Anderson Acoustics

Community Noise Information Report - Draft Camberwell

15th February – 17th October 2018

Introduction

At the request of local residents, Heathrow Airport Ltd installed a temporary noise monitor at the Ark All Saints Academy in Camberwell between 15th February 2018 and the 17th October 2018. This report presents an analysis of operational and noise data over this period.

The report is structured using a template developed by Anderson Acoustics working with members of the Heathrow Community Noise Forum (HCNF) Working Group for Monitoring & Verification. It is set out as:

- **Section 2 – Key Findings** are presented.
- **Section 3 – Background & Methodology** provides an overview of how the airport operates, noise and how the data (both operations and noise) have been analysed.
- **Section 4 – Flight track data** presents analysis of the flight tracks and operations above Camberwell including routes, proximity, spatial distribution, height and aircraft types. As flight track data has been collected for many years in the airport's noise and track-keeping (NTK) system, analysis has compared the noise monitoring period with an equivalent period in 2013.
- **Section 5 – Noise Monitor Data** presents an analysis of aircraft noise event and overall community noise levels as measured at the noise monitor. Noise data is analysed only for the monitoring period. Comparison with a historic period is not possible as monitoring has not taken place at the same location previously.
- **Section 6 – Noise Modelling** This section presents noise levels derived from noise modelling. Aircraft noise models have been generated for easterly and westerly days for the summer periods of both 2013 and 2017 using AEDT. Previous reports have been based on Heathrow's verified noise model using INM. This software has recently been superseded by AEDT.
- **Section 7 – Appendices will** present large scale versions of all of noise modelling results and provides greater detail on noise terminology around how sound is described, how aircraft noise is measured and how differences of sound level relate to human perception.

It should be noted that this report is intended to describe noise exposure rather than the impact of that exposure - we cannot judge how each individual will respond. The report describes exposure and differences therein (as applicable) of aircraft using a variety of both operations and noise related metrics.

Whilst this report is a comprehensive analysis, it is not intended to be exhaustive. Should there be any questions or comments arsing from the data presented herein, these should be addressed to the HCNF for additional analysis.

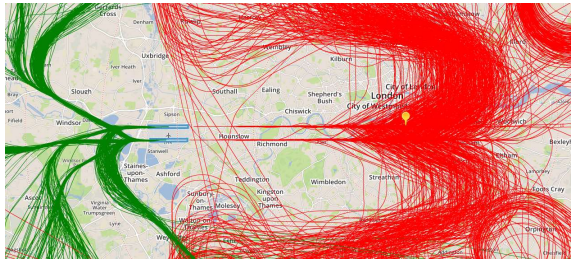
Key Findings

Operations and the community	Noise levels in the community based on measurement at the Camberwell monitor	Difference in community noise levels between 2013 and 2017 based on noise modelling
The noise monitor in Camberwell is predominantly overflown by westerly arrivals. It is located directly under the final approach to the northern runway. Aircraft vectoring from the two northern stacks to the approach to the southern runway may also pass over Camberwell. Noise from aircraft operating into London City Airport may be audible at Camberwell, however this is beyond the scope of this report.	Aircraft noise contributes to the ambient noise at the Camberwell monitor on days of westerly operations.	On full days of westerly operations, there was up to a 1dB decrease in average modelled daytime noise level $L_{Aeq,16hr}$ between 2013 and 2017.
On westerly operations, the number of flights per hour is fairly constant from 6am – 10pm at around 40 flights per hour. Compared to 2013, 2018 saw a small increase in flights in the hour 06:00-07:00 and a small reduction at 14:00-15:00.	Average hourly noise levels are between 3 and 7dB louder on days of westerly operations compared to easterly.	Over the same period, there was also a decrease in the number of events exceeding 65dB by up to an average of 25 per day.
Aircraft on the arrival paths have become marginally more concentrated through the gate above Camberwell.	Average hourly noise levels are up to 2dB greater when the northern runway is in use on westerly operations compared to using the southern runway.	The results indicate average night-time aircraft noise $L_{Aeq,8hr}$ decreased by less than one decibel. It appears that this is due to greater proportion of traffic using the southern runway in the 2017 modelling period.
Aircraft heights have not generally changed above Camberwell over the past 6 years. At this point, most aircraft are fixed on the 3 degree final approach to the airport with little variation.	There were, on average, approximately 585 aircraft noise events registered per full day of westerly operations. On easterly operations, there is usually less than one aircraft noise event per day.	The number of aircraft noise events exceeding 60dB during the night period reduced by up to 2 per day in 2017 compared to 2013.
The fleet mix which passes over Camberwell is reflective of the airport as a whole. The biggest change over the past 6 years has been the introduction and growth of the B787 which account for 9% of the traffic in 2018.	The A320 family is responsible for the highest proportion of aircraft noise events at the Camberwell monitor, accounting for 52% of all noise events from aircraft operating into Heathrow.	
	At the Camberwell monitor, the B747 is the loudest aircraft type followed by the A380 and A340. These are all four engine aircraft.	
	During westerly operations, the hour 06:00-07:00 shows the highest number of noise events and largest average noise levels due to a greater proportion of larger aircraft types arriving at this time and, to a lesser degree, slightly more flights.	

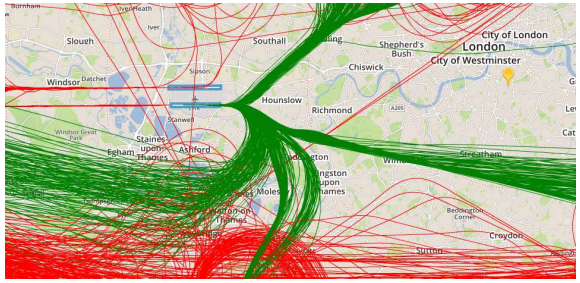
Understanding how wind direction affects aircraft operations

Wind direction and operating direction

- The direction aircraft land and take-off from Heathrow depends on the direction of the wind. For safety reasons, aircraft take-off and land into the wind.
- When the wind blows from the west, aircraft arrive from the east, over central London, and take off to the west. This is called westerly operations. Conversely, when the wind blows from the east, aircraft arrive from the west over Berkshire and take off to the east. This is called easterly operations.
- The figures below show flight tracks for a typical day of easterly and westerly operations. Arrivals are shown red, departures green. The location of the noise monitor is indicated by the yellow pin drop.



Flight tracks on a westerly day (1st October 2018)



Flight tracks on an easterly day (28th September 2018)

The proportion of easterly/westerly operations

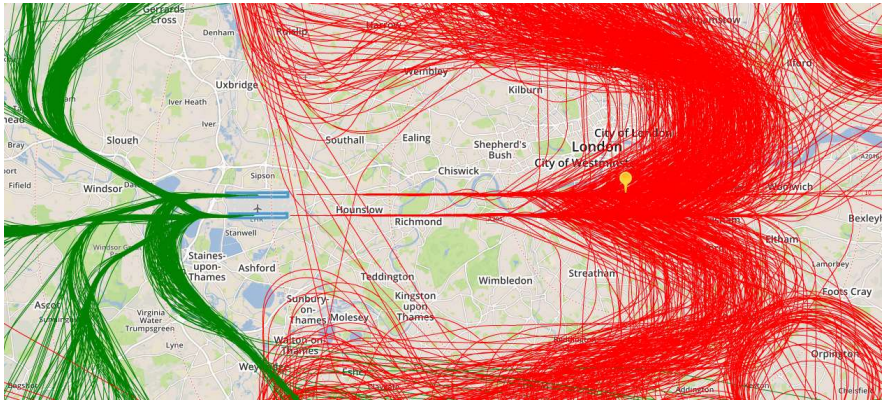
- Around Heathrow, the prevailing wind direction is from the west.
- Heathrow also operates what is known as the 'westerly preference'. Aircraft will continue to operate in a westerly direction until there are tail winds consistently of 5kts or more. This was implemented to protect more densely populated areas to the east of the airport.
- As a result, the airport is typically on westerly operations for about 70-75% of the year.
- The figure below presents the **annual** proportion of easterly and westerly operations for the last 8 full years.

