Brill Place.
Air Quality and Residential Overheating Review.

Introduction.

This air quality review has been prepared for the proposed Brill Place development to consider how often poor external air quality and high temperatures could be expected to occur concurrently.

This information has been prepared in order to inform the design team's recommendation for comfort cooling to be incorporated at the proposed development alongside openable windows on all lower floors up to level 14.

The design intent for the proposed development is for apartments to be able to achieve comfortable internal temperatures (i.e. reduce the risk of overheating) by use of openable windows, when using inputs in line with the methodology set by CIBSE TM 59 (*Design methodology for the assessment of overheating risk in homes* - TM59). This approach thus enables future occupants to reduce the risk of overheating in line with the methodology by use of openable windows, should they so choose.

It is acknowledged that there are times of the year when occupants may need to close their windows due to poor external air quality on-site, and hence this review is produced to clarify to what extent poor external air quality may occur at the same time as high external temperatures, prompting residents to close their windows – in which case it may be necessary to rely on comfort cooling to maintain comfortable internal temperatures.

The proposed development also incorporates mechanical ventilation with heat recovery into the design as this is an energy efficient way of providing filtered air to apartments. The design was previously tested against the TM59 criteria on the basis of windows being closed and the mechanical ventilation running. This was shown to be insufficient to meeting the requirements of TM59 – a result which is expected given the London Design Summer Year (DSY) weather file used in these tests, which in itself fails the test for 2.7% of the year, against a 3% threshold allowance. Mechanical ventilation without cooling would be circulating hot air through the apartment and this would not be able to dissipate the high temperatures arising from the solar and internal gains. The results of the 'sealed façade' / mechanical ventilation scenario modelling were presented in the 'Part L and TM59 inputs and results' report issued as a response to planning comments on 07/02/2020.

The purpose of this analysis is to show how air quality can vary over short periods of time and not an analysis of local air quality at the Site. There are inherent inaccuracies when predicting future air quality and meteorological data (temperature) due to the varying nature of the data. The following analysis has been undertaken based on monitoring data over a five-year period 2014-2018 for external air quality and external temperature at relevant locations. These locations are not specific to the Site and therefore there may be some variance when comparing the data to what will actually occur in the future. These variations have been taken account of by including a range of air quality monitoring locations and by using two temperature "trigger points". The roadside/kerbside external air quality monitoring locations that have been used provide a 'worst case' in terms of air quality at the Site and the urban background monitoring location provides a 'best-case' in terms of air quality at the Site. This is discussed further in the following sections in this review.

It should be noted that previous overheating risk modelling results for the development, as presented in the planning application energy and sustainability statement by Skelly & Couch dated 22/03/2016, pre-dated the implementation and wide-spread adoption of the CIBSE TM59 overheating calculation methodology. The previous overheating assessment does not mention a correlation to acoustic or air quality conditions on site, and merely undertakes a test for the naturally ventilated scenario where windows are open. The updated TM59 assessment provides a more robust test of the overheating risk for the development, taking into account these external factors as well. Further, it is noted that the previous results showed a number of rooms failing the test even in the baseline weather file scenario – a situation which the updated design has improved upon.

Air Quality and High Outdoor Temperatures

Methodology and Criteria

Approach

External air quality monitoring data in the vicinity of the Site from Euston Road, Bloomsbury, Holborn and Swiss Cottage automatic air quality monitoring locations have been considered alongside external temperature data for London from Heathrow Airport Meteorological Station for the five-year period 2014-2018 to understand when high pollutant concentrations and high temperatures occur concurrently.

For this review external air quality data is required, in the absence of site-specific external air quality data proxy data has been used to provide a range of air quality monitoring data that will, based on professional judgement, be representative of the Site. The Site is located approximately 360 m north of the nearest major road (as classified by having a traffic flow greater than 10,000 annual average daily traffic (AADT)) (Euston Road) and therefore the Site is best represented by an urban background monitoring location i.e. locations away from a pollution source such as. a major road. However, to allow for other influence on the Site such as the railway lines leading into St Pancras International station and the Francis Crick Institute, roadside and kerbside locations i.e. locations close to a pollution source (major road) have been included as a worst-case assessment as air quality at the Site is not expected to be as poor as these proxy monitoring locations.

Air Quality

Site specific hourly air quality data is not available, therefore by providing analysis for a range of local air quality monitoring locations (provided in Table 1) a “worst -case” and “best-case” scenario for external air quality at the Site has been considered. For the “worst case” assessment we have used Euston Road, Holborn and Swiss Cottage monitoring locations as they are located within 2m of the nearest pollution source. For the “best-case” assessment we have used Bloomsbury monitoring location as this is located 27m away from the nearest pollution source.

Monitoring locations within the London Borough of Camden (LBC) have been used as these will show local variations in pollutant concentrations compared to other monitoring locations further away from the Site.

The air quality monitoring locations are provided in Table 1 and their locations relative to the Site are provided in Figure 1.

Table 1 LBC Automatic Monitoring Locations and Pollutants Monitored at each Location.

