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RESPIRABLE AIRBORNE DUST MONITORING AT VARIOUS LONDON UNDERGROUND STATIONS

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Executive Summary

At the request of Mr Nick Wilson, Occupational Hygienist – Transport for London, a dust monitoring programme was conducted in July 2019 at various London Underground stations. The scheduled dust monitoring sessions were to be carried out identical to the exercise during February – March 2019 in order to determine whether there is a seasonal effect factor that would contribute to the variations in dust levels generated during train movements.

The works comprised of undertaking respirable static air samples on platforms and gate lines, and personal respirable air samples on station staff at the following stations: 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 results obtained were then assessed for airborne dust 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, 3rd Edition 2018) and compared to the previous report issued 11th June 2019 (*Report ref. 4RS-APO-180487-R646826-Rev01*).

The results from personal sampling indicated a slight increase in dust concentrations during station staff carrying out customer assistance and/or platform duties across Aldgate East, Vauxhall and Oxford Circus. The personal sample collected from personnel at Waterloo station was found with a significantly high increase (0.83 mg/m^3). Two personal samples undertaken on staff members at Hampstead and King's Cross stations showed decrease in respirable dust exposure.

The results obtained from static respirable samples showed a general increase across the majority of LU stations during July monitoring programme when compared to February monitoring programme. The highest increase on platforms was noted at Vauxhall station (0.62 mg/m^3) – Victoria line N/B platform. The highest increase within ticket hall areas was also recorded at Vauxhall station (0.48 mg/m^3). It should be noted that two stations: King's Cross and Paddington had high variation in the two sets of data obtained, during February and July monitoring sessions. Therefore, it could not be determined whether there was significant increase or decrease in dust levels at these locations.

Baker Street and Oxford Circus stations were noted with reduced dust levels during July monitoring session when compared to February monitoring period.

1. Introduction

1.1 At the request of Mr Nick Wilson, Transport for London (Rail and Underground), monitoring for respirable airborne dust exposure was to be undertaken on various London Underground stations.

1.2 The works comprised of undertaking respirable static air samples on platforms and gate lines, and personal respirable air samples on station staff at selected stations (Table 1).

1.3 The results obtained were then assessed for respirable airborne dust Workplace Exposure Limits (WEL's) of 4 mg/m^3 averaged over an 8-hour reference period (Health and Safety Executive Document EH40/05, 3rd Edition 2018) and compared to the previous report issued 11th June 2019 (*Report ref. 4RS-APO-180487-R646826-Rev01*).

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

Stations	Sampling Locations	Sample Type
Vauxhall	Gate line/ platform duties.	Personals
Waterloo	Waterloo & City and Bakerloo line platforms	Statics
	Gate line/ platform duties.	Personals
Paddington	District & Circle, Bakerloo lines platforms	Statics
	Gate line/ platform duties.	Statics (*see note below Table 10*)

Table 1. Locations to be monitored.

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, 3rd Edition 2018). Short-term exposure limits do not currently exist for airborne dust, but usually the short-term exposure limits are taken to be 3 times the long-term exposure limits.

2.3 The long-term 8 hour exposure limits are averages for an 8 hour shift. Consequently, if during a shift the operator is only exposed to a level of dust for 6 hours, to allow comparison with the HSE limits the 8 hour time weighted average (TWA) exposure needs to be calculated. For the example of 6 hours exposure in an 8 hour period the time weighted average is 3/4 of the level measured for the six hour period. The values quoted in the results tables are dust concentrations, therefore they are equivalent to 8 hours exposure in an 8 hour period.

3. Method

3.1 Respirable dust levels were measured following the guidance set out in the Health & Safety Executive Document MDHS 14/4: General methods for sampling and gravimetric analysis of respirable, thoracic and inhalable aerosols, and in house test procedure 4R-E206 Issue 7.

3.2 Sampling pumps equipped with respirable dust cyclone heads were worn by Station Staff carrying out customer assistance duties. The locations and location codes are given in the tables of results. Examples of a cyclone (respirable) dust head and air samplers used in this exercise are shown in Appendix 1.

3.3 On stations where there would be limited or no duties on the platforms, static sampling pumps connected to cyclone heads loaded with PVC filters were set up in strategic locations where possible, generally at the end of each platform ('head wall' – where first the train enters the platform). This procedure was also adopted if station staff were not comfortable wearing personal sampler, e.g. gate lines within ticket hall. However, it should be noted that static results are not the same as personal sampling results, although they can be indicative in some circumstances.

3.4 Respirable airborne dust monitoring was carried out at each of the stations for one shift.

3.5 The main aim was to obtain personal and static monitoring data for each shift and to compare the dust results with the previous dust monitoring programme which took place in February 2019 (Report ref. 4RS-APO-180487-R646826-REV01) in order to determine whether a seasonal effect is causing variations in dust concentrations across London Underground stations.

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-RAIL Services in house test procedure 4R-E206.

5. Results

5.1 *Station Staff*

5.1.1. 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.

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

5.1.3. The result of personal sampling at Piccadilly Circus station was obtained from the 4RS technician shadowing a LU station staff member during his CSA duties.

5.1.4. There was no personal dust exposure data achieved for station staff member at Paddington station. The station supervisor advised the 4RS technician of possible multiple public concerns raised over station staff fitted with sampling equipment.

5.1.5. The lowest respirable dust exposure during this monitoring exercise were noted during CSA duties at Hampstead station (0.04 mg/m^3) and King's Cross station (0.06 mg/m^3).

5.1.6. The highest respirable dust exposure was logged for the personal samples collected from LU station staff carrying out CSA and platform duties at Waterloo station at 1.03 mg/m^3.

5.2 *Stations*

The results for the station monitoring programme are shown in Tables 2 to 13, and compared to results obtained during the previous monitoring exercise carried out in February-March 2019 (Appendix 2).

5.2.1 Waterloo Station

The monitoring was carried out on the 1st July 2019 (Table 2). The results for the static samples throughout the station, on various train line platforms and ticket office were between 0.20 to 1.35 mg/m^3, with highest concentration logged for N/B platform of Bakerloo Line. The majority of the results showed slight increase in dust levels across the station when compared to the previous monitoring programme (Figure 14). It should be noted that no dust results could be achieved for Northern line S/B platform and Jubilee line E/B platform due to air sampler malfunction.

5.2.2 Aldgate East Station

The monitoring was carried out on the 2nd July 2019 (Table 3). The results for the static samples at the ticket hall, westbound and eastbound platforms were found with concentrations between 0.22 and 0.80 mg/m^3. The results showed some variations in dust levels. The increased levels of respirable dust on the E/B platform of Hammersmith & City lines and District line, could possibly be related to engineering works taken place prior to sampling (Figure 3).

5.2.3 Baker Street Station

The monitoring was carried out on the 3rd July 2019 (Table 4). The results for the static samples were found between 0.15 and 1.41 mg/m^3. The highest dust concentrations recorded was noted on both Bakerloo Line platforms. The majority of the results showed a decrease in dust levels when compared to February 2019 results (Figure 4).

5.2.4 Elephant and Castle Station

The monitoring was carried out on the 9th July 2019 (Table 5). The results for the static samples were found between 0.04 and 0.71 mg/m^3, with the highest recorded on the Northern line northbound (N/B) platform. The majority of the results showed a slight increase in dust levels on the Bakerloo line platforms and Northern line N/B platform (Figure 5). It should be noted that no previous dust results were available for Northern line ticket hall due to air sampler malfunction. Additionally, the result from the air sample carried out in July within Bakerloo line ticket hall was indicative only due to sampler malfunction.

5.2.5 Euston Square Station

The monitoring was carried out on the 10th July 2019 (Table 6). The results for the static samples were found between 0.25 and 0.58 mg/m^3. The highest dust concentrations recorded were noted on the platforms. The results showed a general increase across the station when compared to the previous sampling findings obtained in February 2019 (Figure 6).

