Quartz silica and metals results for the train drivers were all below the HSE Workplace Exposure Limits. In a previous Report Ref TM/03/02 low levels of chromium, copper and manganese were detected in addition to iron. In the current monitoring exercise only iron was detected. A possible reason for this could be that the current dust levels are slightly lower than previously or a greater use of regenerative braking.

6.7 Compared to the previous monitoring exercises (4RS-RH-060755-R148027, issued March 2007, 4RS-CSI-080096-R188127, issued 13th October 2008, 4RS-MS-090457-R219301R3, issued 26th May 2010, 4RS-MS-110247-R317726, issued 6th October 2011 and 4RS-RL-120749-R373201, issued 10th May 2013) the majority of the results for the Train Operators and Station personnel are similar and consistently lower than the Workplace exposure limits of 4mg/m^3 for respirable dust (long-term 8 hours time weighted average).

6.8 Although not all of the duties and locations were monitored exactly the same as performed in 2007, 2008, 2009, 2011 and 2013 those that were repeated, in similar locations, generally gave similar results with no significant variations.

6.9 It was observed on site that station staff generally spends around an hour or less at platform level. The 4-RAIL analyst was instructed to spend a greater amount of time at platform level in an attempt to gain worst case results. Hence, higher results are normally obtained for the 4-RAIL analyst in comparison to the station staff.

Table 1: 4-Rail Analyst simulating LUL 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
140792/135	RD	4RS135 - 4-Rail Analyst, Bakerloo Line	28/01/15	13:50	17:30	2.2	484	0.55	Baker Street → Elephant & Castle → Kensal Green → Elephant & Castle → Queen's Park →Elephant & Castle → Queen's park →Elephant & Castle → Waterloo
140792/03	RD	4RS03 - 4-Rail Analyst, Central Line	10/11/14	09:20	13:20	2.2	528	0.07	Epping →West Ruislip → Bethnal Green → Hanger Lane → Bethnal Green → Oxford Circus
140792/134	RD	4RS134- 4-Rail Analyst, Circle Line	27/01/15	13:30	17:55	2.2	583	0.04	Baker Street → (via Paddington) Edgware Road → (via Victoria) Edgware Road → (via King's Cross) Edgware Road → (via Paddington) Victoria
140792/136	RD	4RS136 - 4-Rail Analyst, District Line	03/02/15	14:50	19:10	2.2	561.06	0.04	Victoria → Richmond → Turnham Green → Ealing Broadway → Earl's Court → Wimbledon →Earl's Court → Richmond → Turnham Green → Ealing Broadway → Earl's Court
140792/132	RD	4RS132- 4-Rail Analyst, Jubilee Line	21/01/15	13:40	17:45	2.2	527.33	0.60	Neasden → Canning Town → Finchley Road → Canning Town → Finchley Road → Canning Town → Finchley Road → Stratford → London Bridge
140792/133	RD	4RS133 - 4-Rail Analyst, Northern Line	23/01/15	13:30	17:30	2.2	528	0.32	King's Cross → South Wimbledon → Highgate → Kennington (via Charing Cross) → Edgware (via Charing Cross) → Hampstead → Morden (via Bank) → High Barnet (via Bank) → London Bridge
140792/131	RD	4RS131 - 4-Rail Analyst, Piccadilly Line	20/01/15	09:47	13:47	2.2	528	0.10	King's Cross → Arnos Grove → Barons Court → Arnos Grove → Barons Court → Arnos Grove → Green park
140792/130	RD	4RS130 - 4-Rail Analyst, Victoria Line	19/01/15	13:21	17:21	2.2	528	0.08	Green Park → Walthamstow Central → Brixton → Walthamstow Central → Brixton →Walthamstow Central → Brixton → Walthamstow Central → Brixton → Walthamstow central → Green Park

Table 2: 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
140792/14	RD	LUL14 TO - Driver	13/11/14	09:15	11:43	2.2	466.4	0.51	Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park
				12:26	13:30	2.2			Queens Park → Elephant & Castle → Queens 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^{N} (mg/m^{3})	Route Covered
140792/11	RD	LUL11 TO - Driver	17/11/14	09:11	14:36	2.2	715	0.41	Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park *
									Queens Park → Harrow & Wealdstone → Elephant & Castle → Queens Park

*Change of train at Queen's park and short break but pumps were not disconnected.

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
140792/10F$_{i}$	PM 2.5	LUL10F$_{i}$ TO - Driver	18/11/14	07:30	10:12	3.5	567	0.26	Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle → Queens Park

*Short monitoring time due to a signal failure on this line.

Table 3: 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*
140792/01	RD	LUL01 TO - Driver	10/11/14	08:16 12:50	10:30 13:00	2.2	316.8	0.45	White City→Epping →West Ruislip White City→ Northolt → Loughton → Northolt → White City

* Pump was disconnected at West Ruislip for lunch Break and then re-commenced from White City.

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
140792/6	RD	LUL6 TO - Driver	11/11/14	08:46 12:41	11:02 16:18	2.2	776.6	0.23	White City→ Loughton → West Ruislip West Ruislip→ Epping → West Ruislip → White City

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
140792/8	PM 2.5	LUL8 TO - Driver	12/11/14	10:10	12:40	3.5	525	0.23	White City→ Hainault→ Ealing Broadway → White City

Table 4: Circle and Hammersmith & City 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
140792/45	PM 2.5	LUL45 TO - Driver	10/12/14	10:52	14:40	3.5	798	0.08	Edgware Road (via King's Cross) → Edgware Road (via Paddington)→ Hammersmith (via King's Cross)→ Edgware Road (via Victoria)→ Hammersmith

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
140792/50	RD	LUL50 TO - Driver	11/12/14	08:36	11:30	2.2	558.8	0.07	Hammersmith (via King's Cross) → Edgware Road (via King's Cross) → Edgware Road (via Paddington) → Hammersmith
				11:45	13:05	2.2			Hammersmith (via King's Cross) → 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
140792/47	RD	LUL47 TO - Driver	12/12/14	08:10	09:55	2.2	671	0.04	Hammersmith (via King's Cross)→ Moorgate (via King's Cross) → Edgware Road
				11:05	14:25	2.2			Edgware Road (via Paddington) → Hammersmith (via King's Cross) → Edgware Road (via King's Cross) → Paddington (via White City) →Hammersmith (via Paddington) → Edgware Road

Table 5: 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
140792/34	PM 2.5	LUL34 TO - Driver	27/11/14	09:21	13:00	3.5	766.5	0.09	Acton Town → Upminster → Ealing Broadway → 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^{N} (mg/m^{3})	Route Covered
140792/30	RD	LUL30 TO - Driver	01/12/14	09:15	11:45	2.2	671	0.28*	Acton Town → Dagenham East → Earl's Court → Upminster → Acton Town
				12:55	15:30	2.2			

* This result is possibly indicative because the dust pattern on the filter suggests that the filter has moved within the sampling head.

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
140792/33	RD	LUL33 TO - Driver	02/12/14	08:33	11:21	2.2	605	0.15	Acton Town → Upminster → Earl's Court → Wimbledon → Tower Hill → Earl's Court
				12:10	13:57	2.2			

Table 6: 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
140792/25	RD	LUL25 TO - Driver	24/11/14	10:42	12:30	2.2	635.8	0.14	Stratford → Wembley Park → Stratford Stratford → Willesden Green → Stratford → Stanmore → Neasden
				13:35	16:36	2.2			

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
140792/23	RD	LUL23 TO - Driver	25/11/14	13:30	14:12	2.2	338.8	0.11	North Greenwich → Wembley Park *Wembley Park → Neasden Depot
				15:20	17:12	2.2			

* Issues on the Jubilee line so this train was diverted from Wembley Park to Neasden Depot at 15:20. The driver was sitting within the train cab for 2 hours at Neasden Depot and his pump was running on him for this time.