Note: Further information about operations at Heathrow can be found at http://www.heathrow.com/noise/heathrow-operations

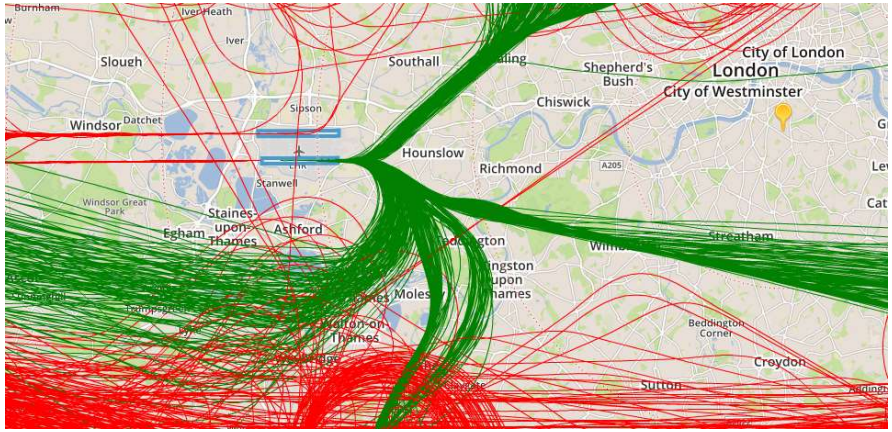
Understanding where aircraft fly near to Camberwell

- The images to the right presents a typical day of westerly operations (top) and easterly operations (bottom) with arrival tracks shown in red and departures in green.
- Camberwell is overflown by westerly arrivals and the noise monitor was located directly under the final approach to the northern runway. It also falls under the route some aircraft may take when vectoring from one of the two stacks to the north of the airport to the final approach to the southern runway.
- During easterly operations Camberwell is not affected by Heathrow aircraft.
- It is possible that Camberwell is affected by air traffic operating into London City Airport however this is out of the scope of this report.

Arrival and departure tracks on westerly operations



Arrival and departure tracks on easterly operations



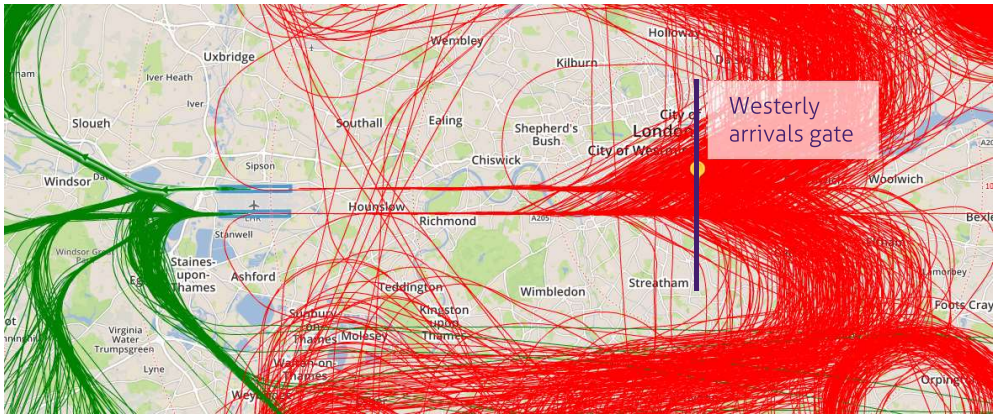
Understanding operational and gate data

Operational data.

- The following operational data were provided for the period 15th February – 17th October 2018 and the same period for the five previous years:
  - Easterly/westerly movements - % of movements in easterly/westerly direction.
  - Daily logs - Number of flights operating from Heathrow per day by runway used
  - Heathrow flight-by-flight data - Aircraft type, departure route, runway.
- Analysis was restricted to the period 1st March – 17th October to avoid conflicting with the Operational Freedom Trials which took place in 2012/13.

Gate analysis.

- To investigate the heights, distribution and concentration of aircraft, the Noise and Track Keeping (NTK) system's "gate analysis" function was used to provide data on where aircraft have flown relative to the noise monitor.
- A gate was drawn over Camberwell centred on the temporary noise monitor to capture movements while the airport is on westerly operations.



- The gate is approximately perpendicular to the arrival tracks and is 13km wide in order to capture the full swathe of arrivals including those already on the final approach and those still joining. The gate extends to a height of 20,000ft.
- The heights and positions of each aircraft passing through the gate were extracted from ANOMS, Heathrow's NTK system. The following data were extracted:
  - Aircraft deviation from the centre of the gate
  - Aircraft height at gate
  - Time that the aircraft penetrated the gate
  - Departure route flown – 'standard instrument departure route' (SID)
  - Aircraft type
  - Runway used

Can the data be trusted?

- Through the Heathrow Community Noise Forum (HCNF), an independent study was carried out, investigating the accuracy of flight track data of Heathrow systems.
- The results confirming the integrity of the data and models are presented in the following report: http://www.heathrow.com/file_source/HeathrowNoise/Static/NLR_HCNF_20160125.pdf

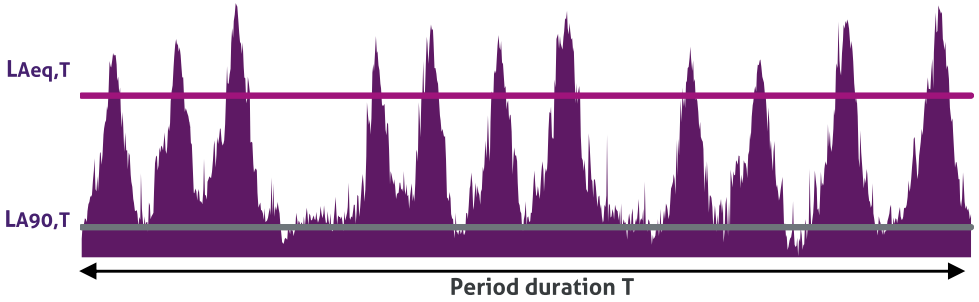
Understanding measured noise data

Measured noise data:

- A Bruel & Kjaer 3639-A, Type 1 integrating sound level meter was set to measure total ambient and background noise levels over hour periods in addition to individual noise events which, where possible, are linked to aircraft operations.
- Measured data is passed into Heathrow's NTK System without modification – no data has been excluded due to adverse weather conditions.
- For this report, noise data has been provided by Heathrow for the period 15th February -17th October 2018. Note that a historical comparison is not available since the noise monitor was not installed at this location in previous years.

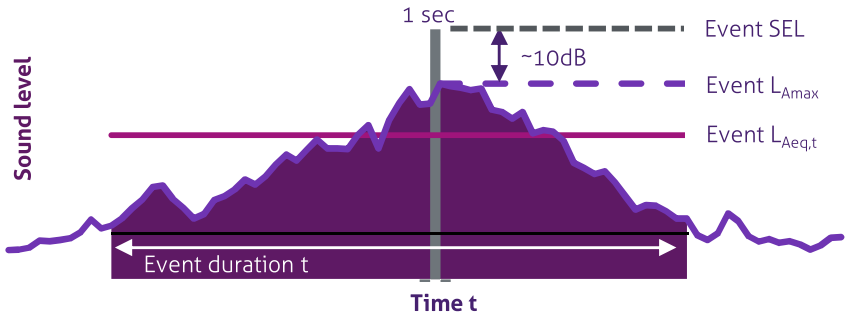
Ambient and background noise levels:

- The figure below illustrates how sound levels can vary over a time period T where aircraft events are experienced. The following metrics are typically used to describe the overall noise environment – $L_{Aeq,T,}$ and $L_{A90,T:}$ These are described as follows:
  - $L_{Aeq,T}$ – the total sound level across period T from all sources;
  - $L_{A90,T}$ - the sound level exceeded for 90% of the time across period T from all sources, this is often regarded as a measure of the background noise;
  - The NTK system provides these metrics in 1hr periods ie T=1hr.