5.2.6 Hampstead Station

The monitoring was carried out on the 19th July 2019 (Table 7). The results for the static samples at the Northern Line N/B and S/B platforms showed dust concentrations of 1.09 mg/m^3. The results were very similar to the previous sampling findings obtained in February 2019 (Figure 7).

5.2.7 King's Cross Station

The monitoring was carried out on the 12th July 2019 (Table 8). The results for the static samples throughout the station, on various train line platforms and ticket offices, were found between 0.35 and 1.45 mg/m^3. The highest dust concentrations recorded were on the Piccadilly line W/B platform and Victoria line S/B platform. The majority of the results showed a slight increase across various parts of the station, e.g. Piccadilly line platforms and ticket halls, when the data was compared to the previous sampling findings obtained in February 2019 (Figure 8). It should be noted that no previous dust results were available for Northern and Victoria lines S/B platforms and Jubilee line E/B platform due to air samplers malfunction.

5.2.8 Oxford Circus Station

The monitoring was carried out on the 15th July 2019 (Table 9). The results for the static samples were found between 0.08 and 1.64 mg/m^3, with the highest concentration recorded on Bakerloo Line S/B platform. The majority of the platforms had dust concentrations greater than 1 mg/m^3. The static sample collected from the main ticket hall was calculated with a dust concentration of 0.08 mg/m^3. The majority of the results showed a slight decrease in dust levels across the station when compared to the previous sampling findings obtained in February 2019 (Figure 9). It should be noted that the result for the static air sample taken from Bakerloo line S/B platform due to air sampler being found faulty.

5.2.9 Paddington Station

The monitoring was carried out on the 26th July 2019 (Table 10). The results for the static samples at the platforms and gate lines were between 0.02 and 1.44 mg/m^3. The highest dust concentrations recorded were on the Bakerloo Line S/B platform. The static sample collected from the ticket hall (to Bakerloo line platforms) was calculated with a dust concentration of 0.67 mg/m^3. The results showed some variations in dust levels when compared to the previous sampling findings obtained in February 2019 (Figure 10). It should be noted that a static air sample was undertaken within the station link passage between District line and Bakerloo line instead of a personal sample. The station supervisor advised that they did not want staff fitted with air monitoring equipment. Additionally, the static air sample taken from Bakerloo line N/B platform resulted in a deviated value due to sampling head being found defective. Therefore, the result was omitted.

5.2.10 Piccadilly Circus Station

The monitoring was carried out on the 29th July 2019 (Table 11). The results for the static samples were found between 0.17 to 1.42 mg/m^3, with the highest result recorded for the sample collected from Bakerloo Line S/B platform. The lowest concentration was calculated for the static sample within the ticket hall (0.17 mg/m^3). When compared to the results obtained in February 2019, it was noted a slight increase in dust levels on Bakerloo line platforms and a slight decrease in dust levels on Piccadilly lines and ticket hall (Figure 11).

5.2.11 Tottenham Court Road Station

The monitoring was carried out on the 30th July 2019 (Table 12). The results for the static samples were between 0.23 to 1.96 mg/m^3, with the highest result recorded for the sample collected from Central Line E/B platform. The lowest concentration was calculated for the static sample within the ticket hall (0.23 mg/m^3). All of the results showed an increase in dust levels throughout the station when compared to the previous sampling findings obtained in March 2019 (Figure 12).

5.2.12 Vauxhall Station

The monitoring was carried out on the 5th August 2019 (Table 13). The results for the static samples were between 0.54 and 1.11 mg/m^3, with the highest concentration recorded on Victoria S/B platform. All of the results showed an increase in dust levels throughout the station when compared to the previous sampling findings obtained in March 2019 (Figure 13).

6. Discussions and Conclusions

6.1 The levels of airborne respirable dust measured for personal samples taken on staff carrying out Customer Service Assistance duties (to include platform/gate line/station checks) during their shifts at six of the selected eight stations were below the workplace exposure limit of 4 mg/m^3 for respirable dust (long-term 8 hour time weighted average).

The majority of the results showed an increase in dust exposures during July 2019 monitoring periods when compared to the results obtained during monitoring sessions carried out in February - March 2019 (Report ref. 4RS-APO-180487-R646826-REV01). Particularly, a significant increase (0.83 mg/m^3) was noted for the personal sample collected from station staff at Waterloo Station. There were dust results showing a decrease in dust levels for station staff at Hampstead and King's Cross stations (0.31 mg/m^3 and 0.23 mg/m^3).

6.2 All of the static samples taken at specifically selected stations, platforms and gate lines, also resulted in concentrations that would be below the workplace exposure limit.

Three stations: Euston Square, Tottenham Court, Vauxhall were noted during July 2019 dust monitoring exercise with increased dust concentrations across all of the selected sampling locations. The highest concentration was recorded on Central Line E/B platform at Tottenham Court Road station (1.96 mg/m^3). However, the highest increase (0.62 mg/m^3) was noted on Victoria Line N/B platform at Vauxhall station.
The majority of the samples collected from Elephant & Castle, King's Cross and Waterloo stations were found with slightly higher dust concentrations than the previous results recorded during February/ March 2019 monitoring session.

Two stations: Baker Street and Oxford Circus were found with the majority of the dust concentrations during July 2019 dust monitoring programme lower than the results obtained during February 2019. The highest decrease was recorded for the static sample collected from the ticket hall at Oxford Circus station (0.70 mg/m^3).

Similar dust data was obtained for samples undertaken at Hampstead station during February and July 2019.

Two stations: Aldgate East and Piccadilly Circus were found with variations in dust concentrations at the selected sampling locations. The results at Piccadilly Circus station were an increase in dust levels on Bakerloo line platforms and a decrease on Piccadilly line platforms. The results at Aldgate East showed an increase in dust levels on E/B platform and a decrease on W/B platform.

The dust results from Paddington station obtained from both monitoring sessions showed dust concentration variations across all the sampling locations and therefore it was not possible to indicate whether there was seasonal trend in dust levels.

6.3 In conclusion, the data collation following two monitoring programmes carried out at selected London Underground stations, during February/ March and during July 2019, showed a slight elevation in respirable dust concentrations across the majority of the static sampling points. The gravimetric analysis of samples collected from LU station personnel also showed a slight increase in dust exposure during July monitoring session for the majority of the stations.

Table 2. 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
190189/01	RD	Personal - LUL Station Staff - CSA2	01/07/19	09:59	14:00	2.2	530.2	1.03	Personal monitoring during gate line duty within main ticket hall. No visible dust at this location, as outside air flowing through constantly.
190189/02	RD	Static – Jubilee Line – Gate line	01/07/19	10:36	14:40	2.2	536.8	0.20	General dust conditions at this location were noted low.
190189/03	RD	Static – Northern Line N/B	01/07/19	10:18	14:20	2.2	532.4	0.86	Moderate levels of dust noted at these location throughout the duration of sampling session.
190189/04	RD	Static – Bakerloo Line S/B	01/07/19	10:08	14:11	2.2	534.6	1.13	
190189/05	RD	Static - Waterloo & City Line – Arrivals	01/07/19	09:57	14:02	2.2	539	0.89	
190189/06*	RD	Static – Jubilee Line E/B	01/07/19	10:28	*Pump failure*				General dust conditions at these locations were noted moderate.
190189/07	RD	Static – Jubilee Line W/B	01/07/19	10:31	14:34	2.2	534.6	0.52	
190189/08	RD	Static – Bakerloo Line N/B	01/07/19	10:04	14:08	2.2	536.8	1.35	
190189/09*	RD	Static – Northern Line S/B	01/07/19	10:12	*Pump failure*				
190189/10	RD	Static - Waterloo & City Line – Departures	01/07/19	09:53	14:04	2.2	552.2	0.37	General dust conditions at this location were noted low.