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
140792/27	PM 2.5	LUL27 TO - Driver	26/11/14	09:40	10:30	3.5	847	0.14	North Greenwich → Wembley Park Wembley Park → Stanmore → North Greenwich → Stanmore → Stratford
				11:38	14:50	3.5			

Table 7: 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
140792/57	RD	LUL57 TO - Driver	15/12/14	07:29	10:15	2.2	880	0.40	Morden → Edgware → Kennington – High Barnet
				11:31	15:25	2.2			High Barnet → Morden → High Barnet → Morden

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
140792/54	RD	LUL54 TO - Driver	16/12/14	08:25	12:25	2.2	756.8	0.61	Morden - High Barnet → Kennington - High Barnet – Morden
				13:16	15:00	2.2			Morden → Colindale → Morden

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
140792/58	PM 2.5	LUL58 TO - Driver	17/12/14	12:00	16:20	3.5	910	0.18	Morden → Edgware → Morden → Edgware → Morden

Table 8: 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
140792/18	RD	LUL18 TO - Driver	19/11/14	11:44	15:31	2.2	499.4	0.18	Acton Town → Cockfosters → Heathrow T4 → 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
140792/15	RD	LUL15 TO - Driver	20/11/14	17:20	20:00	2.2	352	0.60	Acton Town → Cockfosters→ 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
140792/20	PM 2.5	LUL20 TO - Driver	21/11/14	08:25	11:10	3.5	577.5	0.17	Acton Town → Arnos Grove → Cockfosters → Acton Town

Table 9: 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
140792/37	PM 2.5	LUL37 TO - Driver	03/12/14	09:16	12:10	3.5	966	0.16	Brixton → Walthamstow Central → Brixton → Seven Sisters → Brixton→ Seven Sisters
				13:23	15:05	3.5			Seven Sisters → Walthamstow Central → Brixton → Green 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^{N} (mg/m^{3})	Route Covered
140792/38	RD	LUL38 TO - Driver	04/12/14	09:24	13:04	2.2	635.5	1.81	Brixton → Seven Sisters → Northumberland Park Depot → Brixton → Walthamstow Central → Brixton → Seven Sisters → Brixton Brixton →Walthamstow Central → Brixton
				14:10	15:20	2.2			

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
140792/41	RD	LUL41 TO - Driver	08/12/14	09:25	10:45	2.2	343.2	0.46	Brixton → Seven Sisters → Victoria→ Brixton
				11:48	13:04	2.2			Brixton → Walthamstow Central→ Brixton

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})	Locations & Comments
140792/60	RD	LUL60 Station Personnel	18/12/14	08:05	12:05	2.2	528	0.38	Gate line duties, A- end by SSO
140792/61	RD	Static on head wall Platform 1, WB, District Line	18/12/14	08:00	12:00	2.2	528	0.75	Behind gate by tunnel entrance.
140792/62	RD	Static on head wall Platform 2, EB, District Line	18/12/14	12:10	16:10	2.2	528	0.53	Behind gate by tunnel entrance.
140792/63	RD	LUL63 Station Personnel	18/12/14	12:15	15:20	2.2	407	0.26	Gate line duties, B - end
140792/64	RD	4RS64 - 4-Rail Analyst	18/12/14	15:22	16:25	2.2	138.6	0.75	Middle of WB platform 1

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
140792/66	RD	Static on head wall Platform 10, NB, Jubilee Line	19/12/14	10:52	14:55	2.2	534.6	1.03	Behind gate, by tunnel entrance.
140792/67	RD	Static on head wall Platform 7, SB, Jubilee Line	19/12/14	10:43	14:48	2.2	539	1.02	Behind gate, by tunnel entrance.
140792/69	RD	LUL69 Station Personnel	19/12/14	10:33	11:20	2.2	103.4	1.45	S.A.T on Platform 7
140792/70	RD	LUL70 Station Personnel	19/12/14	10:33	14:40	2.2	543.4	0.97	Security checks

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
140792/73	RD	Static on head wall Platform 4, NB, Bakerloo Line	22/12/14	08:47	12:50	2.2	534.6	0.29	Behind gate by tunnel entrance.
140792/74	RD	Static on head wall Platform 3, NB, Bakerloo Line	22/12/14	08:54	12:59	2.2	539	0.27	Behind gate by tunnel entrance.
140792/75	RD	LUL75 Station Personnel	22/12/14	08:59	11:01	2.2	268.4	0.10	Platform 4, platform 3 and ticket hall.
140792/76	RD	LUL76 Station Personnel	22/12/14	09:04	13:05	2.2	530.2	0.84	Gate line duties, Bakerloo line exit
140792/77	RD	4RS77 - 4-Rail Analyst	22/12/14	09:15	11:15	2.2	264	1.76	Platform 4, platform 3 and ticket hall.

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
140792/82	RD	LUL82 Station Personnel	23/12/14	08:56	15:06	2.2	814	0.15	Gate line duties
140792/83	RD	Static on booking hall	23/12/14	09:16	15:05	2.2	767.8	0.39	Booking hall 2/002
140792/84	RD	Static on head wall Platform 1, WB, H&C line	23/12/14	08:50	15:04	2.2	822.8	0.61	Behind gate by tunnel entrance.
140792/85	RD	4RS85- 4-Rail Analyst	23/12/14	10:16	15:07	2.2	640.2	0.23	Shadowing platform and gate line duties
140792/87	RD	Static on head wall Platform 2, EB, H&C line	23/12/14	09:25	15:01	2.2	739.2	0.71	Behind gate by tunnel entrance.

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
140792/01a	RD	LUL01a Station Personnel	05/01/15	08:45	16:30	2.2	1023	0.47	Gate line duty position.
140792/02a	RD	LUL02a Station Personnel	05/01/15	08:50	16:35	2.2	1023	0.32	Gate line duty position.
140792/03a	RD	Static on head wall Platform 2, SB, Northern Line	05/01/15	08:55	16:45	2.2	1034	0.36	Behind gate, by tunnel entrance.
140792/04a	RD	Static on head wall Platform 1, NB, Northern Line	05/01/15	09:00	16:55	2.2	1045	0.93	Behind gate, by tunnel entrance.
140792/05a	RD	Static in Ticket office	05/01/15	12:30	16:33	2.2	534.6	0.27	Ticket office

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
140792/10a	RD	LUL156 Station Personnel	06/01/15	09:00	17:00	2.2	1056	< 0.02	Platform 1 / Gate line duties
140792/12a	RD	Static on head wall Platform 2, Metropolitan Line	06/01/15	09:18	16:50	2.2	994.4	0.05	Behind gate, by tunnel entrance.
140792/13a	RD	Static on head wall Platform 1, Metropolitan Line	06/01/15	09:25	16:56	2.2	992.2	0.05	Behind gate, by tunnel entrance.
140792/14a	RD	Ticket Hall Office	06/01/15	11:00	16:00	2.2	660	< 0.02	Ticket office

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
140792/120	RD	Static on head wall Platform 1, WB, Central Line	15/01/15	09:40	13:55	2.2	561	0.74	Behind gate, by tunnel entrance.
140792/119	RD	Static on head wall Platform 2, EB, Central Line	15/01/15	09:38	16:40	2.2	928.4	0.87	Behind gate, by tunnel entrance.
140792/118	RD	Static on head wall Platform 3, SB, Bakerloo Line	15/01/15	09:45	16:55	2.2	946	0.72	Behind gate, by tunnel entrance.
140792/117	RD	Static on head wall Platform 4, NB, Bakerloo Line	15/01/15	09:15	16:35	2.2	968	0.43	Behind gate, by tunnel entrance.
140792/116	RD	Static on head wall Platform 5, SB, Victoria Line	15/01/15	09:30	16:48	2.2	963.6	0.74	Behind gate, by tunnel entrance.
140792/115	RD	Static on head wall Platform 6, NB, Victoria Line	15/01/15	09:00	16:30	2.2	990	0.31	Behind gate, by tunnel entrance.
140792/114	RD	LUL114 Station Personnel	15/01/15	09:55	17:00	2.2	935	0.14	Gate line Argyll duty
140792/113	RD	LUL113 Station Personnel	15/01/15	09:05	15:00	2.2	781	0.24	S.A.T Platform 6 duty
140792/112	RD	LUL112 Station Personnel	15/01/15	09:20	14:30	2.2	682	0.50	S.A.T Platform 4 duty

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
140792/121	RD	LUL121 Station Personnel	14/01/15	09:04	13:25	2.2	574.2	0.29	S.A.T Platform 4 & Station checks & Ticket Hall duties
140792/122	RD	LUL122 Station Personnel	14/01/15	09:27	13:29	2.2	532.4	0.46	Station checks and various ticket Hall duties
140792/123	RD	LUL123 Station Personnel	14/01/15	09:20	13:32	2.2	554.4	0.25	Station checks and various ticket Hall duties
140792/124	RD	4RS124 - 4-Rail Analyst	14/01/15	09:31	13:33	2.2	532.4	0.53	Shadowing platform and gate line duties
140792/125	RD	Static on head wall Platform 3, NB, Bakerloo Line	14/01/15	09:11	13:22	2.2	552.2	1.03	Behind gate, by tunnel entrance.
140792/126	RD	Static on head wall Platform 4, SB, Bakerloo Line	14/01/15	09:16	13:20	2.2	536.8	1.07	Behind gate, by tunnel entrance

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
140792/92	RD	LUL92 Station Personnel	08/01/15	09:50	17:12	2.2	972.4	0.16	Gate line duties
140792/91	RD	Static in travel Information centre	08/01/15	10:10	17:15	2.2	935	0.45	By travel Information centre
140792/93	RD	Static on head wall Platform 4, WB, Piccadilly Line	08/01/15	09:40	17:01	2.2	970.2	0.40	Behind gate, by tunnel entrance.
140792/94	RD	Static on head wall Platform 3, EB, Piccadilly Line	08/01/15	09:45	17:03	2.2	963.6	0.24	Behind gate, by tunnel entrance.
140792/95	RD	Static in ticket office	08/01/15	10:25	16:50	2.2	847	0.21	Ticket office