Monitoring Location	Pollutants Monitored	Approximate Distance from Site (m)	Approximate Distance from Nearest Main Road (m)	Type of Monitoring location	LAQM TG:16 Site Type Classification
Euston Road	NO_2, PM_{10}, $PM_{2.5}$	450	0.5	Roadside	A site sampling typically within one to five metres of the kerb of a busy road (although distance can be up to 15 m from the kerb in some cases)
Bloomsbury	NO_2, PM_{10}, $PM_{2.5}$	1,150	27	Urban Background	An urban location distanced from sources and therefore broadly representative of citywide background conditions,
Holborn	NO_2	1,750	1	Kerbside	A site sampling within one metre of the kerb of a busy road
Swiss Cottage	NO_2, PM_{10}, $PM_{2.5}$	3,500	1	Kerbside	A site sampling within one metre of the kerb of a busy road

Figure 1 Automatic Air Quality Monitoring Locations surrounding the Site. Contains OS Data © Crown Copyright and Database rights 2020.

The National Air Quality Objectives (NAQO) for annual mean (AM) concentrations have been used as the trigger criteria to determine at what level pollutant concentrations are considered "poor" in terms of air quality, these are provided in Table 2.

Temperature

External temperature data has been obtained from Heathrow Airport Meteorological Site to inform this review for the period 2014-2018 in line with the external air quality data.

Table 2 shows the trigger criteria used to determine poor external air quality and high external temperature. For temperature, 22°C has been set as the trigger point as this correlates to the threshold for when windows would be expected to be open due to overheating. To account for the urban heat island effect and the difference in temperature expected to exist between Camden (site location) and Heathrow (meteorological site location), another trigger criterion has also been used which is set at two degrees lower, 20°C.

Table 2 Trigger Criteria used to Assess Poor Air Quality and High Temperature

Parameter	Trigger Criteria
Temperature 1	22°C
Temperature 2	20°C
NO_2	40 $\mu g/m^3$
PM_{10}	40 $\mu g/m^3$
$PM_{2.5}$	25 $\mu g/m^3$

Table 3 provides the number of hours when the temperature was measured to be above each temperature trigger criteria for the five-year period 2014 to 2018. Monitoring data for each of the monitoring locations has been averaged for the five-year period 2014-2018 to show the fluctuation of pollutant concentrations over the course of a year, these are provided in Appendix 1 in Figure 5 to Figure 7.

Table 3 Number of Hours Above Each Trigger Criteria for Temperature

Parameter	Trigger Criteria	No. of Hours Measured Above Trigger Criteria				
		2014	2015	2016	2017	2018
Temperature 1	20°C	806	559	840	800	1261
Percentage of year, above Temperature 1		9.2	6.4	9.6	9.1	14.4
Temperature 2	22°C	398	270	451	421	814
Percentage of year, above Temperature 2		4.5	3.1	5.1	4.8	9.3

Results

The number of hours where the temperature trigger criteria and the pollutant criteria are exceeded is provided in Table 4. This shows the number of hours where the air quality was poor, and the temperature was high concurrently in each year.

Table 4 Number of Hours Exceeding Both the Temperature and Pollutant Trigger Criteria

	Hours above 20 degrees AND exceeding AM objective				Hours above 22 degrees AND exceeding AM objective			
	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 20°C	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 22°C
2014								
Euston Road	728	0	0	90.3	379	0	0	95.2
Bloomsbury	473	27	45	58.7	210	9	14	52.8
Holborn	734	N/A *	N/A	91.1	370	N/A	N/A	93.0
Swiss Cottage	740	30	38	91.8	376	10	9	94.5
2015								
Euston Road	212	42	40	37.9	111	29	27	41.1
Bloomsbury	249	0	14	44.5	112	0	12	41.5
Holborn	499	N/A	N/A	89.3	247	N/A	N/A	91.5
Swiss Cottage	465	10	10	83.2	227	7	9	84.1
2016								
Euston Road	803	83	125	95.6	439	57	75	97.3
Bloomsbury	256	54	55	30.5	147	29	30	32.6
Holborn	624	N/A	N/A	75.4	303	N/A	N/A	78.3
Swiss Cottage	633	61	90	74.3	353	32	54	67.2
2017								
Euston Road	756	10	14	94.5	406	1	5	96.4
Bloomsbury	251	18	38	31.4	139	8	23	33.0

	Hours above 20 degrees AND exceeding AM objective				Hours above 22 degrees AND exceeding AM objective			
	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 20°C	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 22°C
Holborn	664	N/A	N/A	83.0	378	N/A	N/A	89.8
Swiss Cottage	505	30	61	63.1	310	17	38	73.6
2018								
Euston Road	371	5	9	29.4	186	2	4	22.9
Bloomsbury	250	38	43	19.8	153	21	19	18.8
Holborn	248	N/A	N/A	19.7	102	N/A	N/A	12.5
Swiss Cottage	890	64	55	70.6	630	33	26	77.4

* NO_2 is the only pollutant monitored at Holborn

Using the Bloomsbury monitoring location as the "best-case" for the Site, openable windows would be desirable but not possible due to poor air quality between 19.8% and 58.7% of hours above 20°C based on the five years of monitoring data. Using the Euston Road, Holborn and Swiss Cottage kerbside and roadside monitoring locations as "worst case" in terms of air quality this range increases to between 19.7% and 95.6%.

For Bloomsbury, openable windows would be desirable but not possible due to poor air quality between 18.8% and 52.8% of hours above 22°C based on the five years of monitoring data. At the kerbside and roadside monitoring locations this range increases to between 12.5% and 97.3%.

In comparison, Table 5 shows the number of hours when the temperature was high and air quality was acceptable i.e. when openable windows would have been desirable and also acceptable on air quality grounds.