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

Table 3. 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
190189/11	RD	Personal – LUL Station Staff	02/07/19	09:56	14:01	2.2	539	0.64	LUL gate line staff carrying out Customer Service Assistant Level 1 (CSA1)
190189/12	RD	Static – District, Hammersmith and City Lines, W/B Platform 1	02/07/19	10:03	14:06	2.2	539	0.39	Slight dust levels were visible and noted at the station throughout the sampling duration.
190189/13	RD	Static – District, Hammersmith and City Lines, E/B Platform 2	02/07/19	10:07	14:10	2.2	534.6	0.80	
190189/14	RD	Static – Ticket Hall	02/07/19	09:59	14:05	2.2	541.2	0.22	

Table 4. 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
190189/15	RD	Static - Bakerloo Line	03/07/19	10:15	14:15	2.20	528	1.41	Platform 9 (N/B) Significant level of dust noted at this location.
190189/16	RD	Static - Hammersmith & Circle Lines	03/07/19	09:54	14:23	2.20	591.8	0.72	Platform 6 (W/B) Slight-moderate level of dust noted at this platform compared to E/B platform.
190189/17	RD	Static – Ticket Hall	03/07/19	09:50	14:25	2.20	605	0.15	To platforms 3 & 4 (E/B)
190189/18	RD	Static – Escalator Hall	03/07/19	10:02	14:19	2.20	565.4	0.17	Top of escalator to N/B Jubilee & Bakerloo lines
190189/19	RD	Static - Bakerloo Line	03/07/19	10:09	14:09	2.20	528	1.13	Platform 8 (S/B) Moderate-significant level of dust noted at this location.
190189/20	RD	Static - Jubilee Line	03/07/19	10:05	14:11	2.20	514.2	0.91	Platform 7 (S/B) Moderate-significant level of dust noted at this location.
190189/21	RD	Static - Bakerloo Line	03/07/19	10:13	14:17	2.20	536.8	0.63	Platform 10 (W/B) Moderate-significant level of dust noted at this location.
190189/22	RD	Static - Hammersmith & Circle Lines	03/07/19	09:58	14:21	2.20	578.6	0.26	Platform 5 (E/B)

Table 5. 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
190189/23	RD	Static – Bakerloo Line N/B Platform 3	09/07/19	09:41	13:53	2.2	554.4	0.27	Trains approaching the station at low speed unlikely to cause significant dust disturbance. Therefore the dust levels were noted to be slightly visible on both platforms.
190189/24	RD	Static – Northern line Ticket Hall	09/07/19	10:00	14:04	2.2	536.8	0.04	No visible dust levels noted as outside air circulating through constantly.
190189/25	RD	Static – Northern Line S/B Platform 2	09/07/19	09:55	14:01	2.2	541.2	0.43	Slight - moderate level of dust noted on these platforms.
190189/26	RD	Static – Bakerloo Line N/B Platform 4	09/07/19	09:45	13:55	2.2	550	0.33	Trains approaching the station at low speed unlikely to cause significant dust disturbance. Therefore the dust levels were noted to be slightly visible on both platforms.
190189/27	RD	Static – Northern Line N/B Platform 1	09/07/19	09:50	13:58	2.2	545.6	0.71	Moderate level of dust noted on these platforms.
190189/28*	RD	Static – Bakerloo line Ticket Hall	09/07/19	09:38	*Pump failure*		*327.8*	*0.03*	No visible dust levels noted as outside air circulating through constantly.

Table 6. 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
190189/29	RD	Static - Ticket Hall - Exit A	10/07/19	09:00	13:05	2.2	539	0.25	Slight levels of dust noted at these locations.
190189/30	RD	Static - Hammersmith & Circle line E/B platform	10/07/19	09:13	13:14	2.2	530.2	0.56	Platform 2 – E/B Slight levels of dust noted at this location.
190189/31	RD	Static - Hammersmith & Circle line W/B platform	10/07/19	09:03	13:07	2.2	536.8	0.27	Platform 1 – W/B Slight levels of dust noted at this location.
190189/32	RD	Static - Ticket Hall - Exit B	10/07/19	09:15	13:16	2.2	530.2	0.58	Slight levels of dust noted at these locations.

Table 7. 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
190189/33	RD	Static - Northern Line – S/B Platform 2	19/07/19	06:49	11:00	2.2	552.2	1.09	Moderate dust levels noted throughout the sampling session.
190189/34	RD	Personal – LUL Station Staff	19/07/19	06:40 09:45	09:15 10:23	2.2	424.6	0.04	LU Station staff carrying out CSA1 duties at Gate line, with occasional 10 mins breaks.
190189/35	RD	Static - Northern Line – N/B Platform 1	19/07/19	06:56	11:11	2.2	547.8	1.09	Moderate dust levels noted throughout the sampling session.

Table 8. 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
190189/36	RD	Static - Main Ticket Hall	12/07/19	09:05	13:07	2.2	532.4	0.57	Slight levels of dust noted at this locations throughout the duration of sampling session.
190189/37	RD	Static - Hammersmith & Circle line W/B platform	12/07/19	09:42	13:43	2.2	530.2	0.40	
190189/38	RD	Static - Piccadilly line E/B platform	12/07/19	09:08	13:10	2.2	532.4	0.99	Moderate levels of dust noted on the platforms throughout the duration of sampling session.
190189/39	RD	Static - Northern line S/B platform	12/07/19	09:18	13:21	2.2	534.6	0.70	
190189/40	RD	Static - Piccadilly line W/B platform	12/07/19	09:12	13:13	2.2	530.2	1.45	
190189/41	RD	Static - Victoria line S/B platform	12/07/19	09:29	13:30	2.2	530.2	1.17	
190189/42	RD	Static - Northern Line N/B platform	12/07/19	09:22	13:23	2.2	530.2	0.73	
190189/43*	RD	Static - Hammersmith & Circle line E/B platform	12/07/19	09:38	*12:34*	*2.2*	*237.6*	*0.73*	Slight levels of dust noted at these locations throughout the duration of sampling session.
190189/44	RD	Static - Exit from Circle line	12/07/19	09:46	13:46	2.2	528	0.35	
190189/45	RD	Static - Victoria line N/B platform	12/07/19	09:26	13:27	2.2	530.2	0.73	Moderate levels of dust noted on the platform throughout the duration of sampling session.
190189/46	RD	Personal – LUL Station Staff	12/07/19	09:32	13:48	2.2	563.2	0.06	Slight levels of dust noted at these location throughout the duration of sampling session.

**Note: Air sampler found non-functional at 13:38. The result is reported as indicative only.*

Table 9. 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
192020/21	RD	Personal – LUL Station Staff	15/07/19	07:53	11:12	2.2	437.8	0.69	LUL Station staff carrying out CSA duties.
192020/22*	RD	Static - Bakerloo Line S/B platform	15/07/19	07:59	11:18	2.2	437.6	*1.64**	Significant levels of dust were noted on all platforms throughout the duration of sampling session.
192020/23	RD	Static - Victoria Line S/B platform	15/07/19	08:06	12:12	2.2	541.2	1.10	
192020/24	RD	Static - Bakerloo Line N/B platform	15/07/19	08:15	12:19	2.2	536.8	1.19	
192020/25	RD	Static - Victoria Line N/B platform	15/07/19	08:22	12:22	2.2	528	1.10	
192020/26	RD	Static - Central line W/B platform	15/07/19	08:38	12:40	2.2	532.4	0.98	
192020/27	RD	Static - Central line E/B platform	15/07/19	08:47	12:47	2.2	528	1.12	
192020/28	RD	Static – Main Ticket Hall	15/07/19	08:55	12:55	2.2	528	0.08	Slight levels of dust noted at this location throughout the duration of sampling session.

Note: The sampler was found defective during sampling period and restarted. The result from this sampling is indicative.