Table 19: 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
140792/07a	RD	LUL07a Station Personnel	07/01/15	09:40	16:46	2.2	937.2	< 0.02	Gate line duties
140792/08a	RD	Static on head wall Platform 3, NB, Northern Line	07/01/15	09:18	16:30	2.2	950.4	0.14	Behind gate, by tunnel entrance.
140792/16a	RD	Static on head wall Platform 4, SB, Northern Line	07/01/15	09:15	16:35	2.2	968	0.52	Behind gate, by tunnel entrance.
140792/17a	RD	Static within SSO	07/01/15	12:30	16:55	2.2	583	< 0.02	Station Supervisor's office

Table 20: 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
140792/97	RD	LUL97 Station Personnel	12/01/15	08:25	16:15	2.2	1034	0.04	Platform & Gate line duties
140792/98	RD	LUL98 Station Personnel	12/01/15	08:50	16:35	2.2	1023	0.07	POM room & Gate line duties
140792/99	RD	Static on head wall Platform 2, SB, Victoria Line	12/01/15	08:35	16:20	2.2	1023	0.43	Behind gate, by tunnel entrance
140792/100	RD	Static on head wall Platform 1, NB, Victoria Line	12/01/15	08:38	16:25	2.2	1027.4	0.33	Behind gate, by tunnel entrance
140792/101	RD	LUL101 Station Personnel	12/01/15	09:30	13:30	2.2	528	0.14	Gate line duties
140792/102	RD	4RS102 - 4-Rail Analyst	12/01/15	12:30	16:40	2.2	550	0.09	Shadowing platform and gate line 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
140792/103	RD	LUL103 Station Personnel	13/01/15	08:54	10:00	2.2	145.2	0.80	S.A.T. duty at Platform 3, Bakerloo Line
140792/104	RD	LUL104 Station Personnel	13/01/15	09:04	10:13	2.2	151.8	0.67	S.A.T. duty at WB Platform, Jubilee Line
140792/105	RD	LUL105 Station Personnel	13/01/15	09:08	10:05	2.2	125.4	0.83	S.A.T. duty at EB Platform, Jubilee Line
140792/106	RD	Static on head wall departures Platform, W&C Line	13/01/15	09:16	14:22	2.2	673.2	0.69	Behind gate, by tunnel entrance.
140792/107	RD	Static on middle of Platform 4, Bakerloo Line	13/01/15	09:32	14:35	2.2	666.6	0.08	Middle of Bakerloo Line Platform
140792/108	RD	4RS108 - 4-Rail Analyst	13/01/15	11:01	14:42	2.2	486.2	0.32	Shadowing platform and gate line duties
140792/109	RD	LUL109 Station Personnel	13/01/15	10:46	14:09	2.2	446.6	0.17	Main, Shell and Jubilee ticket hall duties
140792/110	RD	LUL110 Station Personnel	13/01/15	11:06	14:55	2.2	503.8	0.26	Main Ticket Hall & Station checks duties

Table 22: 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
140792/13	RD	Bakerloo Line 4-Rail Analyst Sitting in the train cab	13/11/14	466.4	< 0.01	< 0.02	Queens Park → Elephant & Castle → Queens Park → Elephant & Castle → Queens Park Queens Park → Elephant & Castle → Queens Park
140792/14	RD	Bakerloo Line Train Operator Driving Trains	13/11/14	466.4	< 0.01	< 0.02	
140792/5	RD	Central Line 4-Rail Analyst Sitting in the train cab	11/11/14	772.2	< 0.01	< 0.01	White City→ Loughton → West Ruislip West Ruislip→ Epping → West Ruislip → White City
140792/6	RD	Central Line Train Operator Driving Trains	11/11/14	776.6	< 0.01	< 0.01	
140792/49	RD	Circle and Hammersmith & City Line 4-Rail Analyst Sitting in the train cab	11/12/14	558.8	< 0.01	< 0.02	Hammersmith → Edgware Road → Hammersmith Hammersmith → Edgware Road
140792/50	RD	Circle and Hammersmith & City Line Train Operator Driving Trains	11/12/14	558.8	< 0.01	< 0.02	
140792/32	RD	District Line 4-Rail Analyst Sitting in the train cab	2/12/14	602.8	< 0.01	< 0.02	Acton Town → Upminster → Earl's Court → Wimbledon → Tower Hill → Earl's Court
140792/33	RD	District Line Train Operator Driving Trains	2/12/14	605	< 0.01	< 0.02	
140792/25	RD	Jubilee Line Train Operator Driving Trains	24/11/14	635.8	< 0.01	< 0.02	Stratford → Wembley Park → Stratford Stratford → Willesden Green → Stratford → Stanmore → Neasden
140792/26	RD	Jubilee Line 4-Rail Analyst Sitting in the train cab	24/11/14	629.2	0.01	0.016	
140792/56	RD	Northern Line 4-Rail Analyst Sitting in the train cab	15/12/14	880	< 0.01	< 0.02	Morden → Edgware → Kennington – High Barnet High Barnet → Morden → High Barnet → Morden
140792/57	RD	Northern Line Train Operator Driving Trains	15/12/14	880	< 0.01	< 0.02	
140792/18	RD	Piccadilly Line Train Operator Driving Trains	19/11/14	499.4	< 0.01	< 0.02	Acton Town → Cockfosters → Heathrow T4 → Heathrow T4 → Acton Town
140792/19	RD	Piccadilly Line 4-Rail Analyst Sitting in the train cab	19/14/14	497.2	< 0.01	< 0.02	
140792/41	RD	Victoria Line Train Operator Driving Trains	8/12/14	343.2	< 0.01	< 0.03	Brixton → Seven Sisters → Victoria→ Brixton Brixton → Walthamstow Central→ Brixton
140792/42	RD	Victoria Line 4-Rail Analyst Sitting in the train cab	8/12/14	343.2	< 0.01	< 0.03	

Table 23: 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 concentration (mg/m^3)	zinc concentration (mg/m^3)	Locations & Comments
140792/10F_i	PM 2.5	Bakerloo Line Train Operator Driving Trains	18/11/14	567	0.045	< 0.004	0.079	< 0.007	Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle → Queens Park Queens Park → Baker Street
140792/8	PM 2.5	Central Line Train Operator Driving Trains	12/11/14	525	0.033	< 0.004	0.063	< 0.008	White City→ Hainault→ Ealing Broadway → White City
*140792/44	PM 2.5	Circle and Hammersmith & City Line Train Operator Driving Trains	10/12/14	945	< 0.004	< 0.004	< 0.004	< 0.004	Hammersmith → Edgware Road → Paddington→ Hammersmith→ Edgware Road→ Hammersmith Hammersmith → Whitechapel
140792/34	PM 2.5	District Line Train Operator Driving Trains	27/11/13	766.5	0.017	< 0.004	0.022	< 0.005	Acton Town → Upminster → Ealing Broadway → Earl's Court
140792/27	PM 2.5	Jubilee Line Train Operator Driving Trains	26/11/14	847	0.022	< 0.004	0.026	< 0.005	North Greenwich →Wembley Park Wembley Park → Stanmore → North Greenwich → Stanmore → Stratford
140792/58	PM 2.5	Northern Line Train Operator Driving Trains	17/12/14	910	0.045	< 0.004	0.05	< 0.004	Morden → Edgware → Morden → Edgware → Morden
140792/20	PM 2.5	Piccadilly Line Train Operator Driving Trains	21/11/14	577.5	0.024	< 0.004	0.042	< 0.007	Acton Town → Arnos Grove → Cockfosters → Acton Town
140792/37	PM 2.5	Victoria Line Train Operator Driving Trains	03/12/14	966	0.041	< 0.004	0.042	< 0.004	Brixton → Walthamstow Central → Brixton → Seven Sisters → Brixton→ Seven Sisters Seven Sisters → Walthamstow Central → Brixton → Green park

*Filter worn by the 4-RAIL analyst was analysed instead of the train driver's filter as it looked heavier loaded so it represent s the worst case scenario results.

Table 24: 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 concentration (mg/m^3)	Copper concentration (mg/m^3)	Locations & Comments
140792/ $10F_i$	PM 2.5	Bakerloo Line Train Operator Driving Trains	18/11/14	567	< 0.004	< 0.004	< 0.007	< 0.007	Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle → Queens Park Queens Park → Baker Street
140792/ 8	PM 2.5	Central Line Train Operator Driving Trains	12/11/14	525	< 0.004	< 0.004	< 0.008	< 0.008	White City→ Hainault→ Ealing Broadway → White City
*140792 /44	PM 2.5	Circle and Hammersmith & City Line Train Operator Driving Trains	10/12/14	945	< 0.004	< 0.004	< 0.004	< 0.004	Hammersmith → Edgware Road → Paddington→ Hammersmith→ Edgware Road→ Hammersmith Hammersmith → Whitechapel
140792/ 34	PM 2.5	District Line Train Operator Driving Trains	27/11/13	766.5	< 0.004	< 0.004	< 0.005	< 0.005	Acton Town → Upminster → Ealing Broadway → Earl's Court
140792/ 27	PM 2.5	Jubilee Line Train Operator Driving Trains	26/11/14	847	< 0.004	< 0.004	< 0.005	< 0.005	North Greenwich →Wembley Park Wembley Park → Stanmore → North Greenwich → Stanmore → Stratford
140792/ 58	PM 2.5	Northern Line Train Operator Driving Trains	17/12/14	910	< 0.004	< 0.004	< 0.004	< 0.004	Morden → Edgware → Morden → Edgware → Morden
140792/ 20	PM 2.5	Piccadilly Line Train Operator Driving Trains	21/11/14	577.5	< 0.004	< 0.004	< 0.007	< 0.007	Acton Town → Arnos Grove → Cockfosters → Acton Town
140792/ 37	PM 2.5	Victoria Line Train Operator Driving Trains	03/12/14	966	< 0.004	< 0.004	< 0.004	< 0.004	Brixton → Walthamstow Central → Brixton → Seven Sisters → Brixton→ Seven Sisters Seven Sisters → Walthamstow Central → Brixton → Green park

*Filter worn by the 4-RAIL analyst was analysed instead of the train driver's filter as it looked heavier loaded so it represent s the worst case scenario results.