Table 5 Number of Hours Exceeding the Temperature Trigger Criteria but NOT the Pollutant Trigger Criteria.

	Hours above 20 degrees and below AM objective				Hours above 22 degrees and below AM objective			
	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 20°C	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 22°C
2014								
Euston Road	78	806	806	9.7	19	398	398	4.8
Bloomsbury	333	779	761	41.3	188	389	384	47.2
Holborn	72	N/A	N/A	8.9	28	N/A	N/A	7.0
Swiss Cottage	66	776	768	8.2	22	388	389	5.5
2015								
Euston Road	347	517	519	62.1	159	241	243	58.9
Bloomsbury	310	559	545	55.5	158	270	258	58.5
Holborn	60	N/A	N/A	10.7	23	N/A	N/A	8.5
Swiss Cottage	94	549	549	16.8	43	263	261	15.9
2016								
Euston Road	37	757	715	4.4	12	394	376	2.7
Bloomsbury	584	786	785	69.5	304	422	421	67.4
Holborn	216	N/A	N/A	25.7	148	N/A	N/A	32.8

	Hours above 20 degrees and below AM objective				Hours above 22 degrees and below AM objective			
	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 20°C	NO_2	PM_{10}	$PM_{2.5}$	% of hours above 22°C
Swiss Cottage	207	779	750	24.6	98	419	397	21.7
2017								
Euston Road	44	790	786	5.5	15	420	416	3.6
Bloomsbury	549	782	762	68.6	282	413	398	67.0
Holborn	136	N/A	N/A	17.0	43	N/A	N/A	10.2
Swiss Cottage	295	770	739	36.9	111	404	383	26.4
2018								
Euston Road	890	1256	1252	70.6	628	812	810	77.1
Bloomsbury	1011	1223	1218	80.2	661	793	795	81.2
Holborn	1013	N/A	N/A	80.3	712	N/A	N/A	87.5
Swiss Cottage	371	1197	1206	29.4	184	781	788	22.6

* NO_2 is the only pollutant monitored at Holborn

To Summarise, Tables 3-5 can be used to identify the following three scenarios: i.e.

- The number of hours when temperature is high enough that openable windows may be desirable see Table 3,
- The number of hours when openable windows may be desirable from a temperature perspective, but pollutant concentrations show poor air quality, Table 4.
- The number of hours when openable windows may be desirable from a temperature perspective and pollutant concentrations show air quality is acceptable, Table 5.

A comparison is provided overleaf of the percentage of hours above each temperature trigger point (averaged for the five-year period) when openable windows would be desirable (due to high temperature) and possible (due to acceptable AQ)versus when openable windows would be desirable and not possible, i.e. when it is expected that active cooling would be required. This comparison is provided in Figure 2 for the 20°C trigger point and Figure 3 for the 22°C trigger point.