Noise events:

- For ALL noise events, two descriptors are provided:
  - L_{Amax} - the maximum A-weighted sound pressure level during the event
  - SEL (sound exposure level or singe event level) - the sound level of a one second burst of steady sound level that contains the same A-weighted sound energy as the whole event; and
- For noise events linked to an aircraft operation the following data is also provided :
  - Aircraft type
  - Runway
  - Route
  - Position at time of L_{Amax}
  - Position at point of closest approach.
- The figure below illustrates the sound metrics associated with an aircraft noise event. The difference between L_{Amax} and SEL is typically around 10dB.

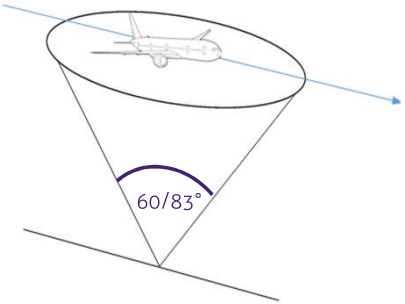


Analysing noise levels from aircraft in this area

To undertake analysis of measured aircraft noise events, two perspectives are considered.

- Firstly, noise in the community. Aircraft overhead will generally have a higher noise level than those further away. However, noise from aircraft further away still contributes to the noise environment. So when describing noise from aircraft in an area all aircraft noise events should be considered.
- Secondly, if considering relative noise levels of aircraft it is best practice to restrict analysis to aircraft deemed 'overhead' to enable like for like comparison. This ensures that flights that are quieter purely as a result of being further away do not artificially reduce the analysed noise levels from that aircraft type.
- There is no consensus as to what constitutes an overhead flight. In February 2017 the CAA published guidance (CAP 1498) recommending the use of an imaginary cone over the receiver with an apex of 60 or 83 degrees. This is illustrated in the figure below.

Flights are considered overhead if the aircraft pass within cone above the noise monitor

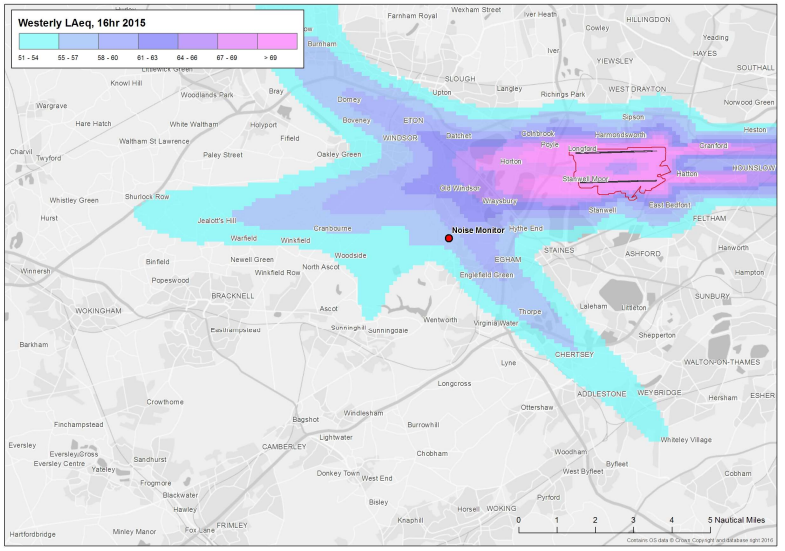


- This community information report will, where applicable, present results for overhead flights determined by CAA guidance as well as all registered aircraft noise events.

Noise Modelling

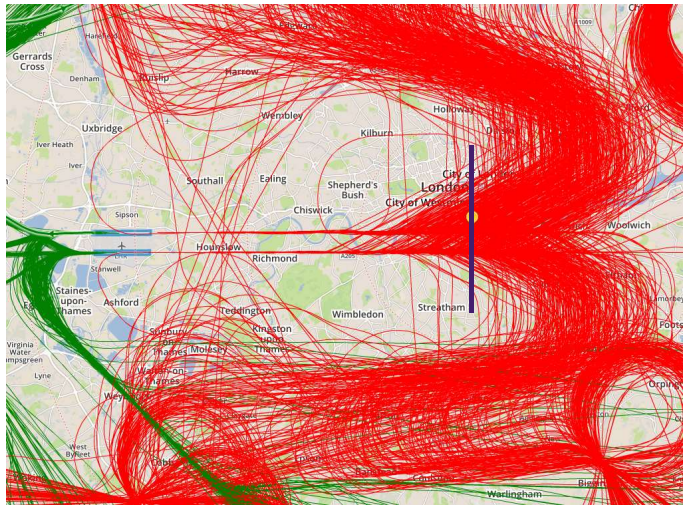
- Aircraft noise modelling has been used to provide an understanding of differences in the noise environment between 2013 and 2017 over the wider geographic area.
- Levels and corresponding differences for an **average day and night of westerly operations** across the summer of 2013 and 2017 have been derived using the Heathrow AEDT (Aviation Environmental Design Tool) model.

Example contours generated by aircraft noise modelling



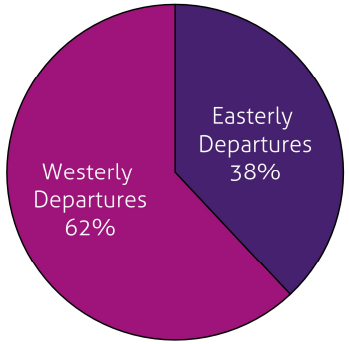
Overview of flight track data

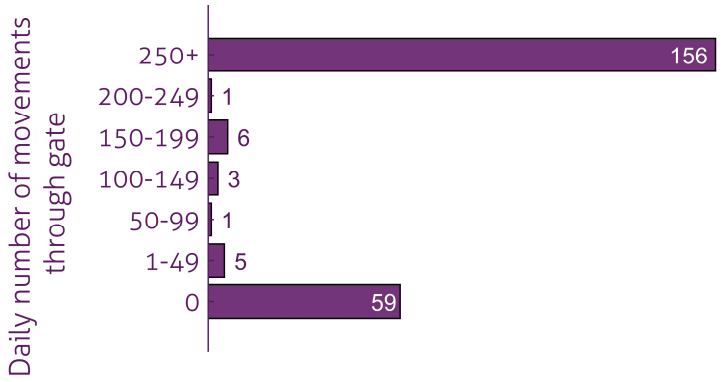
1st March 2018 - 17st October 2018



Example day of arrival aircraft tracks in the vicinity of Camberwell during westerly operations & the westerly gate (width 13km)