Table 25: 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 concentration (mg/m^3)	Manganese concentration (mg/m^3)	Locations & Comments
140792/ $10F_i$	PM 2.5	Bakerloo Line Train Operator Driving Trains	18/11/14	567	< 0.004	< 0.004	< 0.007	< 0.007	Queens Park → Elephant & Castle → Stonebridge Park → Elephant & Castle → Queens Park Queens Park → Baker Street
140792/ 8	PM 2.5	Central Line Train Operator Driving Trains	12/11/14	525	< 0.004	< 0.004	< 0.008	< 0.008	White City→ Hainault→ Ealing Broadway → White City
*140792 /44	PM 2.5	Circle and Hammersmith & City Line Train Operator Driving Trains	10/12/14	798	< 0.004	< 0.004	< 0.004	< 0.004	Hammersmith → Edgware Road → Paddington→ Hammersmith→ Edgware Road→ Hammersmith Hammersmith → Whitechapel
140792/ 34	PM 2.5	District Line Train Operator Driving Trains	27/11/13	766.5	< 0.004	< 0.004	< 0.005	< 0.005	Acton Town → Upminster → Ealing Broadway → Earl's Court
140792/ 27	PM 2.5	Jubilee Line Train Operator Driving Trains	26/11/14	847	< 0.004	< 0.004	< 0.005	< 0.005	North Greenwich →Wembley Park Wembley Park → Stanmore → North Greenwich → Stanmore → Stratford
140792/ 58	PM 2.5	Northern Line Train Operator Driving Trains	17/12/14	910	< 0.004	< 0.004	< 0.004	< 0.004	Morden → Edgware → Morden → Edgware → Morden
140792/ 20	PM 2.5	Piccadilly Line Train Operator Driving Trains	21/11/14	577.5	< 0.004	< 0.004	< 0.007	< 0.007	Acton Town → Arnos Grove → Cockfosters → Acton Town
140792/ 37	PM 2.5	Victoria Line Train Operator Driving Trains	03/12/14	966	< 0.004	< 0.004	< 0.004	< 0.004	Brixton → Walthamstow Central → Brixton → Seven Sisters → Brixton→ Seven Sisters Seven Sisters → Walthamstow Central → Brixton → Green park

*Filter worn by the 4-RAIL analyst was analysed instead of the train driver's filter as it looked heavier loaded so it represent s the worst case scenario results.

Figure 1: GRIMM monitor dust concentration data at the Bakerloo line on the 18th November 2014.

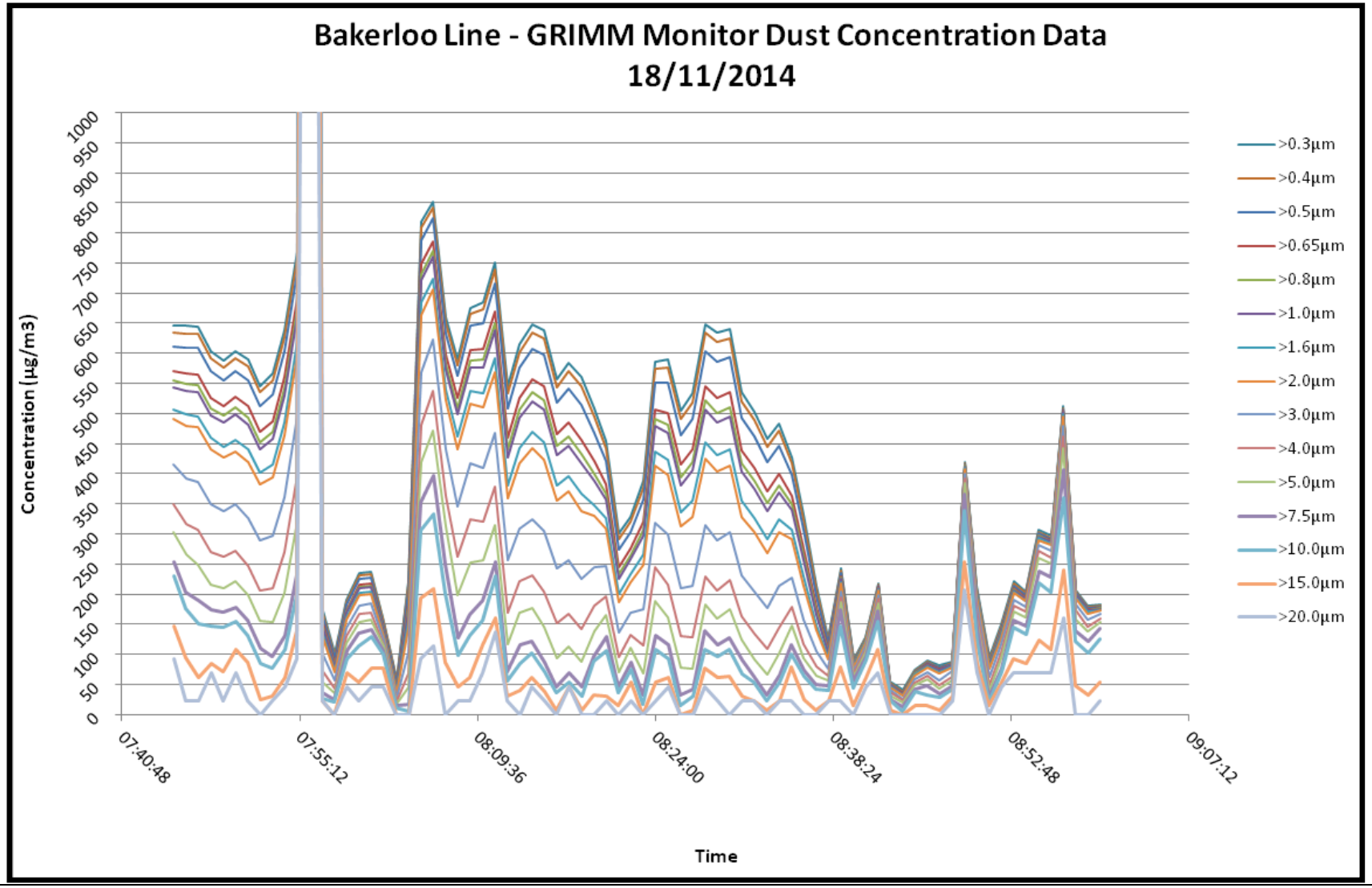

Figure 2: GRIMM monitor dust concentration data at the Central line on the 12th November 2014.