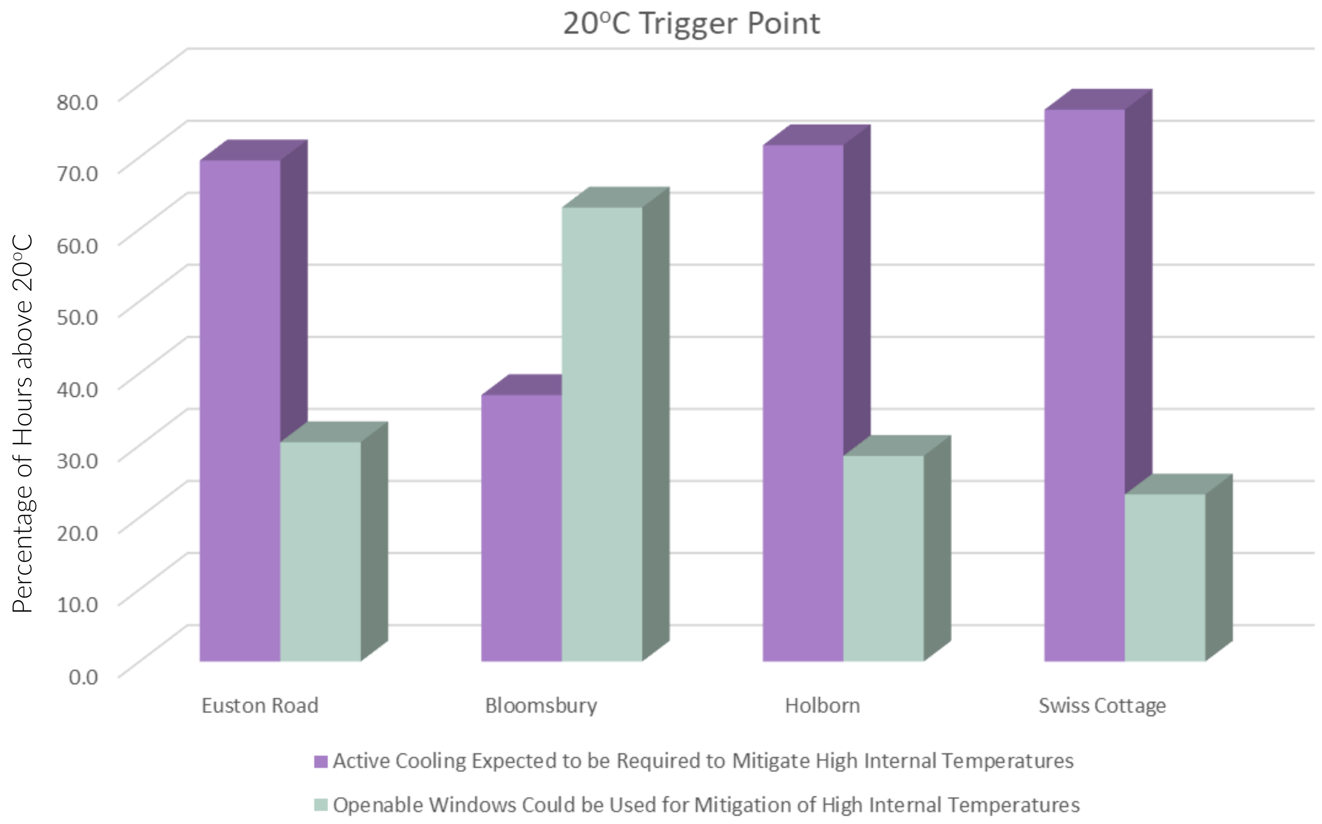

Figure 2 Comparison of When Active Cooling Could be Used (i.e. when windows would have to be closed on a warm day) Versus When Openable Windows Could be Used for the 20°C Trigger Point.

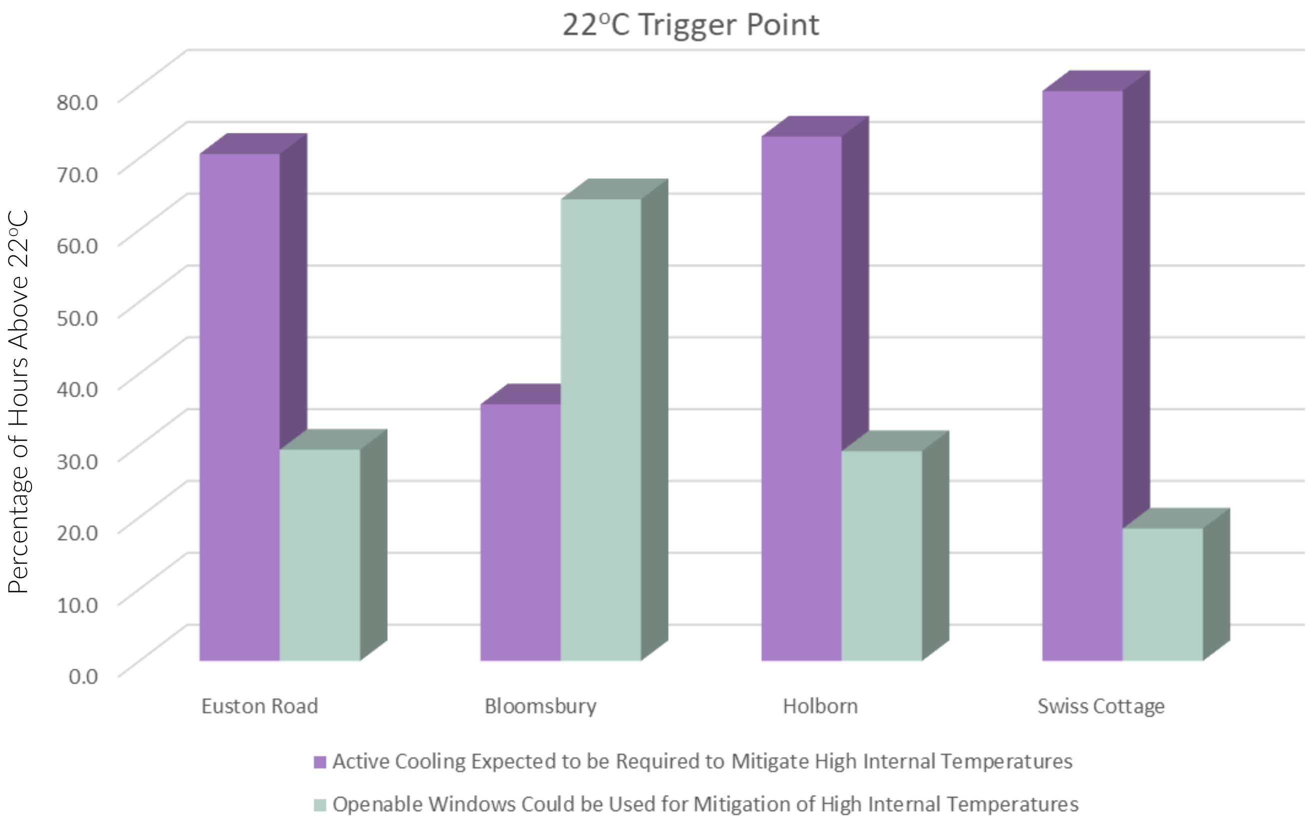

Figure 3 Comparison of When Active Cooling Could be Used Versus When Openable Windows Could be Used for the 22°C Trigger Point.

As shown in Figure 2 and Figure 3 it is expected to be possible for part of the year to achieve acceptable internal temperature conditions by use of openable windows with regards impact from external air quality, however there are certain times of the year when it would be expected that active cooling would be required due to poor external air quality conditions requiring the windows to be closed on warm days. . The dependency on either option varies on the NO_2 concentrations in the area with the kerbside (worst case) Swiss Cottage location showing a greater reliance on active cooling and the background monitoring location (Bloomsbury - best case) being able to rely more on openable windows.