Table 10. 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
190189/47	RD	Static – Bakerloo Line S/B Platform 4	26/07/19	10:01	14:11	2.2	550	1.44	Moderate – significant levels of dust noted throughout the duration of sampling session.
190189/48*	RD	Static – Ticket Hall A	26/07/19	09:52	14:05	2.2	556.6	0.11	Slight levels of dust visible.
190189/49	RD	Static – Circle and District Line E/B Platform 2	26/07/19	09:55	14:07	2.2	554.4	0.11	
190189/50[#]	RD	Static – Bakerloo Line N/B Platform 3	26/07/19	10:04	14:14	2.2	550	-	Moderate – significant levels of dust noted throughout the duration of sampling session.
190189/51	RD	Static – Ticket Hall C	26/07/19	10:07	14:17	2.2	550	0.67	Slight levels of dust noted at these locations throughout the duration of sampling session.
190189/52	RD	Static – Ticket Hall B	26/07/19	09:58	14:09	2.2	552.2	0.48	

**Note: The station supervisor on duty at the time of sampling refused for LUL station staff to wear any air samplers, based on possible terrorist related concerns raised by the public.*

[#]Note: Air sampler was functional and the flow rate checks were carried out throughout the sampling session. However, the filter was noted without any depositions at the end of sampling period. It is possible that the sampling head could have been defective. This is a deviated result and it was omitted.

Table 11. 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
190189/58*	RD	Static – Bakerloo Line S/B	29/07/19	10:21	14:24	2.2	534.6	1.56	Moderate – significant levels of dust noted on all platforms throughout the duration of sampling session.
190189/59	RD	Static – Piccadilly Line E/B	29/07/19	10:30	14:33	2.2	534.6	1.03	Slight dust levels noted at this location.
190189/60	RD	Personal – 4RS Technologist	29/07/19	10:32	14:37	2.2	539	0.05	Slight dust levels noted during sampling station within ticket hall area. Moderate levels on platforms.
190189/61	RD	Static – Bakerloo Line N/B	29/07/19	10:16	14:20	2.2	536.8	1.24	Moderate – significant levels of dust noted on all platforms throughout the duration of sampling session.
190189/62	RD	Static – Piccadilly Line W/B	29/07/19	10:26	14:28	2.2	532.4	1.02	
190189/63	RD	Static – Main Ticket Hall	29/07/19	10:11	14:17	2.2	514.2	0.17	Slight dust levels noted at this location.

**Note: LUL staff refused to wear an air sampler. 4RS technologist carried out a personal sample on himself, whilst shadowing station staff in their CSA duties.*

Table 12. 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
190189/53	RD	Static - Northern Line S/B	30/07/19	09:37	13:44	2.2	543.4	1.12	No visible levels of dust noted within ticket hall throughout the duration of sampling session. General dust levels on all platforms were noted to be moderate/ significant throughout the duration of sampling session.
190189/54	RD	Static - Central Line E/B	30/07/19	09:31	13:39	2.2	545.6	1.96	
190189/55	RD	Static - Central Line W/B	30/07/19	09:34	13:41	2.2	609.4	1.09	
190189/56	RD	Static – Ticket Hall	30/07/19	09:26	13:35	2.2	547.8	0.23	
190189/57	RD	Static- Northern Line N/B	30/07/19	09:41	13:47	2.2	541.2	1.13	

Table 13. 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
190189/64	RD	Personal – LUL station staff	05/08/19	11:00	14:30	2.2	462	0.19	Slight dust levels noted during sampling station within ticket hall area. Moderate levels on platforms.
190189/65	RD	Static – Victoria Line N/B	05/08/19	10:40	14:45	2.2	539	1.00	Moderate – significant levels of dust noted on all platforms throughout the duration of sampling session.
190189/66	RD	Static – Victoria Line S/B	05/18/19	10:47	14:50	2.2	534.6	1.11	
190189/67	RD	Static – Ticket Hall	05/18/19	10:55	14:56	2.2	530.2	0.54	Slight dust levels noted at this location

Appendix 1. Photos of type of samplers and sampling heads used in the monitoring programme.

Figure 1. Cyclone Dust Head to monitor Respirable Dust.

Figure 2. Examples of air samplers used for collecting airborne dust.

Appendix 2. Graphic representation of dust concentrations during two monitoring exercises

Figure 3. Respirable dust concentration results obtained for February and July 2019 for Aldgate Station

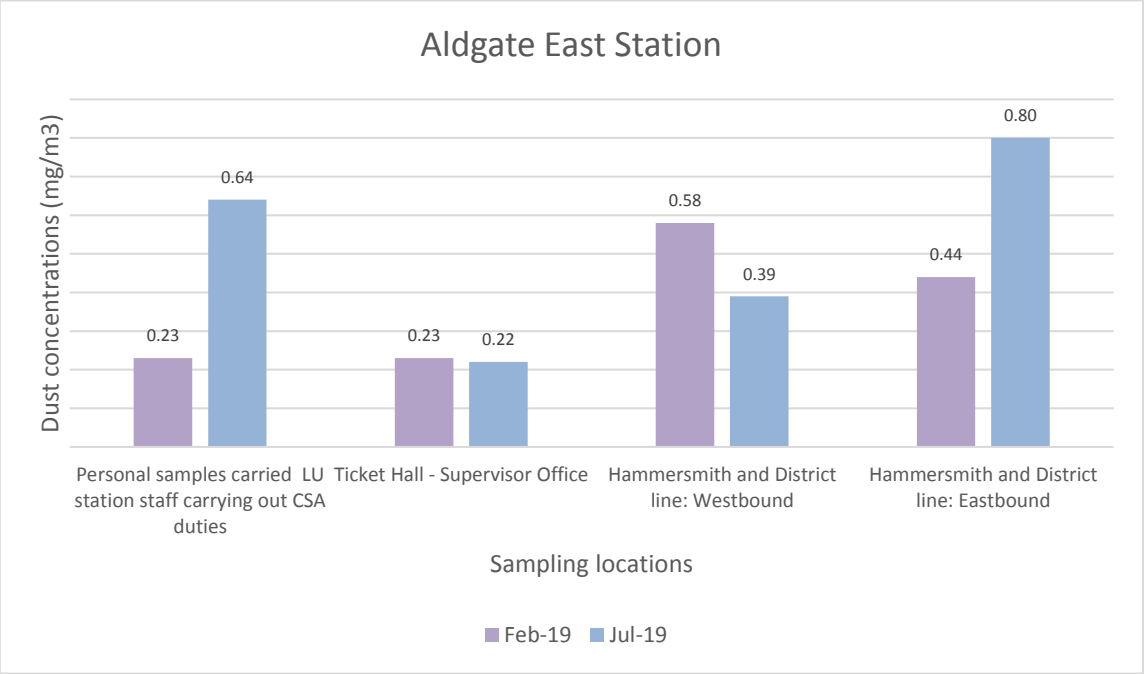

Figure 4. Respirable dust concentration results obtained for February and July 2019 for Baker Street Station