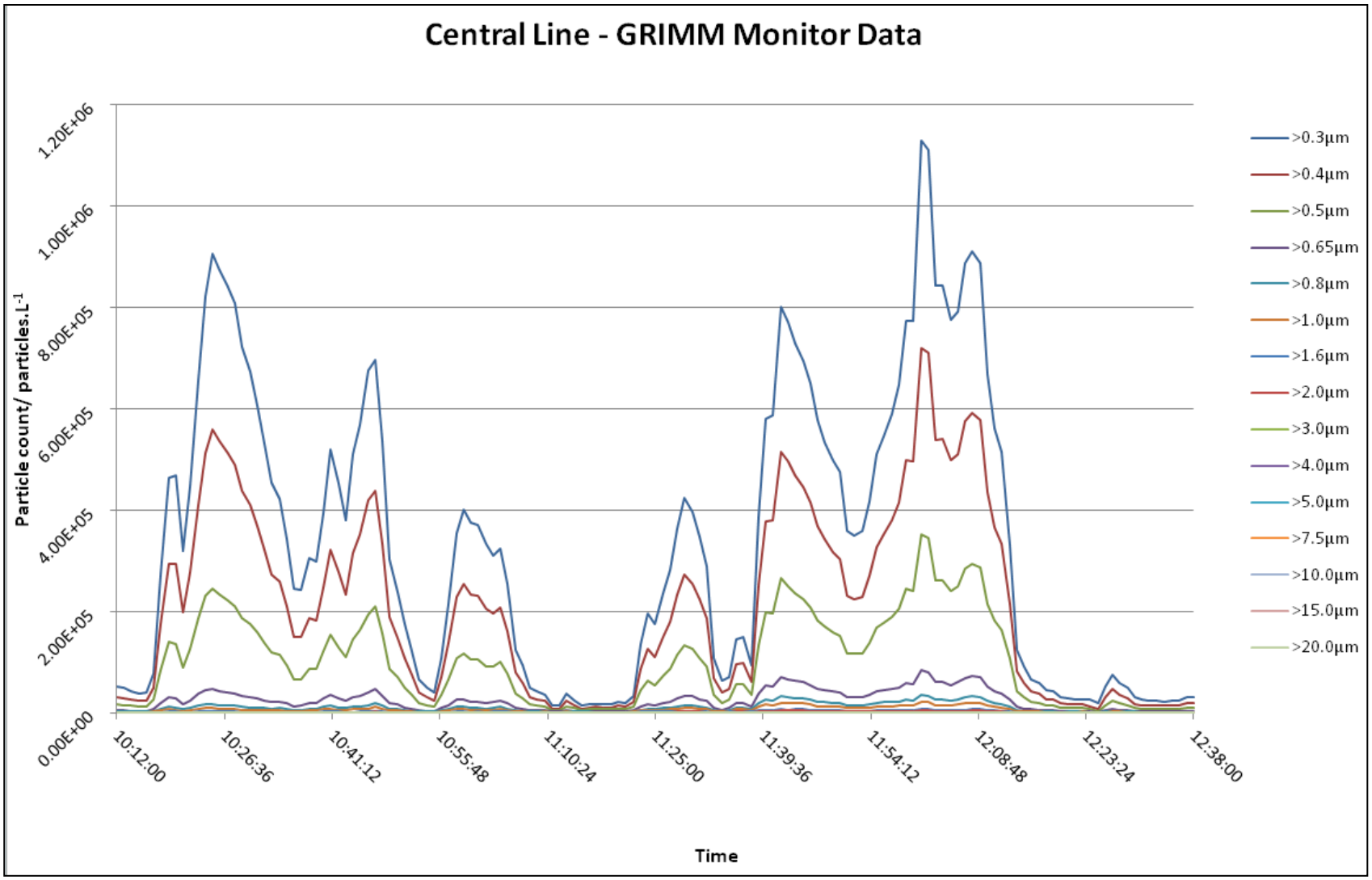

Figure 3: GRIMM monitor dust concentration data at the Circle and Hammersmith & City line on the 12th December 2014.

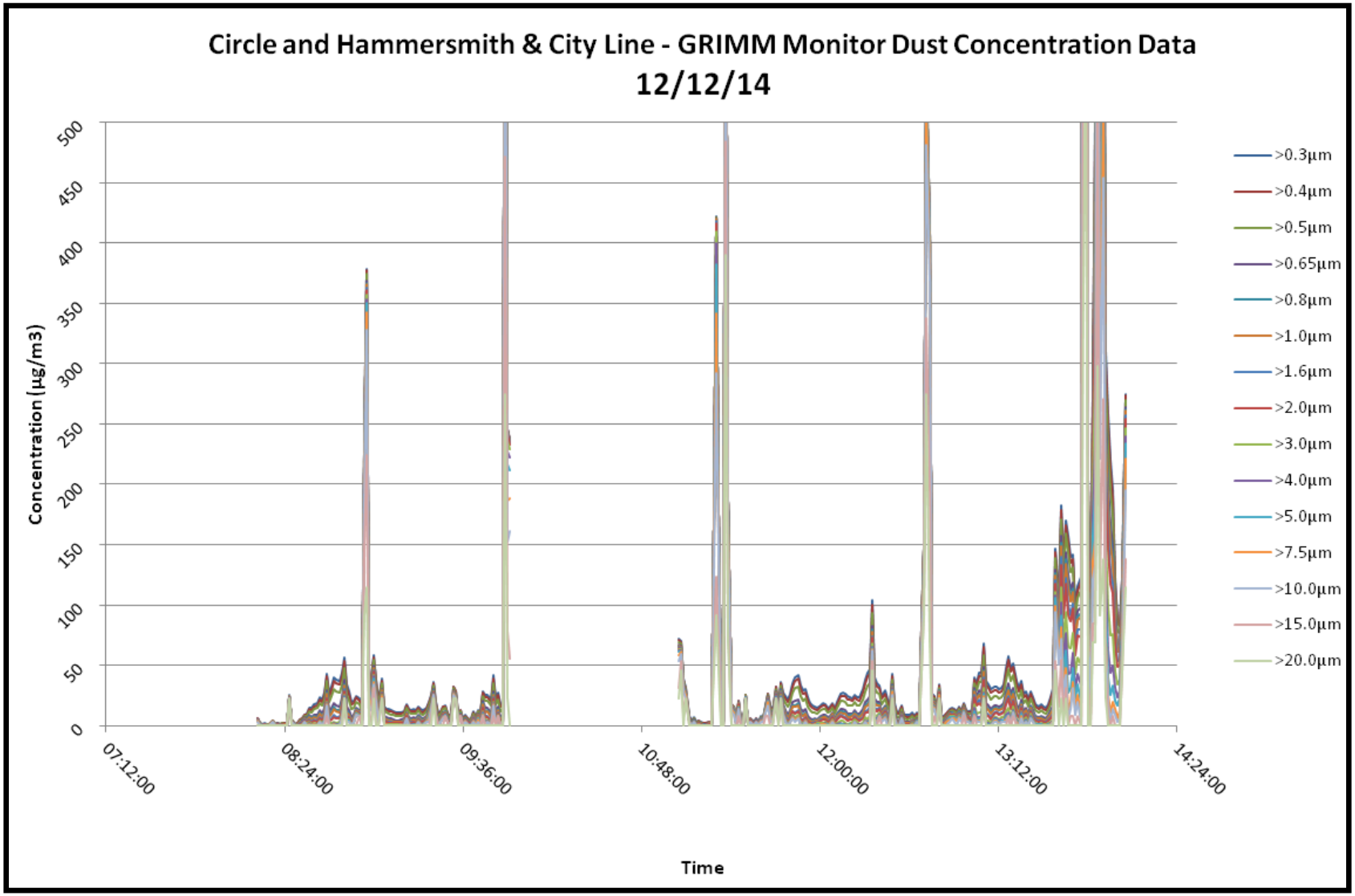

Figure 4: GRIMM monitor dust concentration data at the District line on the 27th November 2014.

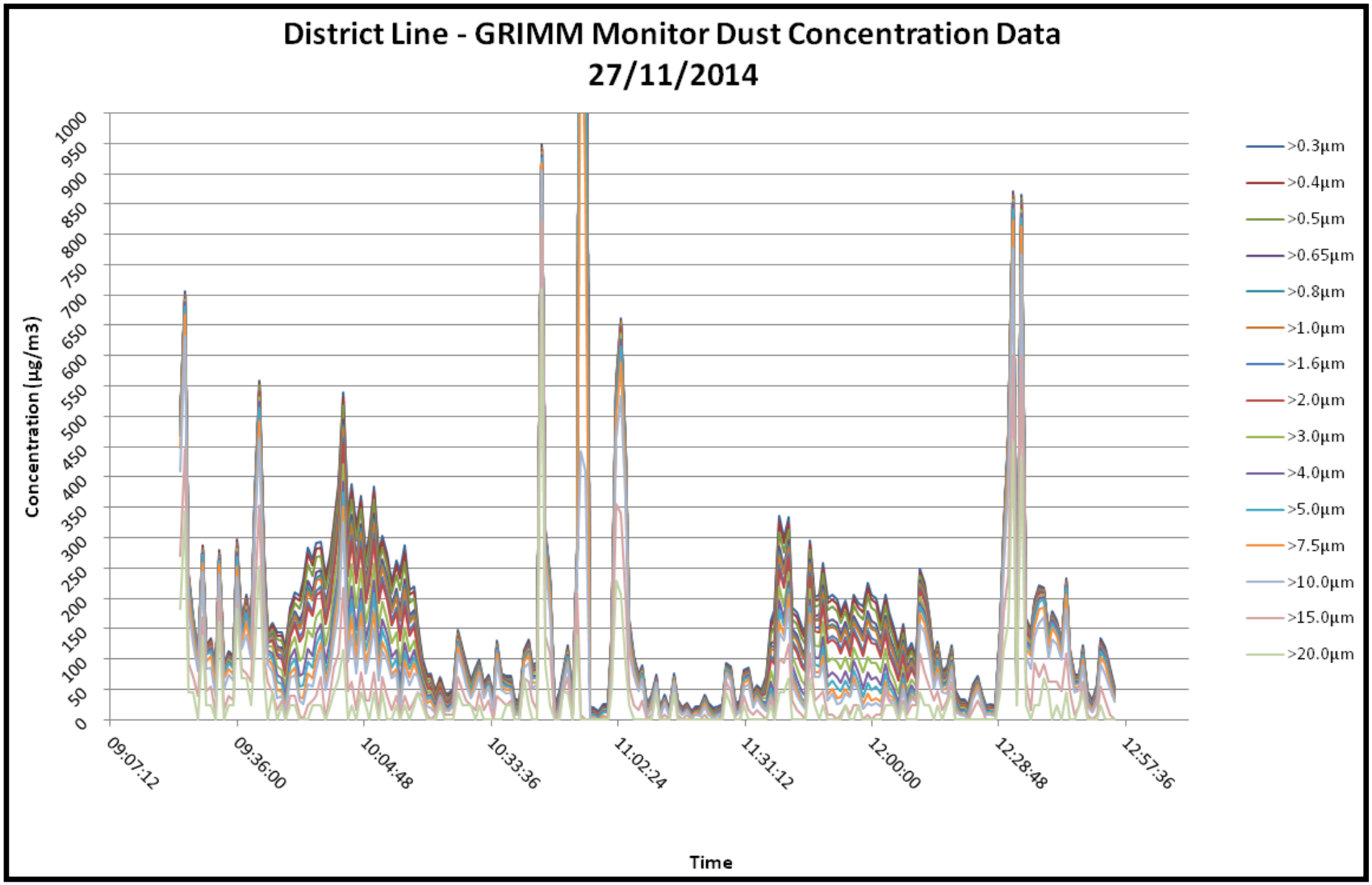

Figure 5: GRIMM monitor dust concentration data at the Jubilee line on the 24th November 2014.