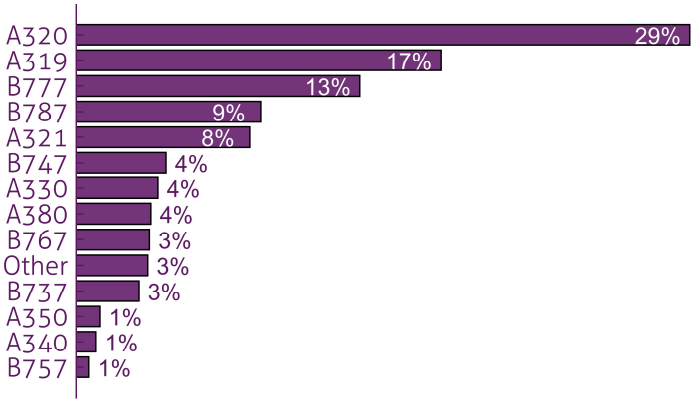
Total 164,651 departures from Heathrow



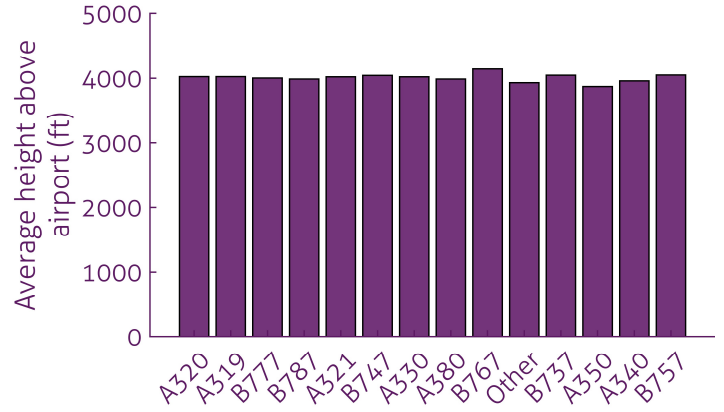


Number of westerly arrivals per day passing through the gate (231 days in total)

Proportion of aircraft types passing through the gate

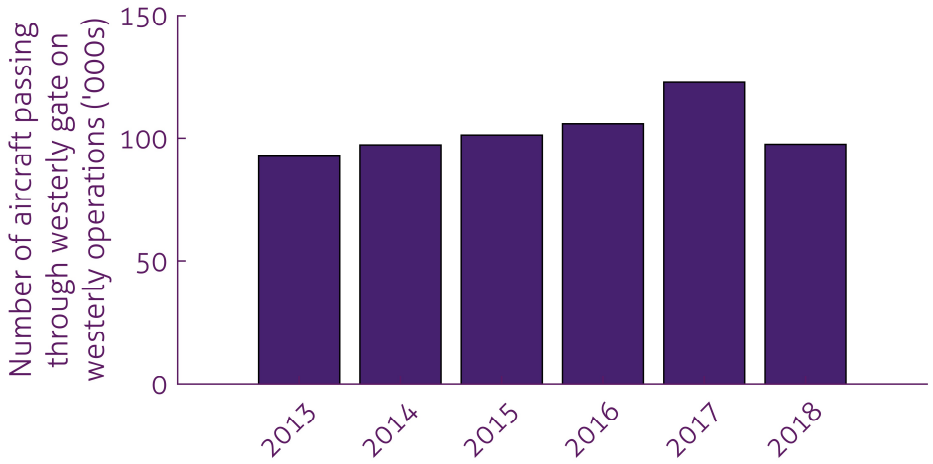


Average height of arriving aircraft as they pass through the gate



Is the number of flights over the area different in 2018 to 2013?

- The figure to the right shows the total number of arrivals that passed through the gate (on westerly arrivals) in the period from 1st March to 17th October from 2013 to 2018.
- Annually, between around 95,500 and 125,00 movements passed through the gate during the monitoring period of which the vast majority are arrivals on westerly operations.
- In this case, year to year changes can be attributed to fluctuations in the proportion of westerly operations (determined by wind direction) and, to a lesser extent, the total number of movements operating into the airport. In 2017, there was an unusually high proportion of westerly operations which is reflected in the greater number of movements through the gate.
- The table indicates that the proportion of westerly operations in the 2013 period was 63%, in 2018 64%.
- On a full day of westerly operations;
  - There was a 2% increase in arrivals through the gate in the 2018 period compared to 2013.
  - The number of departures passing overhead at the monitor has not changed in the same period (as indicated by the numbers in parentheses).



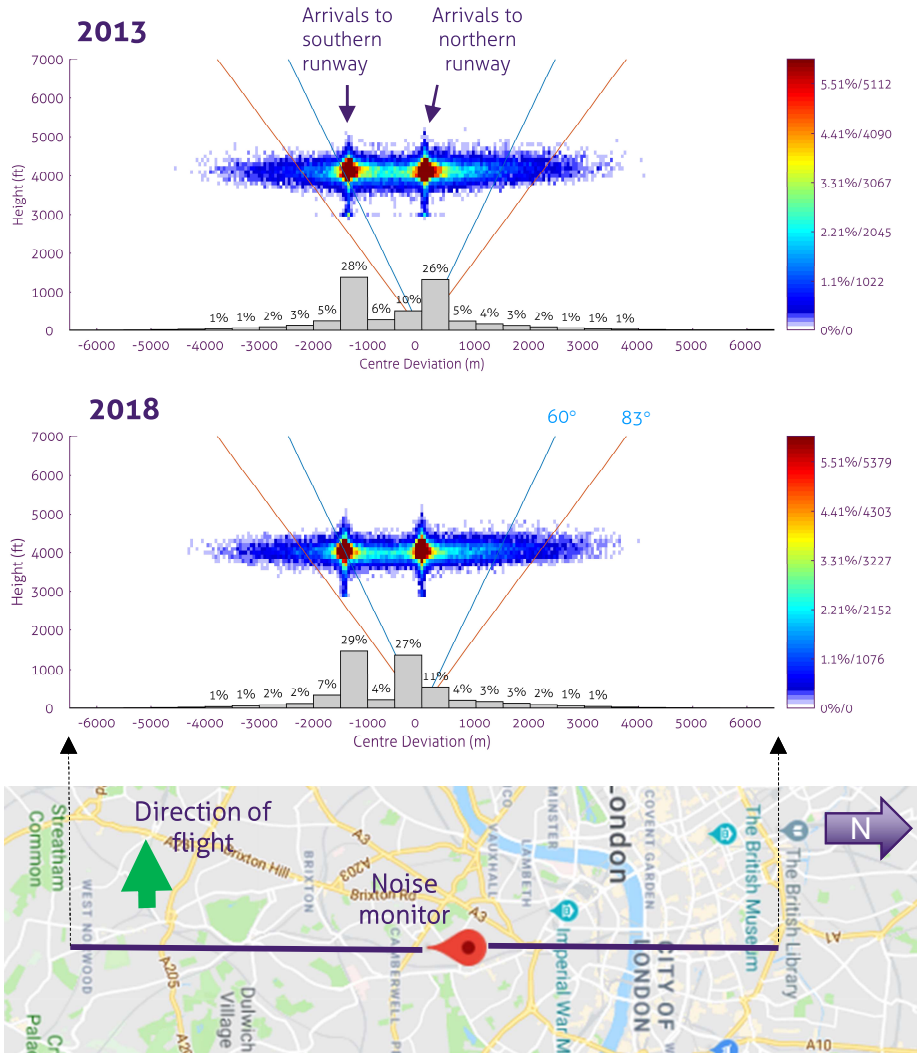
	2013	2018	Change	Change (%)
Proportion of westerly operations (all Heathrow flights)	63%	64%	+1%	N/A
Average number of westerly arrivals passing through the gate during days of 100% westerly operations.	648 (276)*	662 (276) *	+14 (+0)*	+2% (+0%)*

* Figures in parentheses indicate the number of flights passing through the 60° overhead cone.

Note: Wherever this section of the report refers to *2018*, it should be noted that this is specifically the measurement period from 1st March 2018 to 17th October 2018. Similarly, 2013 specifically refers to the period from 1st March 2018 to 17th October 2018.

Is the concentration of westerly operations different between 2018 and 2013?

- The figures to the right are heat maps showing the 2D concentrations of departing aircraft as they pass through the westerly gate during the 2013 (the upper figure) and 2018 (the lower figure) monitoring period. In addition, the concentration at different distances from the centre along the length of the gate is shown by the grey bars.
- The scale presents colours for the proportion of aircraft in each grid square (pixel) - blue represents smaller proportions,, red higher proportions. For example a "red" indicates 5.5% of the movements passing through a grid square in the gate in both figures (it should be noted that the number of movements this represents may differ between the figures – in 2013, 5,112 flights represent 5.5%, in 2018 this figure was 5,379).
- The gate has been designed to be perpendicular to the westerly arrival paths. The two centres of concentration (darkest red) are representative of aircraft established on the northern and southern runway final approach. The broader swathe is representative of aircraft flying from the holding stacks preparing to join the final approach. This is shown clearly on by the image of the flight paths on Page 11.
- The figures indicate that the arrival tracks are marginally more concentrated in 2018 compared to 2013.