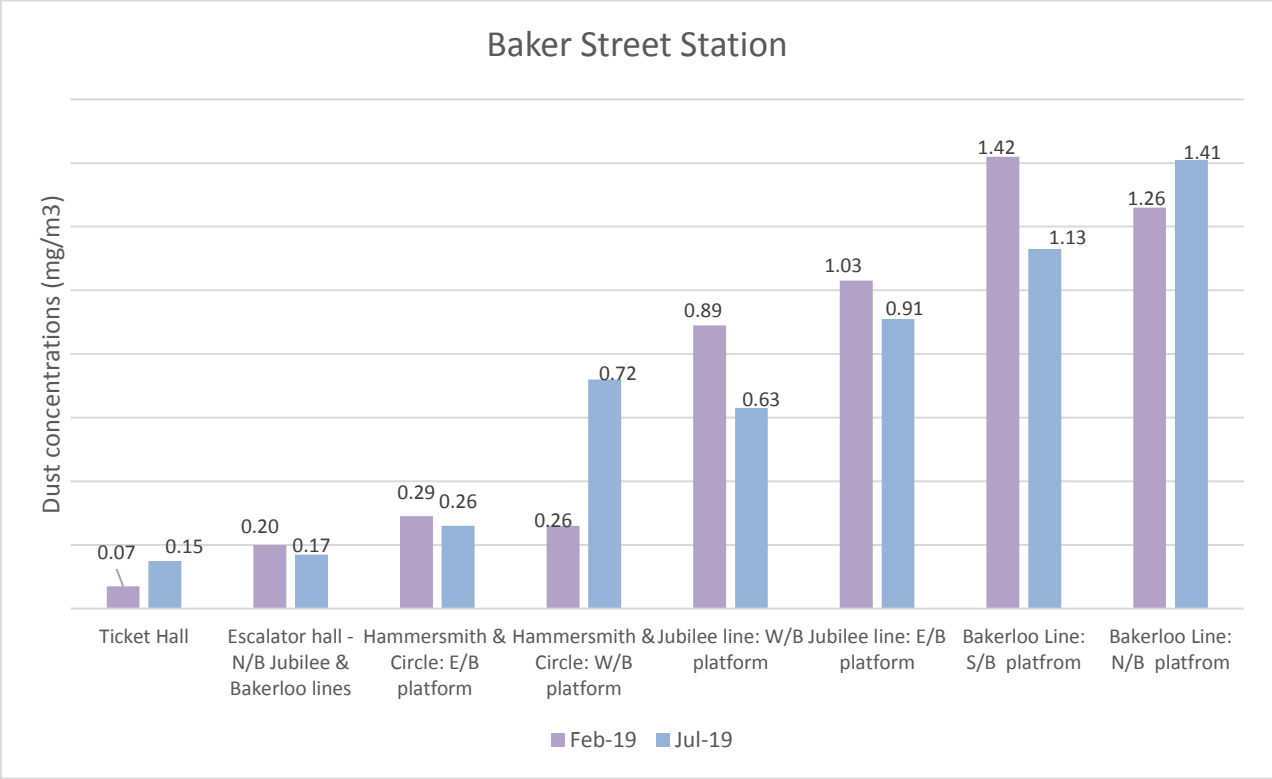

Figure 5. Respirable dust concentration results obtained for February and July 2019 for Elephant & Castle Station

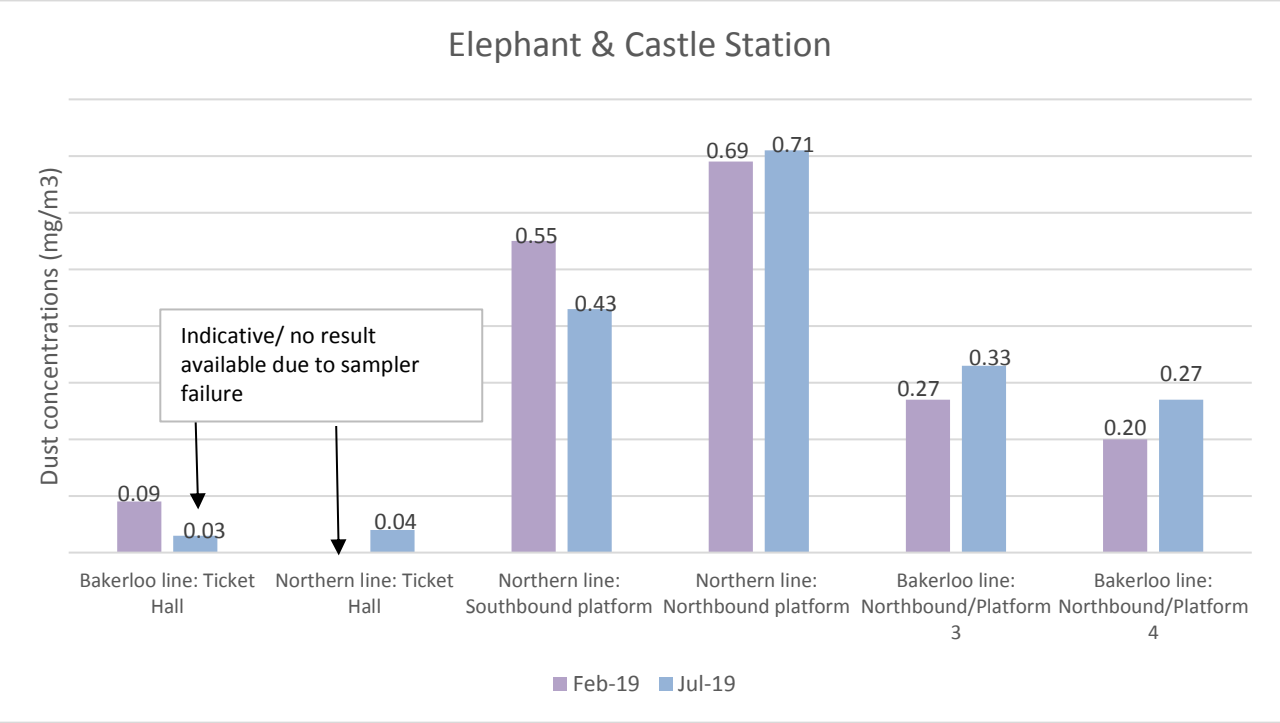

Figure 6. Respirable dust concentration results obtained for February and July 2019 for Euston Square Station

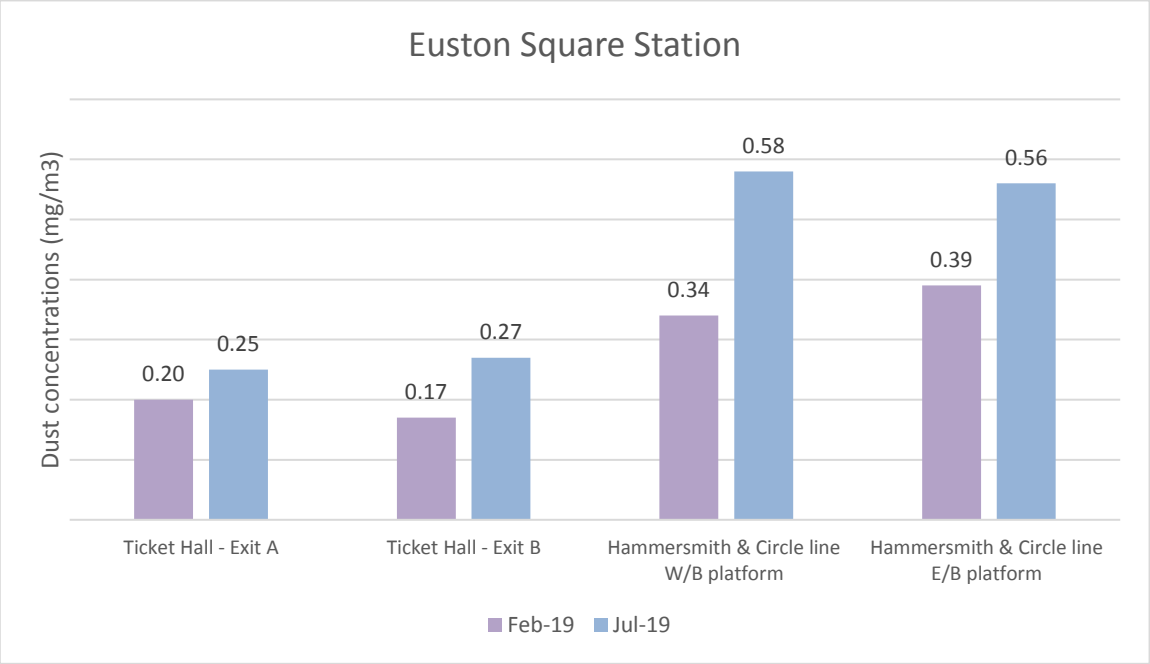

Figure 7. Respirable dust concentration results obtained for February and July 2019 for Hampstead Station