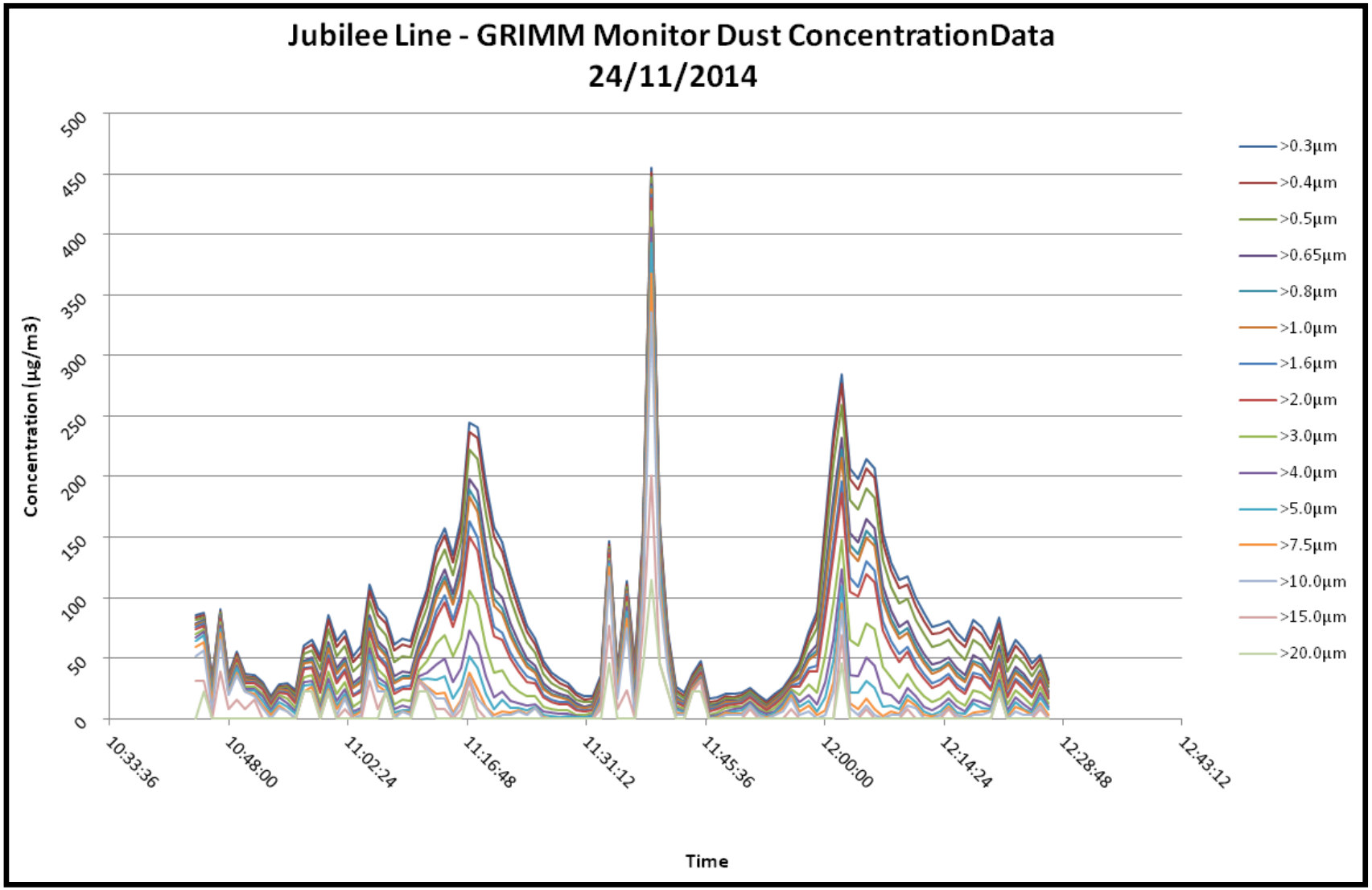

Figure 6: GRIMM monitor dust concentration data at the Northern line on the 16th December 2014.

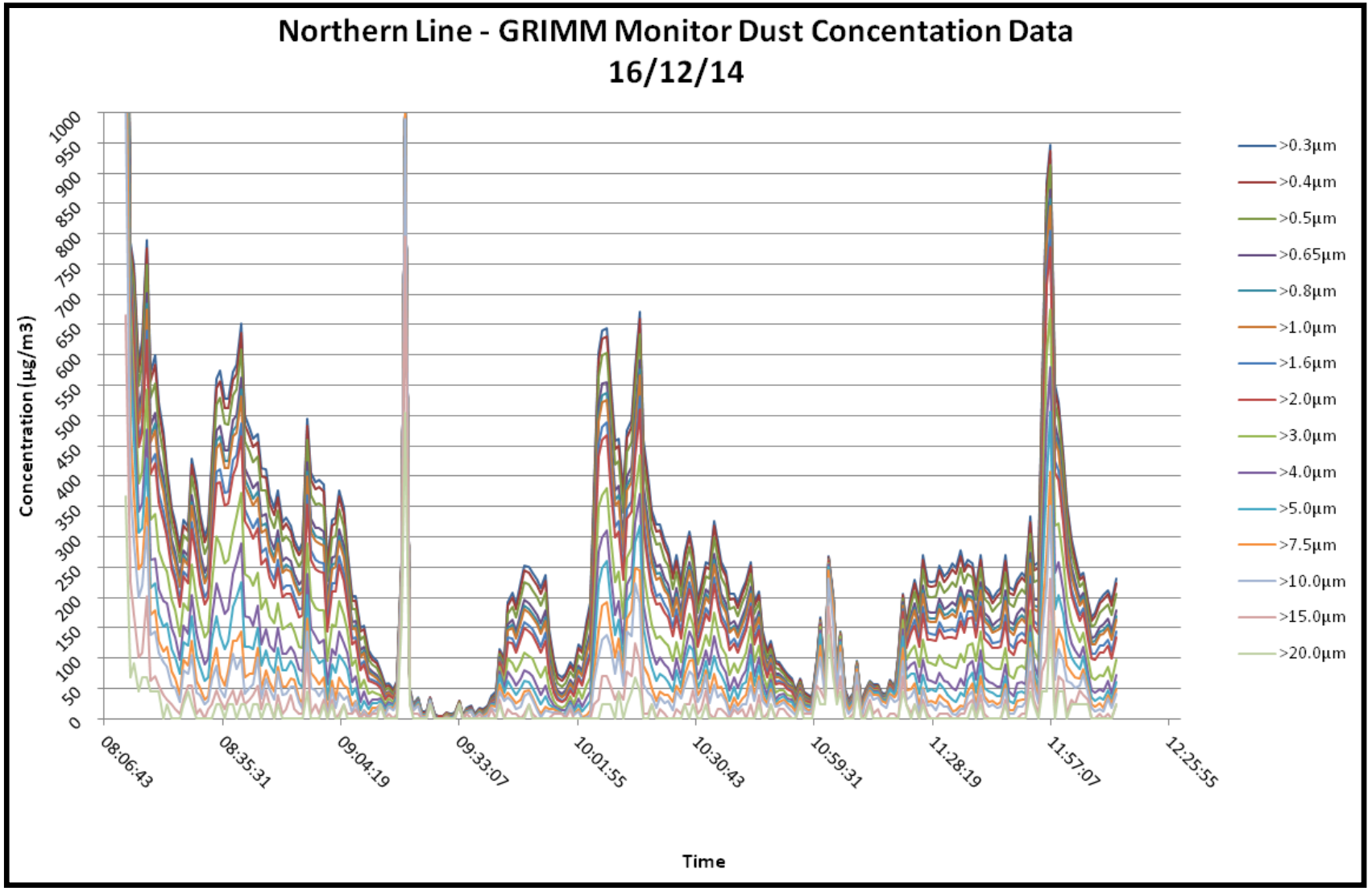

Figure 7: GRIMM monitor dust concentration data at the Piccadilly line on the 21st November 2014.