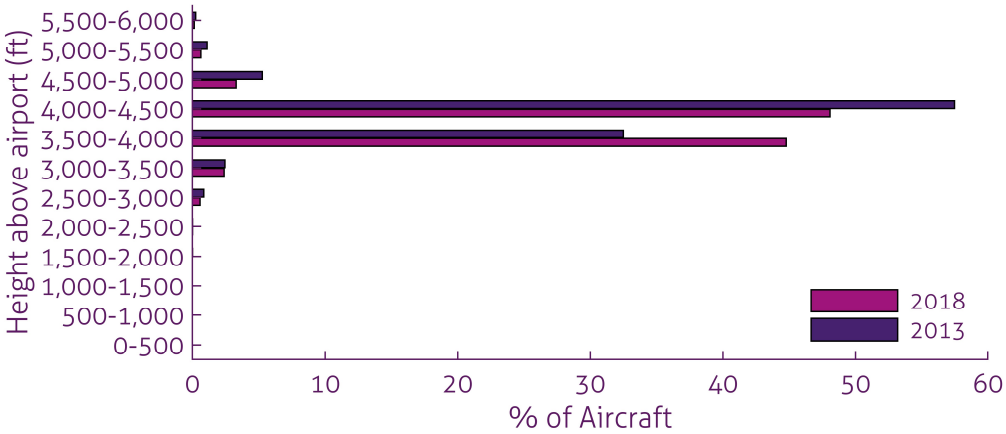


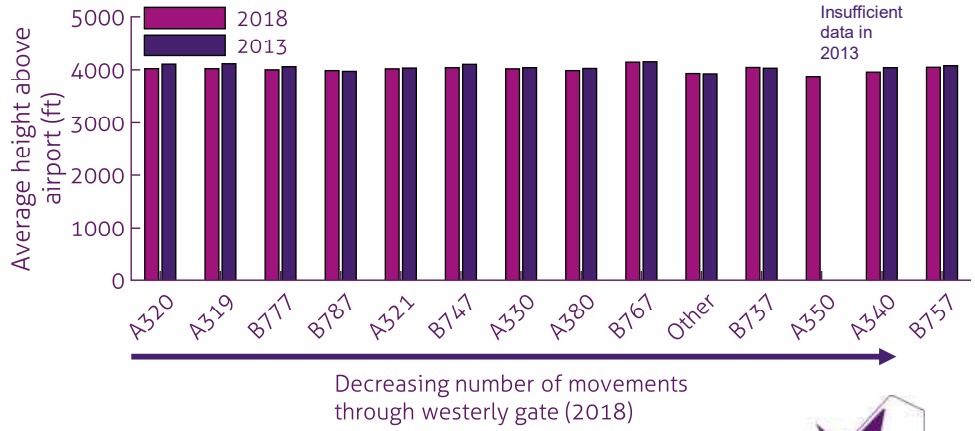
Note: The "heat maps" have been normalised to account for differences between the number of westerly departures in each of the monitoring periods. This allows the concentrations in each graph to be compared. This method does not account for any changes in daily number of movements passing through the gate - these changes are presented on Page 12. The maps are divided into grid squares, 50m horizontally by 60ft vertically.

Are aircraft heights different between 2013 and 2018?

- The table to the right presents the average height of arriving aircraft above Camberwell as they pass through the gate on westerly operations.
- This indicates that aircraft above Camberwell were, on average, a similar in height in 2018 and 2013.
- The figures present the distribution of these aircraft height through the westerly gate comparing 2013 with 2018 (upper figure) and the average height by aircraft type (lower figure).
- The upper figure shows that although the average aircraft height is similar in the two years, there was a greater proportion of arrivals that were under 4,000ft above Camberwell.
- The lower figure shows that the height of aircraft varies with type. Since most aircraft will be following the same approach path into Heathrow, the heights of the each aircraft type are generally similar.

	2013	2018	Difference
Average height of arrivals through the gate on westerly operations	4,080ft	4,020ft	-60ft

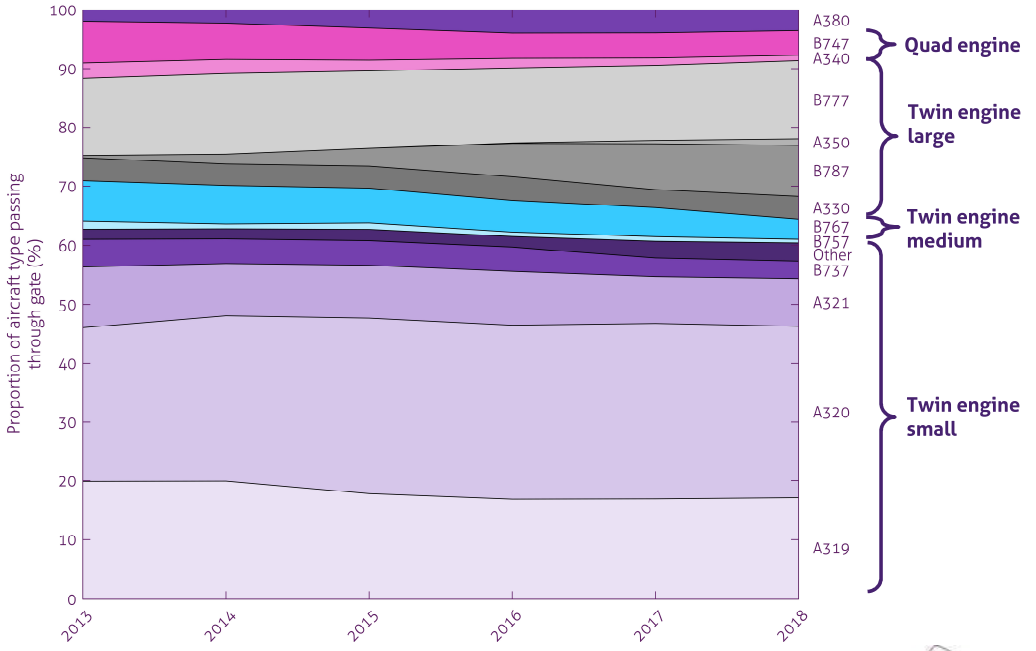




Is the fleet mix different between 2013 and 2018?

- The table to the right presents the mix of departing aircraft that passed through the gate in the 2013 and 2018 periods.
- For simplicity the fleet mix has been split in to 5 groups:
  - the A380
  - quad (four) engine aircraft (including B747, A340),
  - twin engine large aircraft (B777, A350, B787, A330)
  - twin engine medium aircraft (B767) and
  - twin engine small aircraft (B737, A320 family).
- Previous slides indicated that the number of aircraft flying through the gate has increased by 2% on an average day of full westerly operations between 2013 and 2018.
- The analysis on this page indicates that there was an increase in the proportion of A380 operations passing through the gate from 1.9% in 2013 to 3.5% in 2018.
- The proportion of large twin engine aircraft increased, primarily due to the introduction and increased use of the B787 Dreamliner while the proportion of the other 4 engine (quad) and small and medium twin engine aircraft types reduced.
- The figure provides a more detailed picture of how the fleet mix has changed across the period. The aircraft categories used in this report are distinguished by the different colour schemes. As gate encompasses both arrival paths, the aircraft that pass through the gate are representative of the fleet mix operating at the airport as a whole.