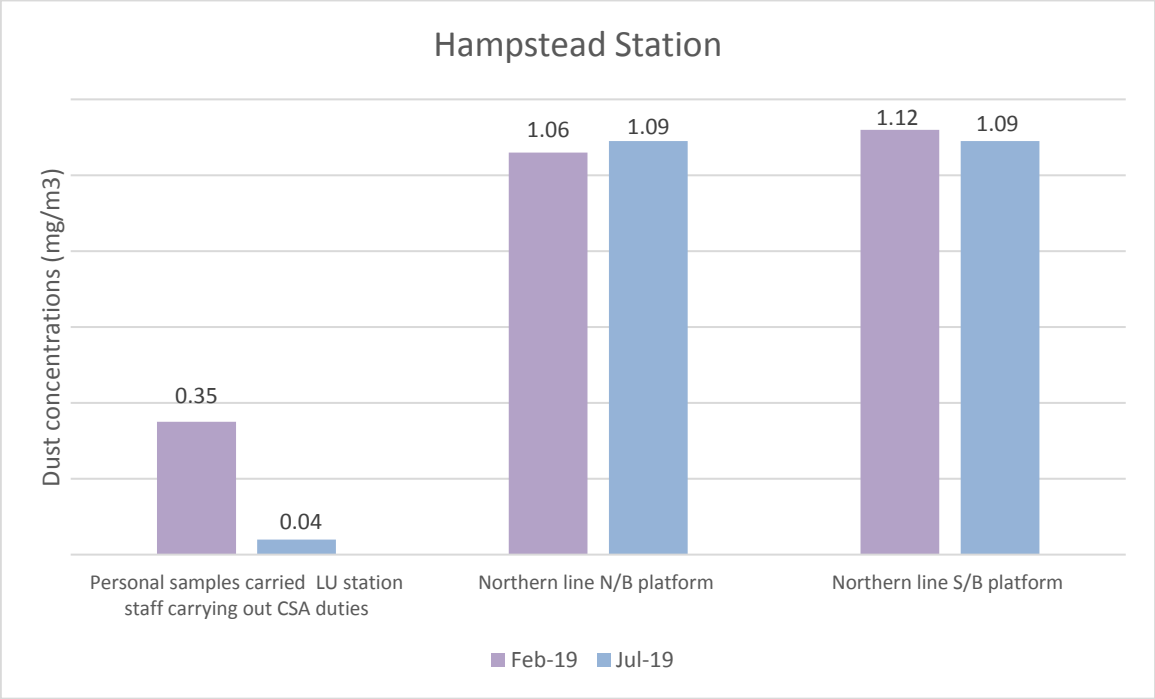

Figure 8. Respirable dust concentration results obtained for February and July 2019 for King's Cross Station

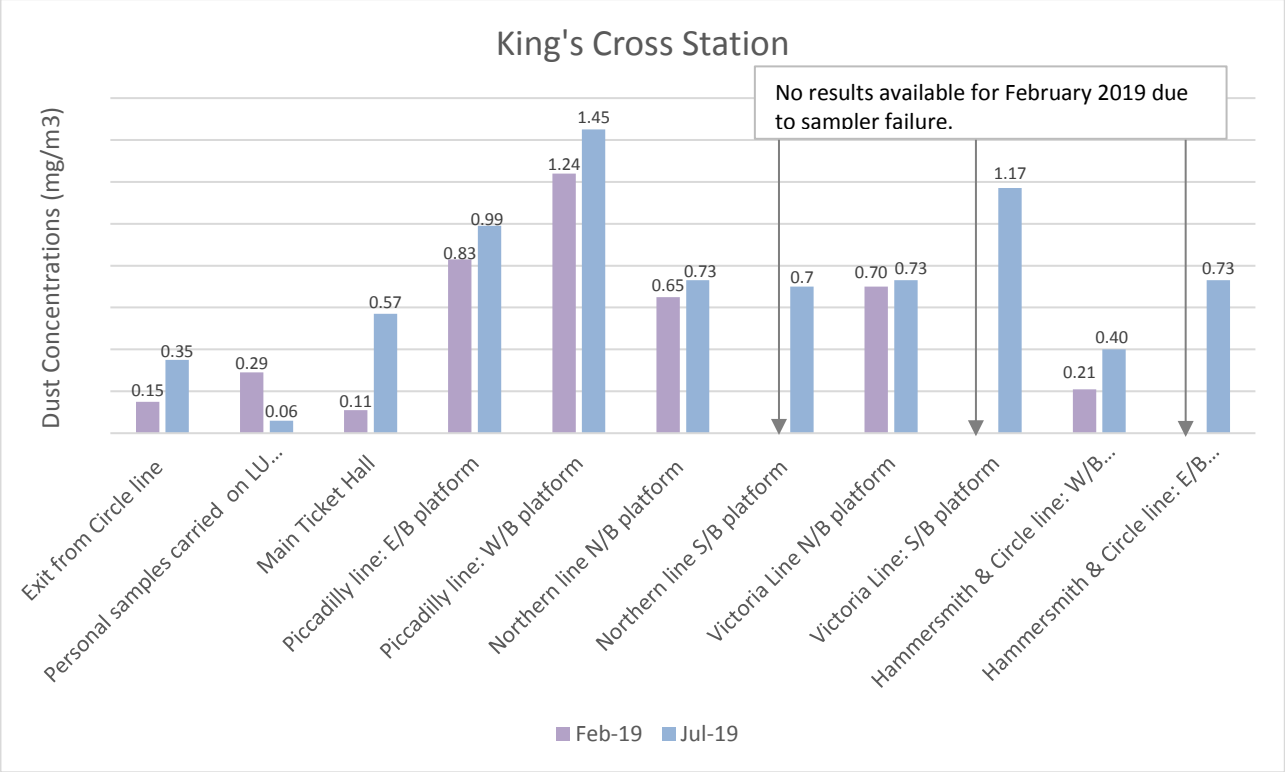

Figure 9. Respirable dust concentration results obtained for February and July 2019 for Oxford Circus Station