Commentary on the Camden 'efficient ventilation and cooling' hierarchy list

The Camden Planning Guidance states a number of measures which should be considered prior to the implementation of cooling. The team's response to each of these in turn is provided here:

Water based cooling *systems reduce the need for air conditioning by running cold water through pipes in the floor and/or ceiling to cool the air.*
Water based cooling systems are considered as slow response systems that typically rely upon a centralised refrigerated cooling equipment to remove the heat from the water which is passing through the slabs. As cooling will only be used periodically and a fast response will be required to prevent overheating upon the closing of the windows, slab and ceiling-based systems are not considered appropriate in this instance.

Evaporation cooling *could also be investigated, this cools air through the simple evaporation of water.*
We do not consider evaporative cooling to be appropriate as such systems add humidity to the air instead of removing it. Over time, this can result in high humidity inside of a home, which can lead to clamminess, discomfort and a risk of mould growth.

Ground source cooling*. Ground source* cooling *is provided by a 'ground source heat pump' in the summer the ground stays cooler than the air and the difference in temperature can be harnessed for cooling.*
The consented scheme did not incorporate ground source cooling and it is considered that there is insufficient space available within the redline boundary of the site achieve the level of heat rejection that will be required.

Exposed concrete slabs can provide natural cooling*. This leaves internal thermal mass (concrete slabs, stone or masonry which form part of the construction) inside a building exposed so that it can absorb excess heat in the day and slowly release it at night.*
Exposed concrete slabs are not a practical solution for a high-rise curtain walling design such as Brill Place. Thermal mass has to be adjacent to the internal spaces in order to provide any benefit, and this would have great implications for the current design. Further, in order to exposed thermal mass to be utilised, it must specifically be implemented in rooms that are expected to be occupied in the daytime, so that the thermal mass can be cooled down from naturally lower temperatures overnight, and coolth dissipated to the room in question during the day. This implies a solution most suited to living rooms / kitchen areas – arguably not the most 'at risk' areas in terms of overheating risk assessment. The greatest concern is for bedrooms to comply with criteria, as these rooms are the ones most expected to impact general occupant comfort (ability to sleep). As such, implementing any thermal mass would not be assisting with minimising the risk to the most vulnerable areas of the development.

Developments could adopt a natural 'stack effect' which draws cool air from lower levels whilst releasing hot air.
Natural stack effect requires air to travel by natural buoyancy as a result of temperature differences (hot air rises). This 'chimney' effect is achieved by a large difference in height between air intake and extract and is therefore not a suitable solution to implement for apartments which are individual compartments. Some element of stack effect is expected to be present for the external staircase, where openings will be included at low and high levels, thus allowing some hot air to naturally dissipate in this way in the staircase area.

The tested sample of apartments at Brill Place has been shown to meet the requirements of CIBSE TM59 by use of openable windows ('naturally ventilated scenario') under the DSY1 weather file. This confirms a robust approach to passive design in terms of minimising the reliance on mechanical cooling for the development, allowing residents to make use of openable windows should they so choose.

Air Quality Management Strategy

In order to reduce the use of active cooling when air quality is acceptable, an automatic monitoring system is proposed to ensure that air quality concentrations are below set criteria before windows may be opened. The air quality trigger criteria would be set at 40 µg/m^3 for NO_2 and PM_{10} and 25 µg/m^3 for $PM_{2.5}$ to align with the NAQO, below these concentrations' windows would be openable, above this an alarm would be triggered. The system would operate via a cloud-based database and upon activation of the air quality alarm the building manager will contact all occupiers and advise them to close their windows. These alerts can also be provided via text and/or through an app connected to the cloud-based database.

In addition, building management staff will be alerted and will be able to inform residents on entry, as well as putting a display board in the reception. The building manager will also advise residents when the air quality has improved sufficiently to remove the need to close windows.

The windows will be fitted with contact sensors on the window frames which will de-activate the comfort cooling system in order to conserve energy and to ensure there is no scenario where active cooling is running whilst windows are open and passive cooling is taking place.

Specific sensors have not been specified at this stage and details will be provided alongside the detailed façade design. The following air quality sensors provide an example of the type of equipment that are available and would provide the capability to undertake the monitoring as set out above:

- AQMesh
- Aeroqual – AQM, AQS or AQY
- Libelium Waspmote Plug and Sense
- IAConnect SEN024

Summary and Conclusions

This note has confirmed there are times of the year when it is expected that the air quality at the Brill Place site will be at acceptable levels for occupants to be able to make use of openable windows to achieve thermally comfortable conditions. It has previously been shown in the 'Part L and TM59 inputs and results' report, issued as a response to planning comments on 07/02/2020, that the design is expected to allow for this.

It is however also shown that there are certain times of the year when it is expected that the air quality will be poor, exceeding the NAQO used as the trigger, thus requiring occupants to close their windows.

The design has previously been tested with just the mechanical ventilation running in such a situation (i.e. circulating air, but at ambient temperatures), and it was found that the overheating risk criteria could not be met by mechanical ventilation alone. This result is expected, for the following reasons:

- The 'fixed' criterion used for mechanical ventilation scenario testing states that occupied spaces should not exceed an operative temperature of 26^{o}C for more than 3% of annual occupied hours (Jan-Dec)
- External ambient temperatures in the London DSY1 exceed 26^{o}C for 2.7% of annual hours, leaving very little margin (0.3%) to the maximum allowed 3% of annual hours exceedance. <u>This is the weather file alone, prior to adding any internal heat gains.</u> Once unavoidable internal heat gains are added (cooking, lighting, occupants etc.) the internal temperatures will therefore be expected to exceed the threshold quite quickly. Mechanical ventilation without cooling would be circulating air through the apartment at ambient temperatures, but as can be seen from the weather file temperatures themselves, this would not be sufficient to dissipate the high temperatures arising from a combination of the weather file, and the unavoidable internal gains.