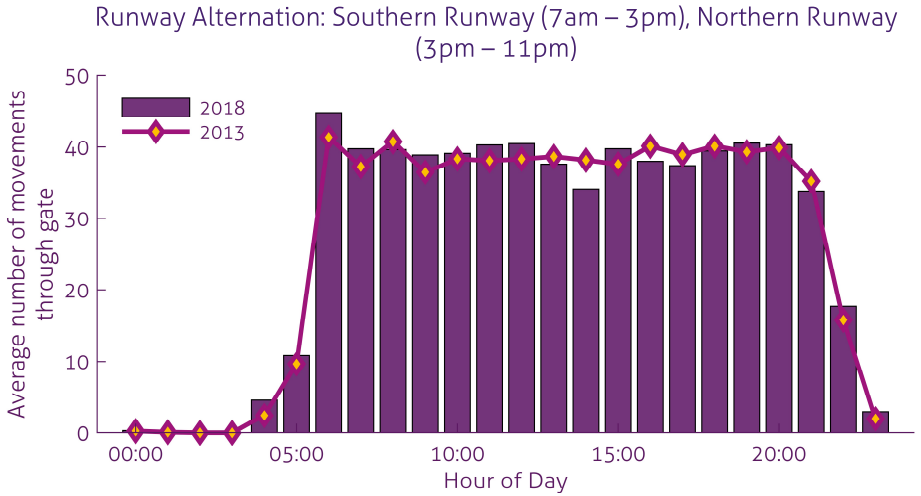
Fleet mix		
Category	**2013**	**2018**
A380	1.9%	3.5%
Quad engine	9.7%	5.1%
Twin engine large	17.5%	26.9%
Twin engine medium	7.2%	3.8%
Twin engine small	63.7%	60.6%

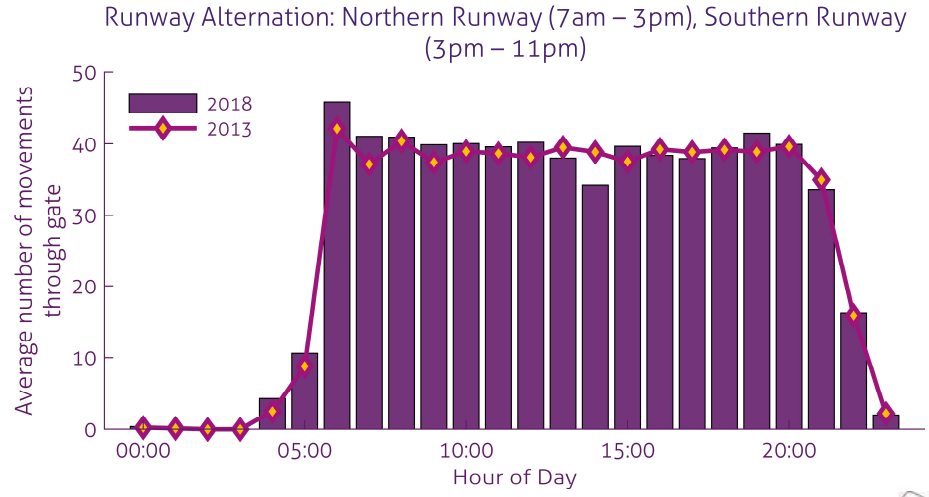


* Days of 100% westerly operations only

Does the number of flights over the area vary across the day? Is there a difference between 2013 and 2018?

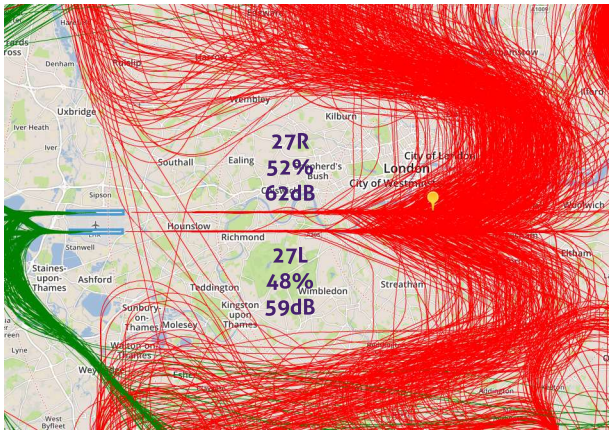
- The figures to the right present the average number of arrivals through the gate per hour in 2013 and 2018 during days of 100% westerly operations. The two plots represent the two modes of runway alternation; the upper plot shows the days where the southern runway is used for arrivals for the period 07:00 – 15:00 and the northern runway is then used from 15:00 to 23:00. The lower plot shows the days where the alternation pattern switches.
- The distribution of movements through the gate is the very similar regardless of the alternation schedule.
- The figures show that in the hours 06:00-22:00 there are roughly the same number of flights passing through the gate each hour (~35-45 flights per hour). The first flights pass through the gate at around 04:30 every morning and the busiest hour is 06:00-07:00.
- The distribution of flights during the day is similar in 2013 and 2018; the biggest difference is that in 2018 there were on average approximately 4 extra flights in the hour 06:00 to 07:00 and a similar number less in the hour 14:00 – 15:00.
- Of the total 231 days in the 2018 monitoring period, 110 days (48%) were 100% westerly operations and 54 days (23%) were on 100% easterly operations. The remainder had a mixture of easterly and westerly operations as the wind direction changed during the day.





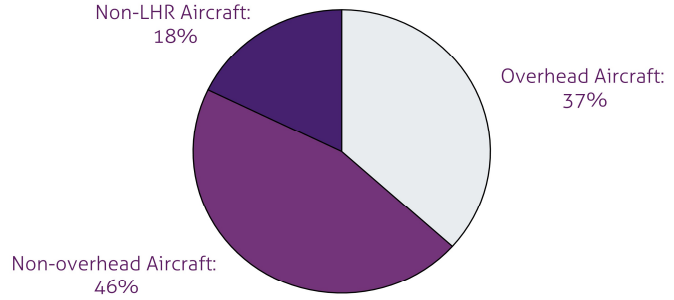
Overview of noise monitor data recorded at Camberwell noise monitor

15th February – 17th October 2018



Monitor location, % noise events by arrival track & average L_{Amax}

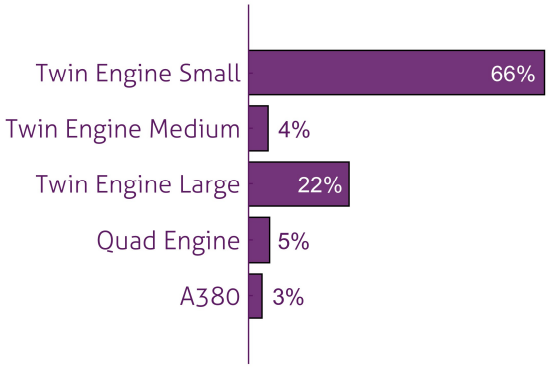
106,688 Measured Noise Events



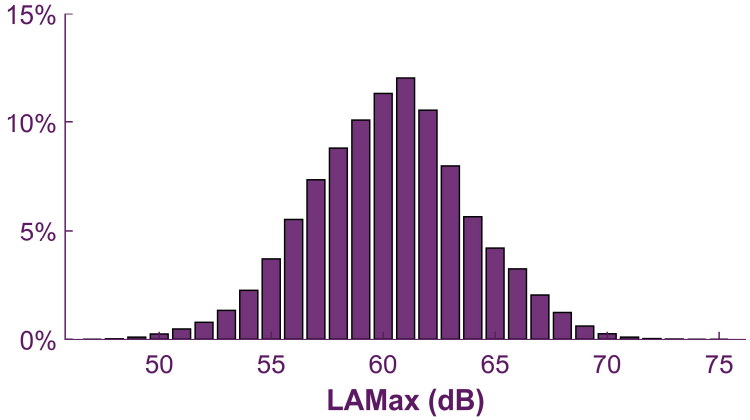
* From all noise sources

37%

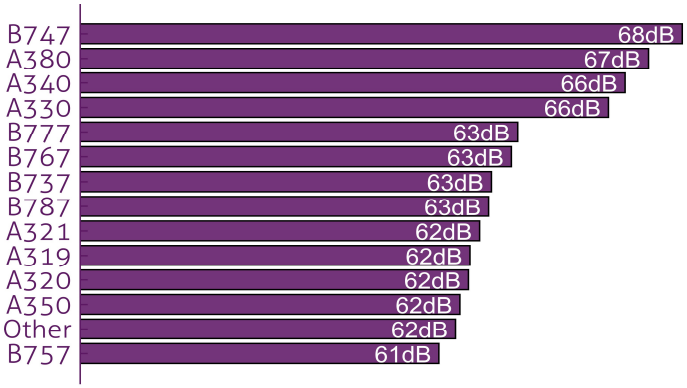
of aircraft noise events recorded when aircraft were within 60° cone over the noise monitor



Noise events by aircraft size



Overall distribution of maximum event noise level L_{Amax} - Heathrow aircraft



Average L_{Amax} by Aircraft Type*

*Overhead aircraft on westerly arrivals only

Noise monitoring overview.