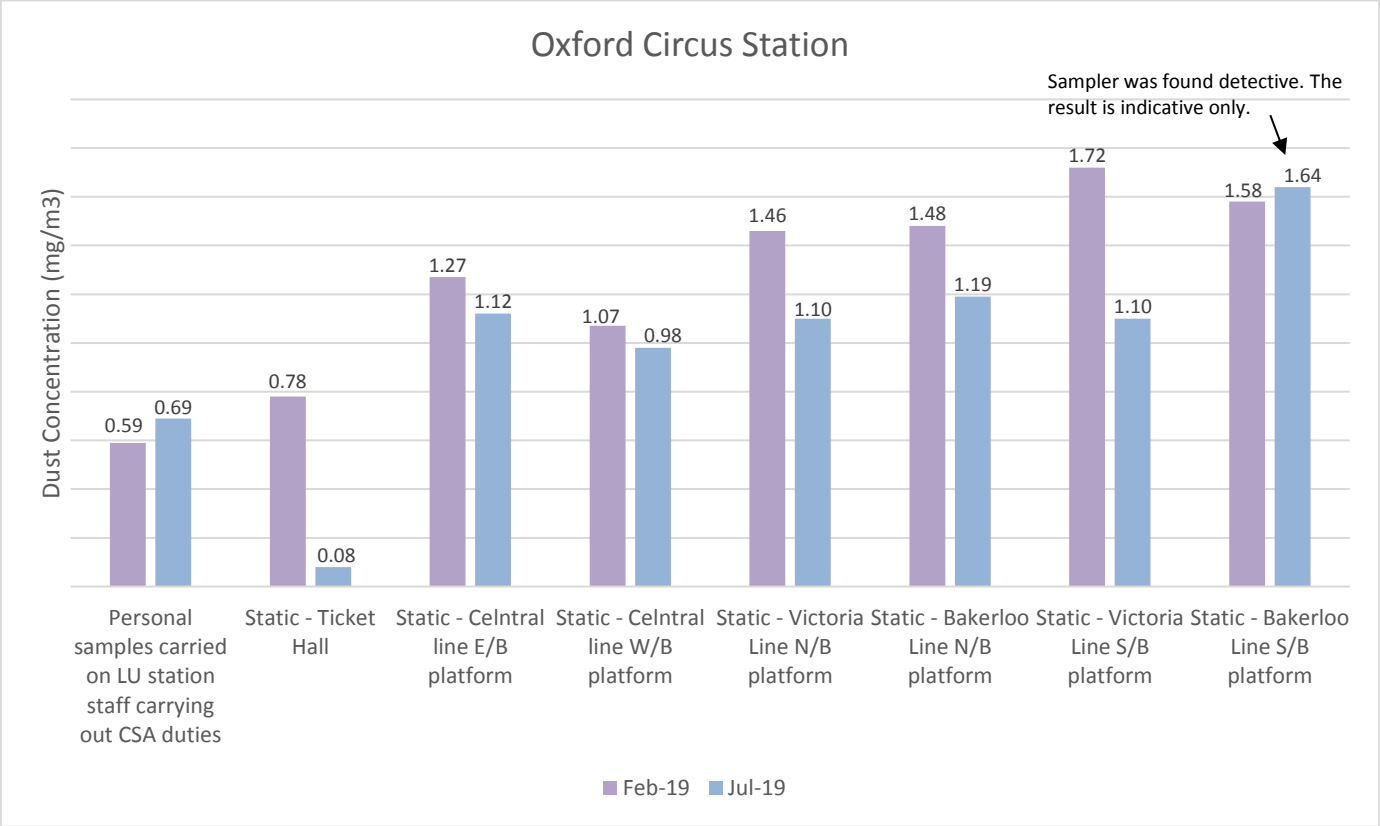

Figure 10. Respirable dust concentration results obtained for February and July 2019 for Paddington Station

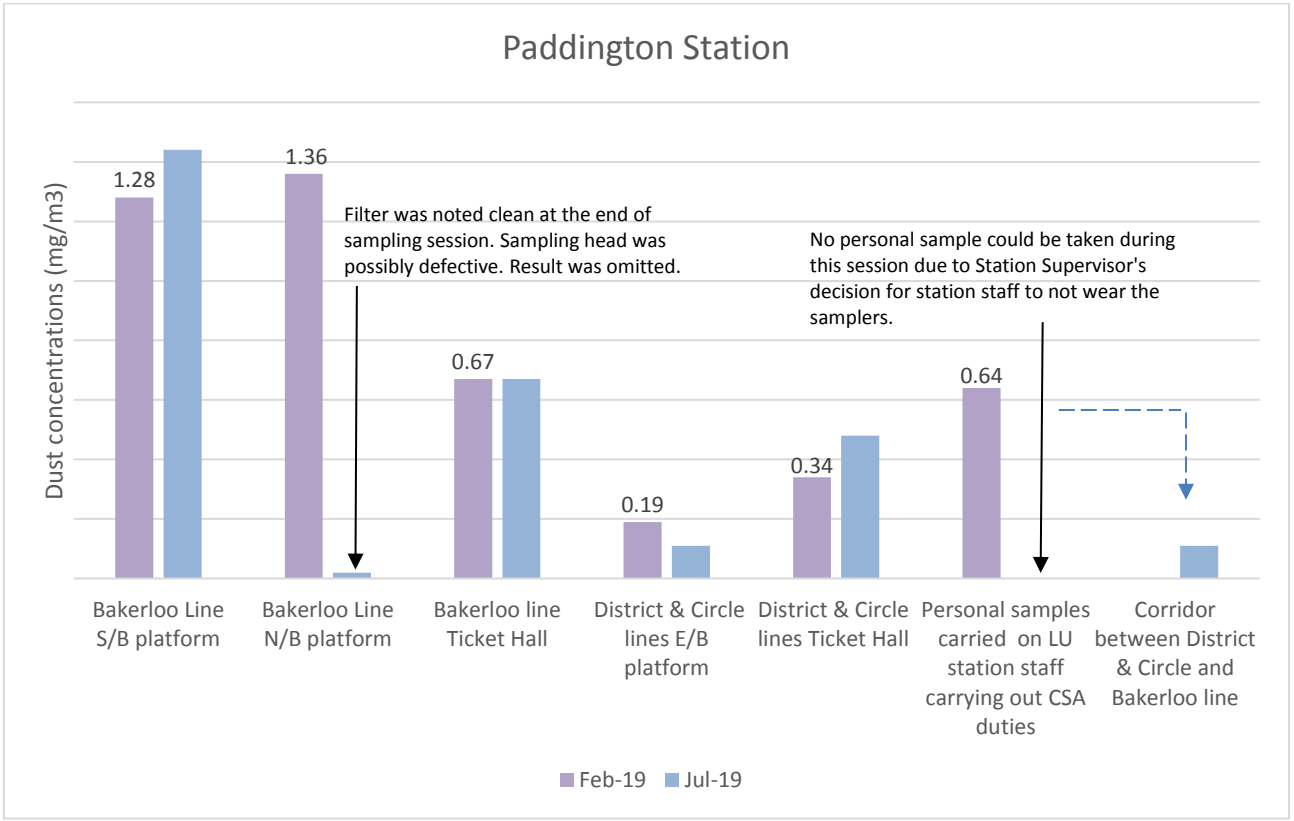

Figure 11. Respirable dust concentration results obtained for February and July 2019 for Piccadilly Circus Station