These results were previously presented in the 'Part L and TM59 inputs and results' report issued in response to planning comments on 07/02/2020.

Comfort cooling is therefore proposed for occupants to achieve thermally comfortable conditions at these times, should they so choose.

Given there is a possibility for both openable windows and comfort cooling to be used based on "best -case" and "worst-case" external air quality data, provision of openable windows would allow occupants of the proposed development to realise energy savings associated with not using comfort cooling when air quality is acceptable.

It is considered that the most efficient solution has been proposed for Brill Place, as occupants will have an option to use openable windows for overheating risk mitigation at certain times of the year, should they so choose, thus minimising the reliance on comfort cooling for levels 1-14. If facades were to be sealed, occupants would have no choice but to use cooling for a greater amount of the year to alleviate high internal temperatures – this would be expected to lead to a greater overall cooling demand for the development.

Further, it is considered this solution provides a degree of futureproofing. As a result of the UK Government strategic targets for electric vehicle uptake, it is anticipated that the general car fleet will move towards more electrical and fewer petrol and diesel cars. This is expected to lead to a better background air quality level for the Site, and thus may enable future occupants to utilise openable windows as an overheating risk mitigation measure for a greater amount of the year than is expected based on current air quality measurements presented in this note.

Appendix 1 – Air Quality Monitoring Data

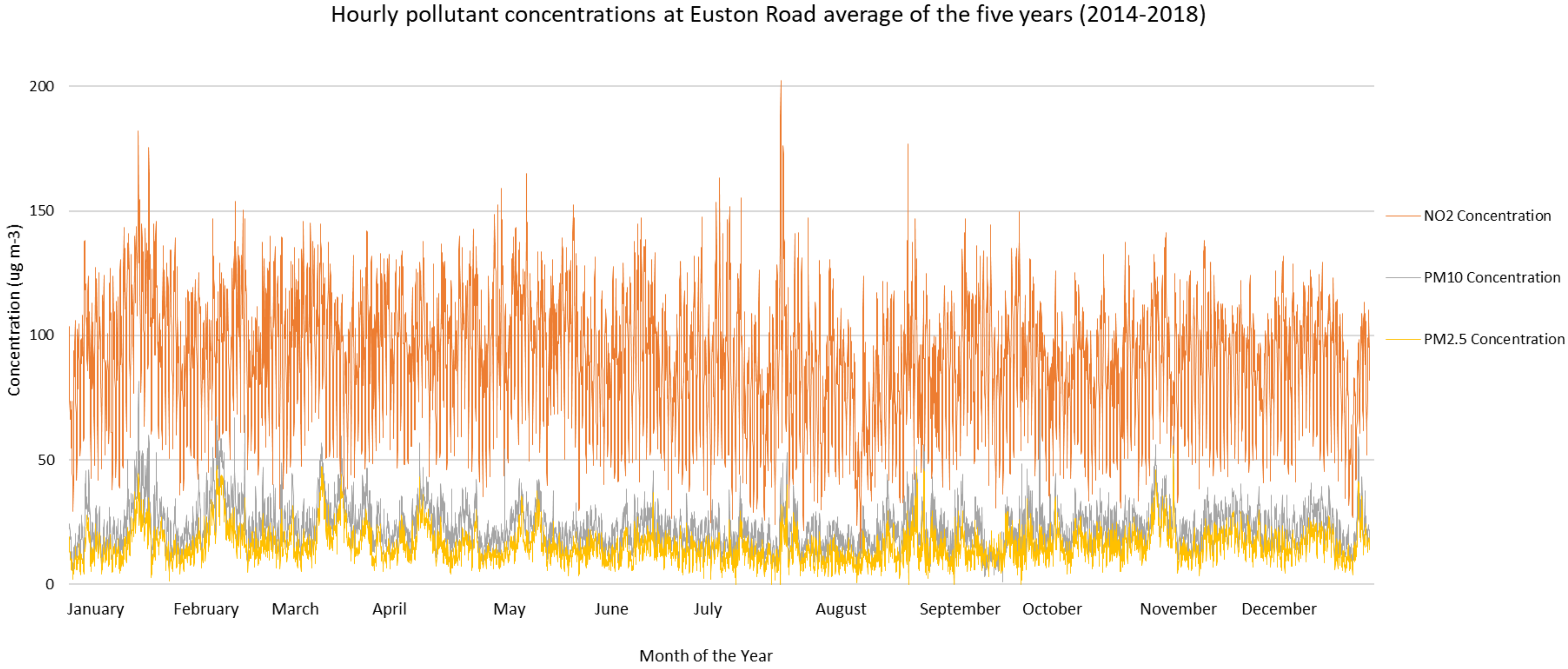

Figure 4 Hourly Air Quality Monitoring Data for Euston Road Averaged over the Five-Year Period 2014-2018. Source - londonair.org.uk