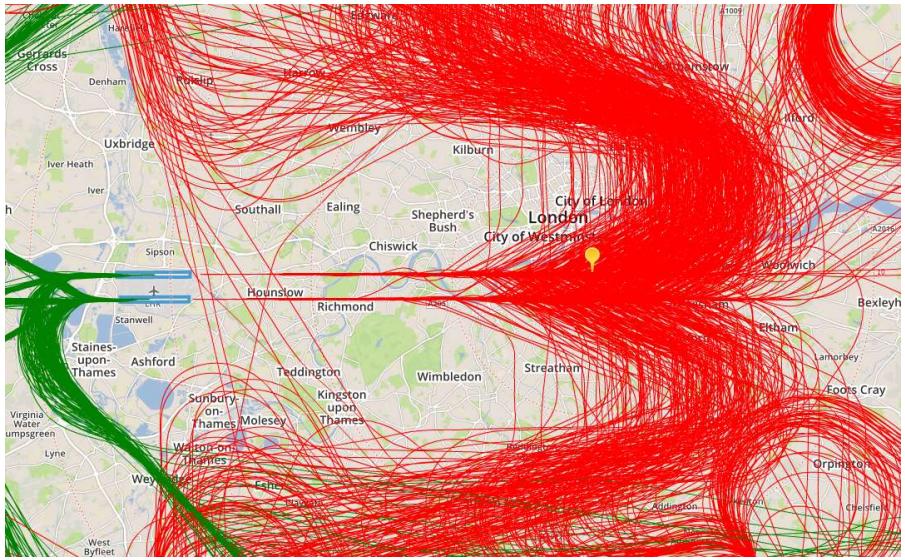
Monitoring location, duration and setup

- A temporary noise monitor was installed at the Ark All Saints Academy in Camberwell between 15/02/2018 and 17/10/2018. .
- The location of the noise monitor is shown in the figure to the right. It is directly under the arrival path for the northern runway and is also overflown by some aircraft flying from the stacks north of the airport to join the approach to the southern runway.

Noise event summary

- A total of 106,688 noise events were measured during the monitoring period. Of these around 82% were from aircraft using Heathrow, the remainder were aircraft or helicopters not operating into Heathrow.
- Of those noise events from aircraft operating into Heathrow, slightly more were measured from aircraft approaching the northern runway (27R) compared to the southern runway (27L).
- Overall, 37 % of aircraft registering noise events were overhead (based on the 60° cone).

Arrival tracks and monitor position on a typical westerly day

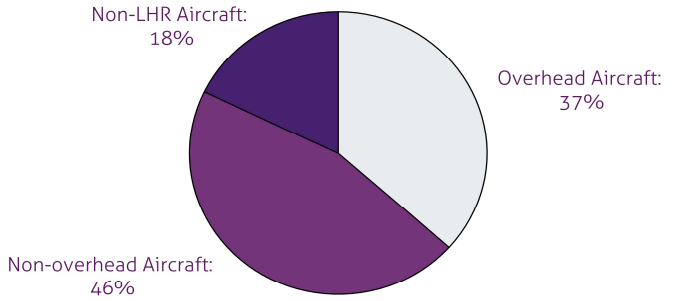


Percentage of aircraft noise events by route

Westerly		Easterly		Overhead*
27L	27R	09L	09R	
48	52	0	0	45

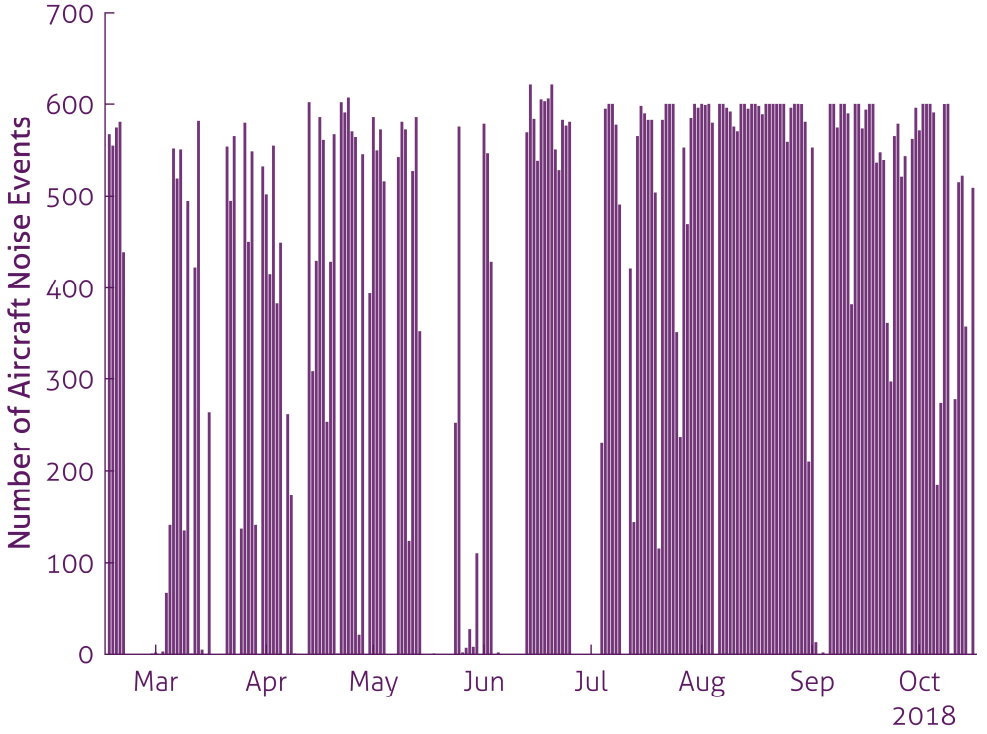
*This is a percentage of noise events from LHR, not all noise events as shown in the pie chart to the right

Measured noise event summary



Does the direction of operation affect the number of measured aircraft noise events?

- Noise events at the monitor caused by aircraft operating into Heathrow are almost entirely during periods of westerly operations by aircraft and predominantly landing on the northern runway.
- During the monitoring period, 115 out of 244 days (47%) were 100% westerly operations and 62 days (25%) were 100% easterly operations. On the remaining days, the airport switched direction of operation during the day.
- During days of full westerly operations, there were, on average, 585 aircraft noise events triggered per day.
- During days of full easterly operations there was an average of less than one aircraft noise event per day.
- 45% of measured aircraft noise events were recorded by aircraft passing within the 60° overhead cone.
- It is noted that an absence of aircraft noise events does not mean that aircraft would not necessarily be audible or even visible. There may be aircraft further away that are audible that were not registered by the noise event detection system.