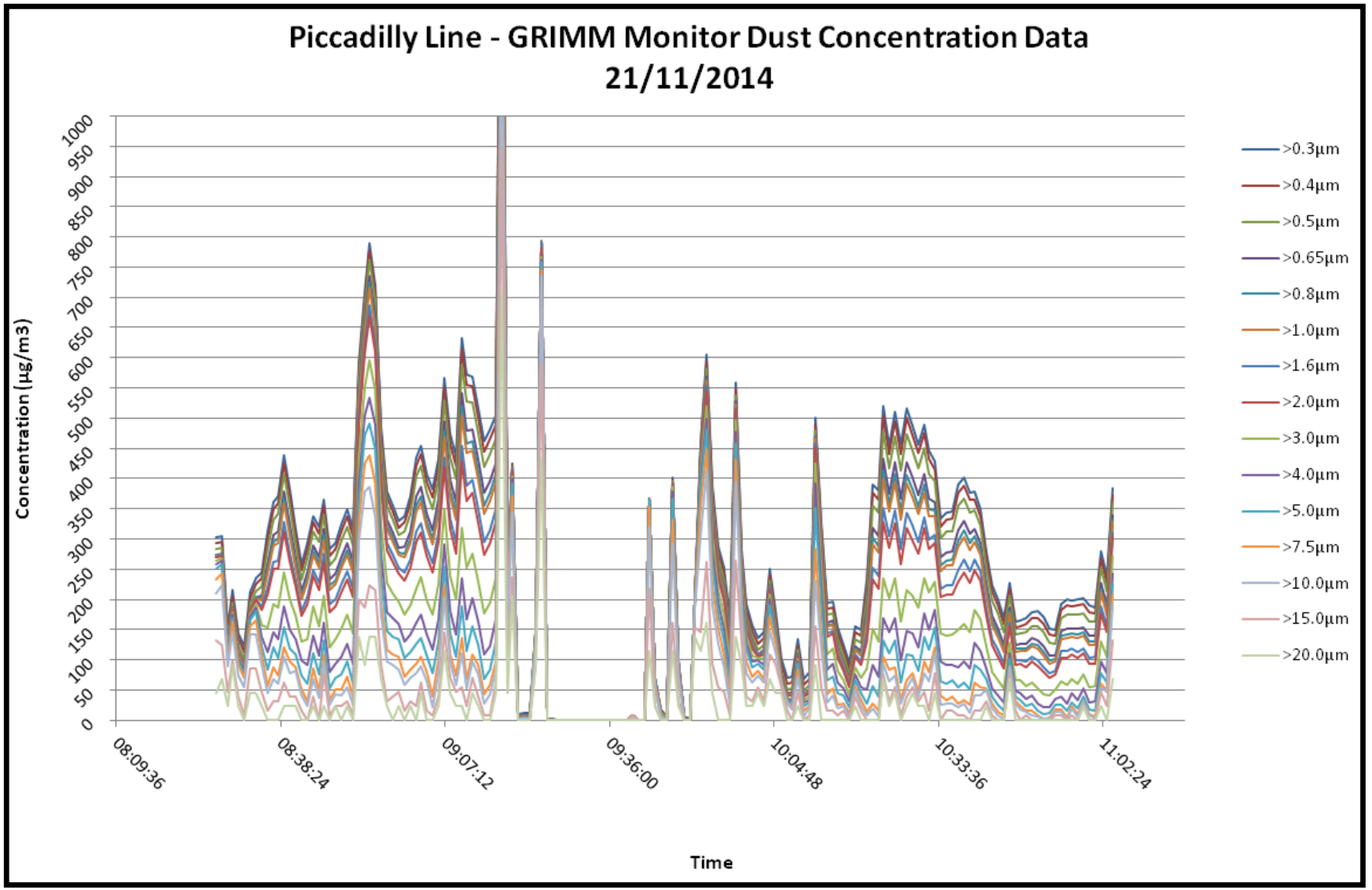

Figure 8: GRIMM monitor dust concentration data at the Victoria line on the 3rd December 2014.

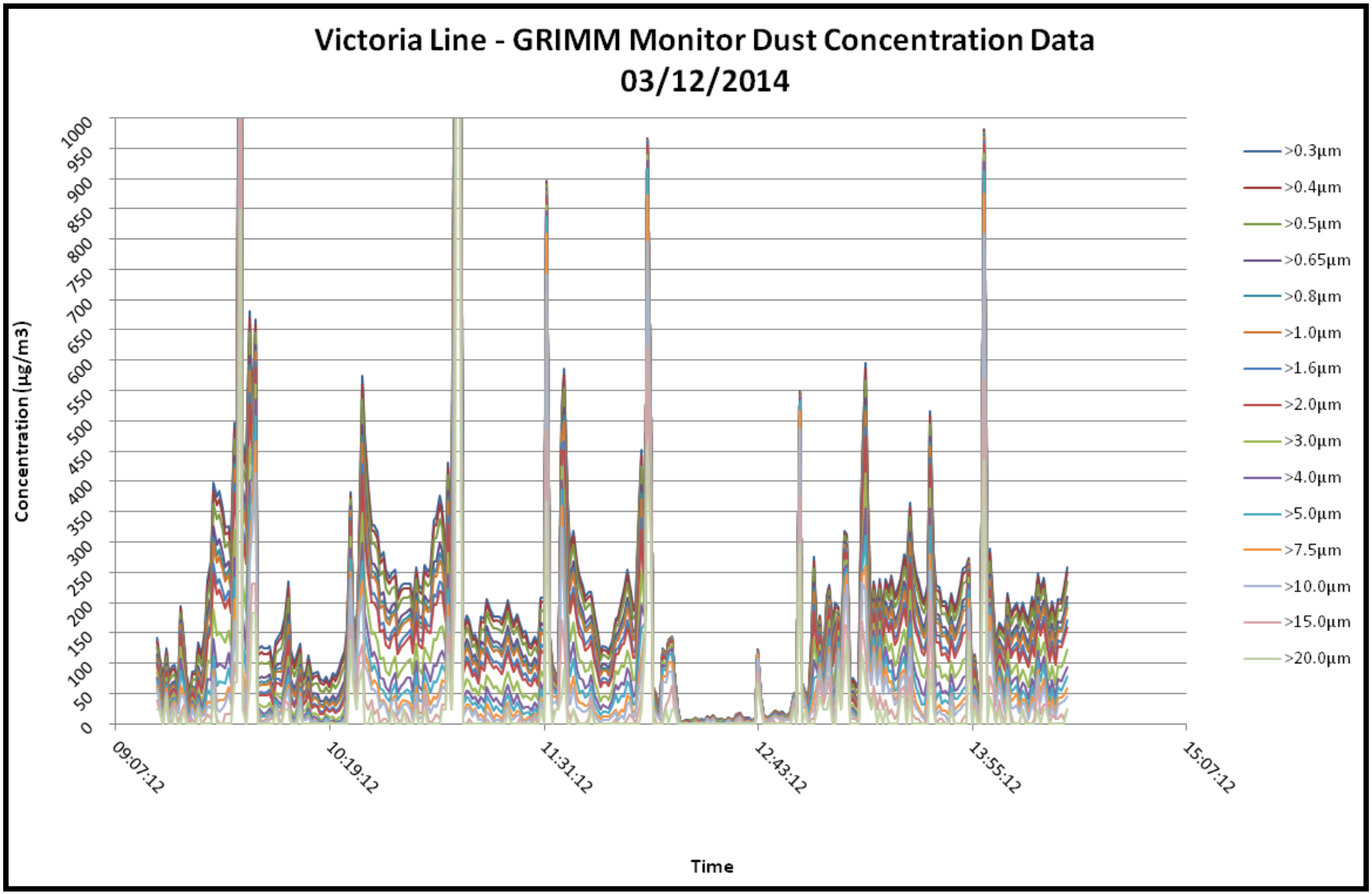

Figure 9: Cyclone Dust Head to monitor Respirable Dust.

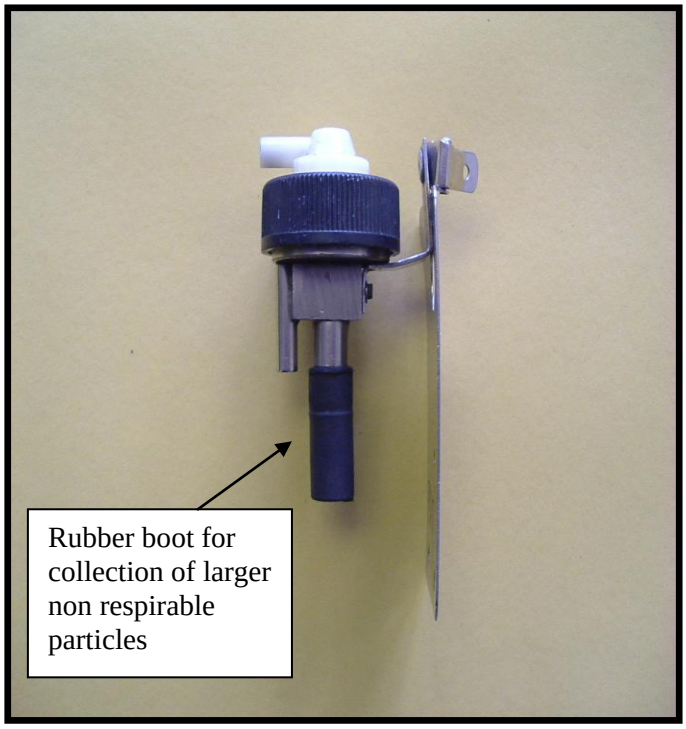

Figure 10: Cyclone Inhalable Sampler to monitor PM 2.5.