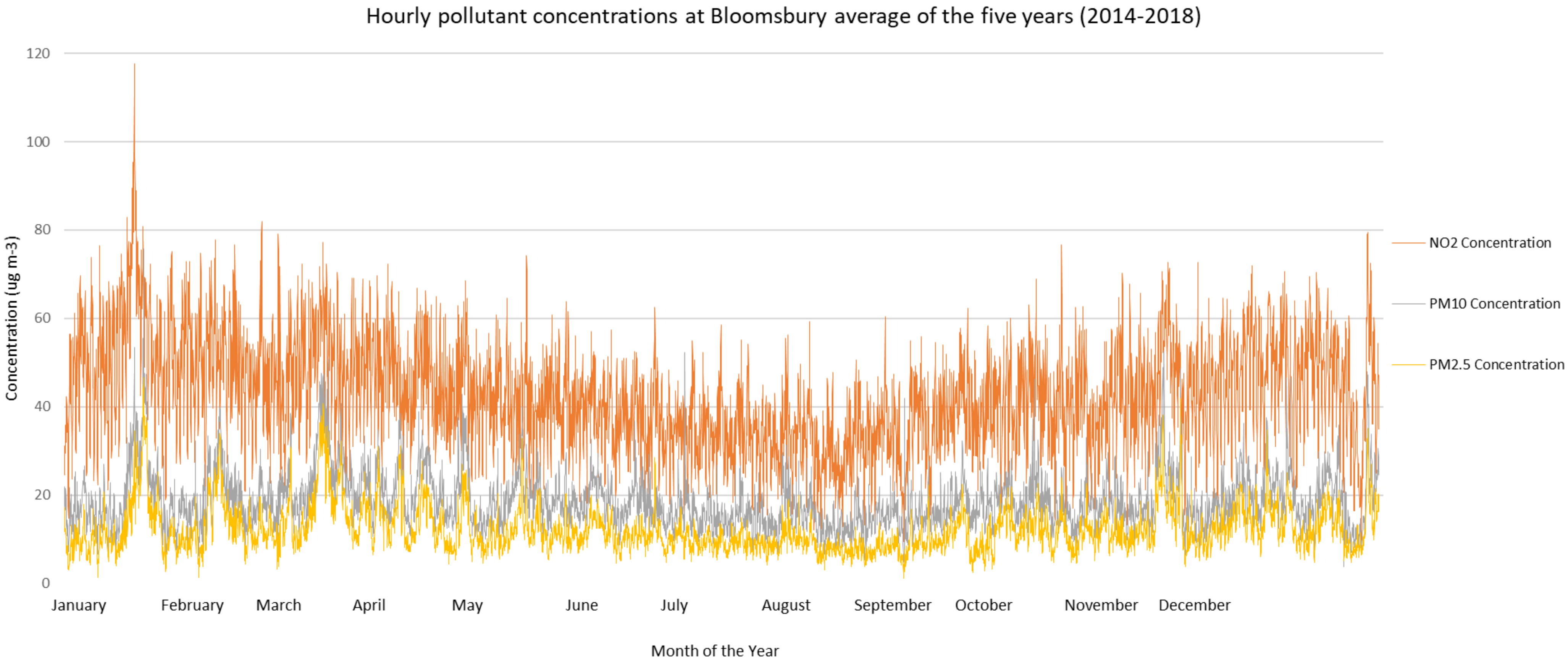

Figure 5 Hourly Air Quality Monitoring Data for Bloomsbury Averaged over the Five-Year Period 2014-2018. Source - londonair.org.uk