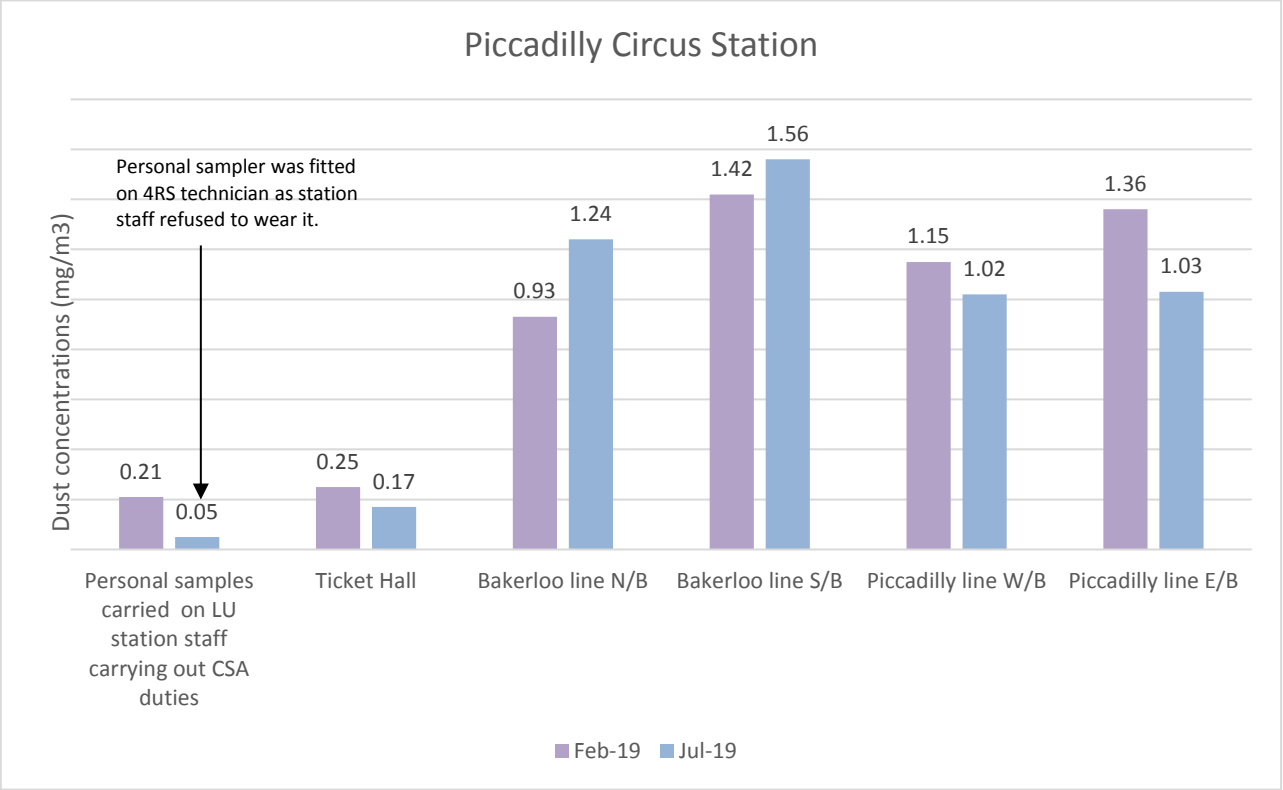

Figure 12. Respirable dust concentration results obtained for March and July 2019 for Tottenham Court Road Station

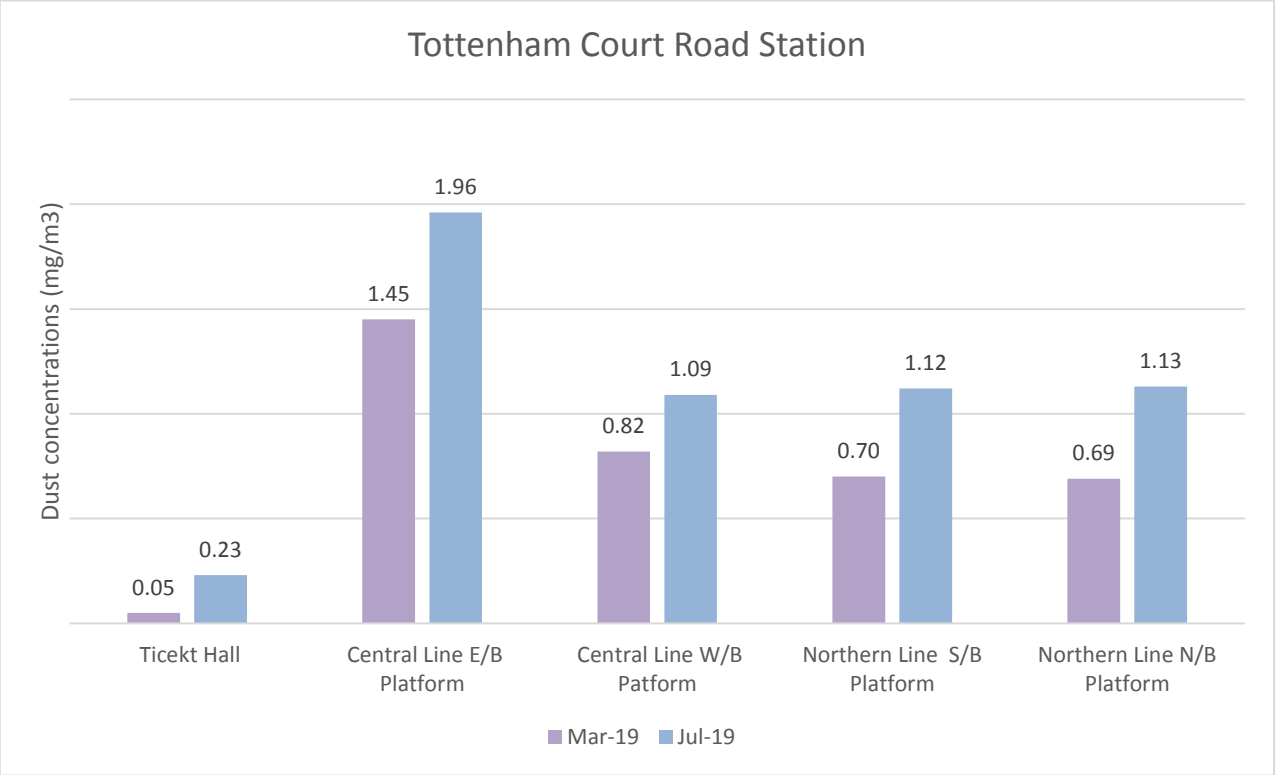

Figure 13. Respirable dust concentration results obtained for March and August 2019 for Vauxhall Station

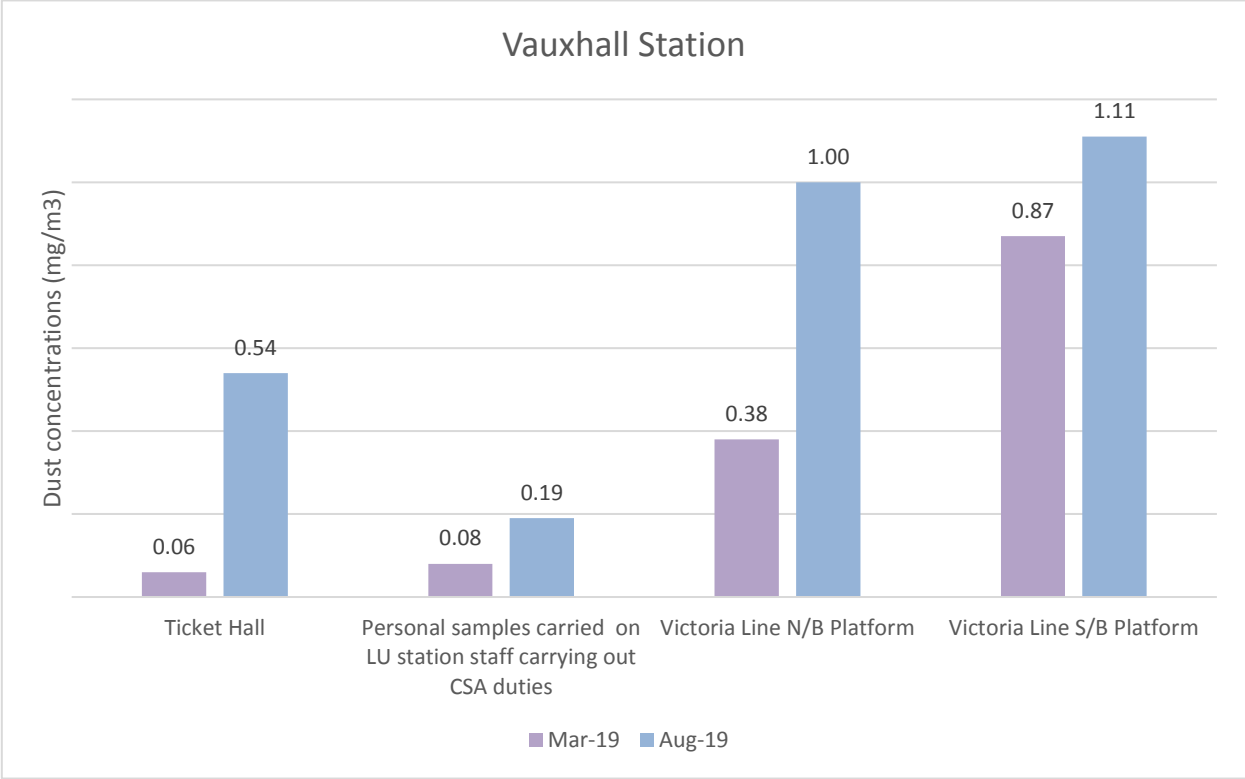

Figure 14. Respirable dust concentration results obtained for February and July 2019 for Waterloo Station