Appendix 1 : Laboratory certificates for crystalline Respirable Silica results.

IOM
WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 41533
PROJECT NO: 610
DATE OF ISSUE: 25.11.14

DATE SAMPLES RECEIVED: 17.11.14

DATE SAMPLES ANALYSED: 24.11.14

SAMPLES: 25mm "GLA-5000" 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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

Page 1 of 2

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
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING 0374

CONTRACT NO: 41533
PROJECT NO: 610
DATE OF ISSUE: 25.11.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/5	<0.01
140792/6	<0.01
140792/13	<0.01
140792/14	<0.01
140792/B6	<0.01
140792/B15	<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

IOM
WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

ANALYSIS REQUESTED BY:

Rosanna Smart
4-Rail Services Ltd
Unit 11
Ironbridge Close
Great Central Way
London
NW10 0UF

CONTRACT NO: 41628

PROJECT NO: 610

DATE OF ISSUE: 02.12.14

DATE SAMPLES RECEIVED: 24.11.14

DATE SAMPLES ANALYSED: 01.12.14

SAMPLES: 25mm "GLA-5000" PVC filters

NO. OF SAMPLES: Three

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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

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
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING
0374

CONTRACT NO: 41628
PROJECT NO: 610
DATE OF ISSUE: 02.12.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/18	<0.01
140792/19	<0.01
140792/B19	<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

WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

ANALYSIS REQUESTED BY:

Rosanna Smart
4-Rail Services Ltd
Unit 11
Ironbridge Close
Great Central Way
London
NW10 0UF

CONTRACT NO: 41711

PROJECT NO: 610

DATE OF ISSUE: 02.12.14

DATE SAMPLES RECEIVED: 27.11.14

DATE SAMPLES ANALYSED: 01.12.14

SAMPLES: 25mm "GLA-5000" PVC filters

NO. OF SAMPLES: Three

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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

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

IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING 0374

CONTRACT NO: 41711
PROJECT NO: 610
DATE OF ISSUE: 02.12.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/25	<0.01
140792/26	0.01
140792/B30	<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: Steve Clark

S Clark
Mineralogy Section Manager

WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 41837

PROJECT NO: 610

DATE OF ISSUE: 15.12.14

DATE SAMPLES RECEIVED: 05.12.14

DATE SAMPLES ANALYSED: 11.12.14

SAMPLES: 25mm "GLA-5000" 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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

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
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING 0374

CONTRACT NO: 41837
PROJECT NO: 610
DATE OF ISSUE: 15.12.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/32	<0.01
140792/33	<0.01
140792/B37	<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

IOM
WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 41941

PROJECT NO: 610

DATE OF ISSUE: 16.12.14

DATE SAMPLES RECEIVED: 11.12.14

DATE SAMPLES ANALYSED: 15.12.14

SAMPLES: 25mm "GLA-5000" 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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

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
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING
0374

CONTRACT NO: 41941
PROJECT NO: 610
DATE OF ISSUE: 16.12.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/41	<0.01
140792/42	<0.01
140792/B49	<0.01

*** Results from other projects were removed from this certificate**

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: Steve Clark

S Clark
Mineralogy Section Manager

IOM
WORKING FOR A HEALTHIER FUTURE

CERTIFICATE OF ANALYSIS

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

CONTRACT NO: 42047
PROJECT NO: 610
DATE OF ISSUE: 22.12.14

DATE SAMPLES RECEIVED: 19.12.14

DATE SAMPLES ANALYSED: 22.12.14

SAMPLES: 25mm "GLA-5000" 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: Health and Safety Executive (2005). "Crystalline silica in respirable airborne dusts". Direct on filter analyses by infrared spectroscopy and X-ray diffraction. Methods for the Determination of Hazardous Substances No. 101. HMSO, London.

Page 1 of 2

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
IOM CONSULTING LIMITED, registered in Scotland No. SC205670

UKAS TESTING
0374

CONTRACT NO: 42047
PROJECT NO: 610
DATE OF ISSUE: 22.12.14

RESULTS:

Sample Reference	Quartz Weight (mg)
140792/49	<0.01
140792/50	<0.01
140792/56	<0.01
140792/57	<0.01
140792/B60	<0.01
140792/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.

AUTHORISED BY:

Carolyn McGonagle
Senior Chemist

Appendix 2 : Laboratory certificates for 2.5 µm metal results.

Exova (UK) Ltd
70 Montrose Avenue
Hillington Park
Glasgow
G52 4LA

T: +44 (0)141 941 2022
F: +44 (0)141 952 7099
E: info@exova.com
W: www.exova.com

Test Certificate

Client: 4-RAIL Services Limited
Unit 11, Ironbridge Close, Great Central Way, London, NW10 0UF
Site: 140792 samples
Date Tested: 07/01/15
Date Reported: 7 January, 2015
Date Received: 22 December, 2014
Sample Type: Filter

Certificate No: 14/5268/RG/S/C1
File No: 14/5268/RG/S
Client Ref: 24404

Lab sample ref:					C198189	C198190	C198191	C198192	C198193
Client sample ref:					140792/8	140792/10	140792/20	140792/27	140792/34
Date sampled:					Not provided	Not provided	Not provided	Not provided	Not provided
Sample matrix (see notes page):					Filter	Filter	Filter	Filter	Filter
Determinand	**Method**	**Units**	**ISO17025**	**LOD**					
Deviation Assessment									
Deviation(s)	C. Review	N/A	N/A	N/A	4	4	4	4	4
Chromium (total)	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Copper	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Iron	AN8e	mg on filter	N	0.004	0.033	0.045	0.024	0.022	0.017
Manganese	AN8c	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Nickel	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Zinc	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Exova (UK) Ltd
70 Montrose Avenue
Hillington Park
Glasgow
G52 4LA

T: +44 (0)141 941 2022
F: +44 (0)141 952 7099
E: info@exova.com
W: www.exova.com

Test Certificate

Client: 4-RAIL Services Limited
Unit 11, Ironbridge Close, Great Central Way, London, NW10 0UF
Site: 140792 samples
Date Tested: 07/01/15
Date Reported: 7 January, 2015
Date Received: 22 December, 2014
Sample Type: Filter

Certificate No: 14/5268/RG/S/C1
File No: 14/5268/RG/S
Client Ref: 24404

Lab sample ref:					C198194	C198195	C198196	C198197	C198198
Client sample ref:					140792/37	140792/44	140792/58	140792/B10	140792/B44
Date sampled:					Not provided	Not provided	Not provided	Not provided	Not provided
Sample matrix (see notes page):					Filter	Filter	Filter	Filter	Filter
Determinand	**Method**	**Units**	**ISO17025**	**LOD**					
Deviation Assessment									
Deviation(s)	C. Review	N/A	N/A	N/A	4	4	4	4	4
Chromium (total)	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Copper	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Iron	AN8e	mg on filter	N	0.004	0.041	<0.004	0.045	<0.004	<0.004
Manganese	AN8c	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Nickel	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004
Zinc	AN8b	mg on filter	N	0.004	<0.004	<0.004	<0.004	<0.004	<0.004

Exova (UK) Ltd
70 Montrose Avenue
Hillington Park
Glasgow
G52 4LA

T: +44 (0)141 941 2022
F: +44 (0)141 952 7099
E: info@exova.com
W: www.exova.com

Test Certificate

Client: 4-RAIL Services Limited
Unit 11, Ironbridge Close, Great Central Way, London, NW10 0UF
Site: 140792 samples
Date Tested: 07/01/15
Date Reported: 7 January, 2015
Date Received: 22 December, 2014
Sample Type: Filter

Certificate No: 14/5268/RG/S/C1
File No: 14/5268/RG/S
Client Ref: 24404

Lab sample ref:	**C198199**
Client sample ref:	**140792/B68**
Date sampled:	**Not provided**
Sample matrix (see notes page):	**Filter**

Determinand	Method	Units	ISO17025	LOD	
Deviation Assessment					
Deviation(s)	C. Review	N/A	N/A	N/A	4
Chromium (total)	AN8b	mg on filter	N	0.004	<0.004
Copper	AN8b	mg on filter	N	0.004	<0.004
Iron	AN8e	mg on filter	N	0.004	<0.004
Manganese	AN8c	mg on filter	N	0.004	<0.004
Nickel	AN8b	mg on filter	N	0.004	<0.004
Zinc	AN8b	mg on filter	N	0.004	<0.004

Notes
1. The laboratory has tested the material/items supplied by the client as sampled in accordance with the client's own requirements.
2. Results as mg on filter.

Signed for, and on behalf of Exova (UK) Ltd.

Prepared by:
F Barr
Administrator

Approved by:
J McEleny
Laboratory Manager