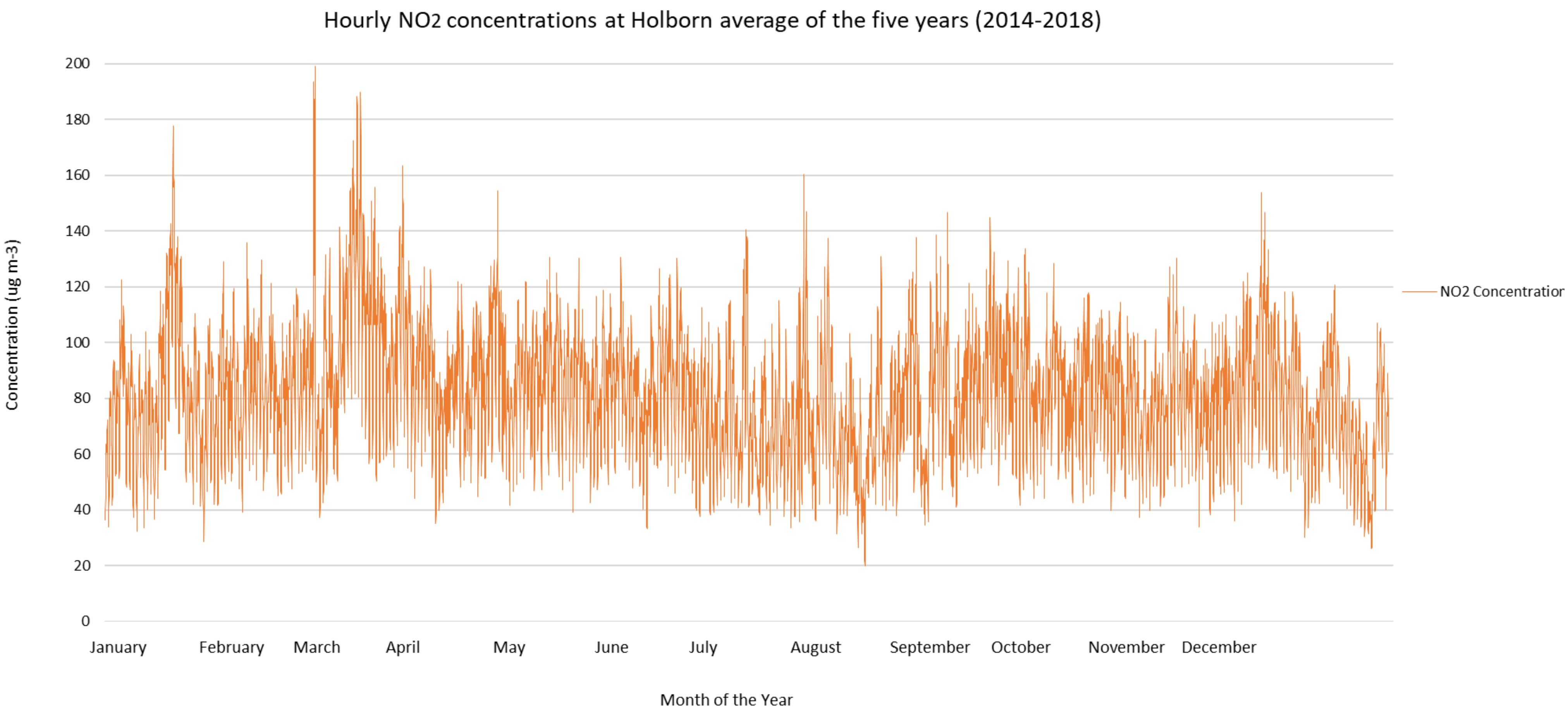

Figure 6 Hourly Air Quality Monitoring Data for Holborn Averaged over the Five-Year Period 2014-2018. Source - londonair.org.uk

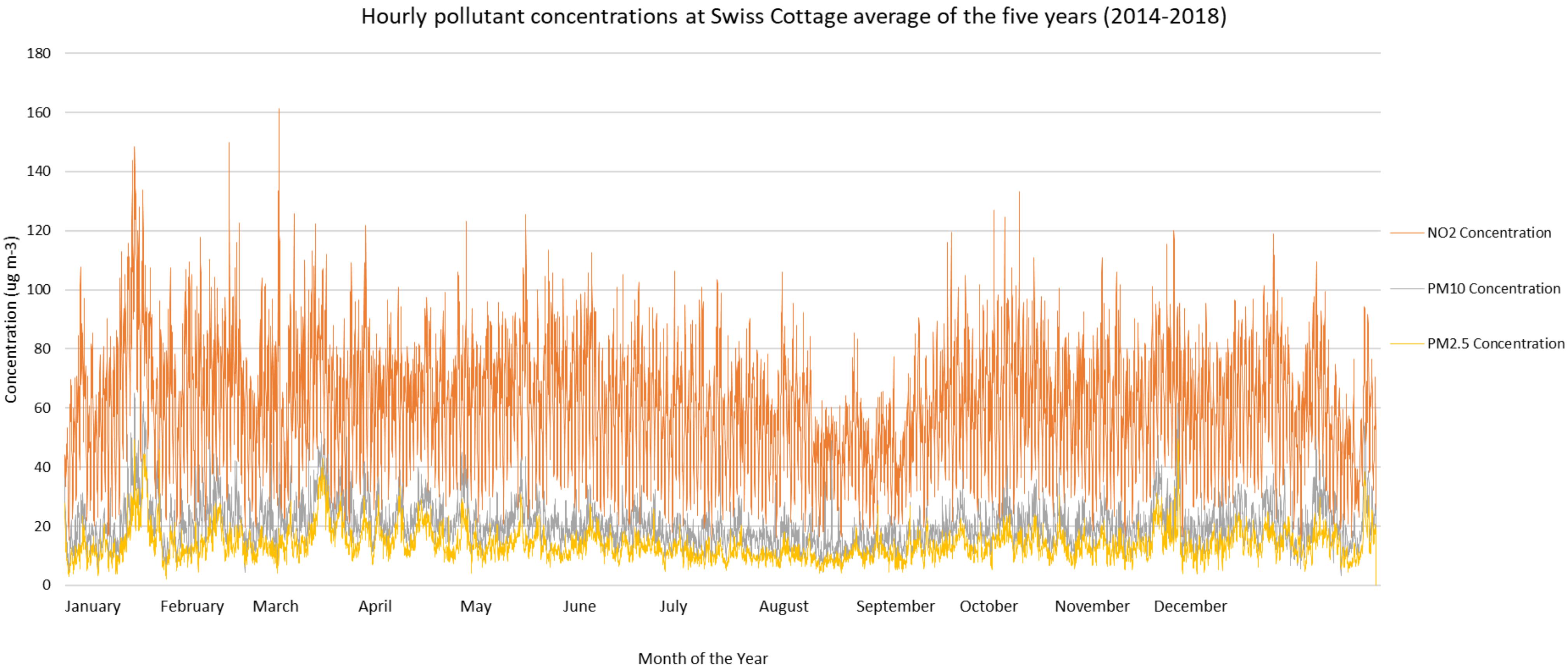

Figure 7 Hourly Air Quality Monitoring Data for Swiss Cottage Averaged over the Five-Year Period 2014-2018. Source - londonair.org.uk