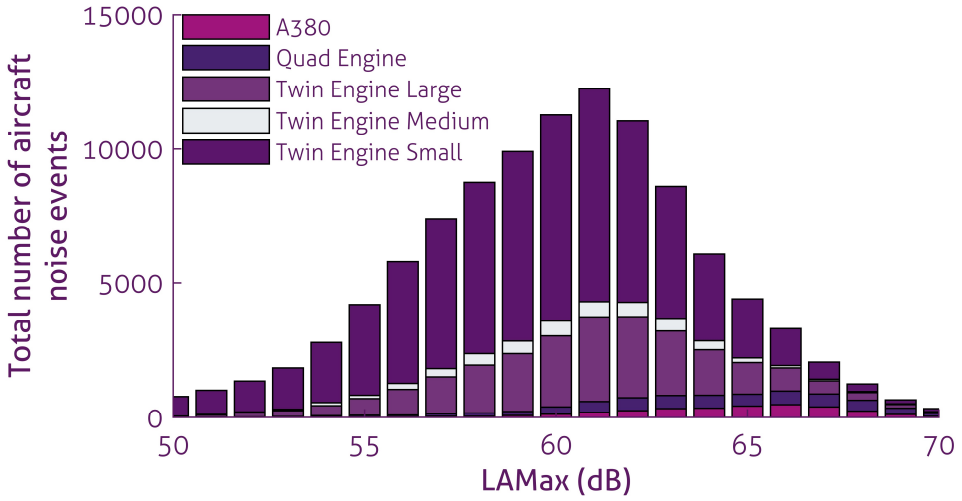


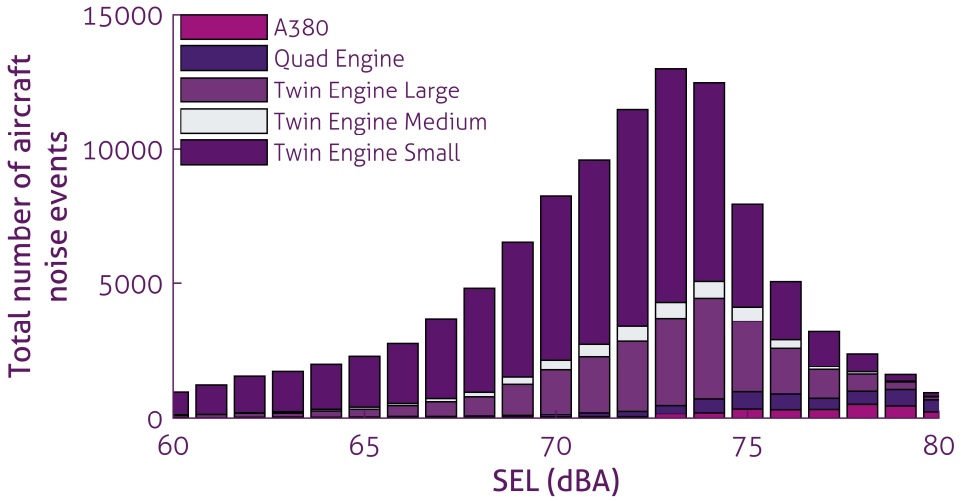
What was the range of L_{Amax} and SEL noise levels from aircraft events?

- The figures to the right present the range of L_{Amax} (top) and SEL (bottom) noise levels for all aircraft noise events measured at the Camberwell monitor during the monitoring period. An explanation of metrics is given on page 8.
- The table below presents the average* L_{Amax} and SEL for each aircraft type group.
- The average L_{Amax} and SEL of all aircraft events operating into Heathrow are 60.7 and 72.2 dB respectively. The distribution of the noise levels is dependent on aircraft size with the larger aircraft generally recording louder events.

Aircraft group	Average L_{Amax}	Average SEL, dBA
A380	64.7	76.8
Quad engine	64.2	75.8
Twin engine large	61.3	72.8
Twin engine medium	60.8	72.3
Twin engine small	59.7	70.7

- As this analysis considers ALL events measured at this monitor regardless of distance or route these results cannot be used to compare the relative noise levels of aircraft types. An analysis of aircraft type noise levels is presented on page 23.





* **Note: throughout this report, unless otherwise stated, the arithmetic mean is calculated.**

Which aircraft types account for the measured noise events?

- The table to the right shows the proportion of aircraft noise events recorded for each aircraft type overall, by arrival runway and whether the analysis shows it to be overhead at the noise monitor.
- The aircraft types listed are limited to the most common aircraft types operating at Heathrow. The remaining aircraft types are listed under 'Other'.
- As with the Heathrow Airport's traffic in general, the A320 family (A319, A320 & A321) dominate - accounting for 52% of all aircraft noise events detected by the monitor.
- The B777 (twin-engine large) series of aircraft account for around 14% of the measured aircraft noise events.
- The B747 and the A380, generally considered the loudest aircraft that operate into Heathrow, both accounted for 5% and 4% of the noise events respectively, just over half of which passed overhead.
- The newest aircraft types in service, the B787 and A350 accounted for 9% and 1% respectively of all recorded aircraft noise events.
- A slightly higher proportion of events were recorded from aircraft approaching the northern runway (27R) compared to the southern runway (27L)

Aircraft Type	Total*	Runway				Overhead**
		27L	27R	09L	09R	
A320	27	13	15	0	0	12
A319	17	8	9	0	0	8
B777	14	7	8	0	0	6
B787	9	4	5	0	0	4
A321	8	3	4	0	0	4
B747	5	3	2	0	0	2
A330	4	2	2	0	0	2
B767	4	2	2	0	0	1
A380	4	2	2	0	0	2
Other	3	2	2	0	0	1
B737	3	1	2	0	0	1
A350	1	1	1	0	0	0
A340	1	0	1	0	0	0
B757	1	0	0	0	0	0
Total* **	**100%**	**48%**	**52%**	**0%**	**0%**	**45%**

* Percentage based on 106,688 aircraft noise events recorded between 15th February and 17th October 2018.
** Defined as being with the 60 degree cone described on page 9
***Totals may differ to sum of aircraft types due to integer rounding

Comparison of average noise levels for different aircraft types

L_{Amax}

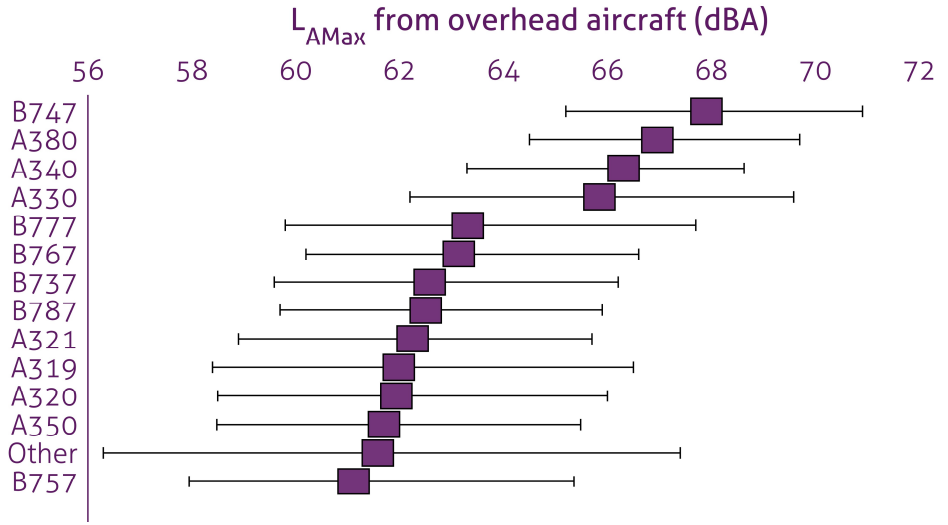
The plot in the top right show the average (arithmetic mean) L_{Amax} of each aircraft type in addition to the 5th and 95th percentile within the 60° **overhead** cone.

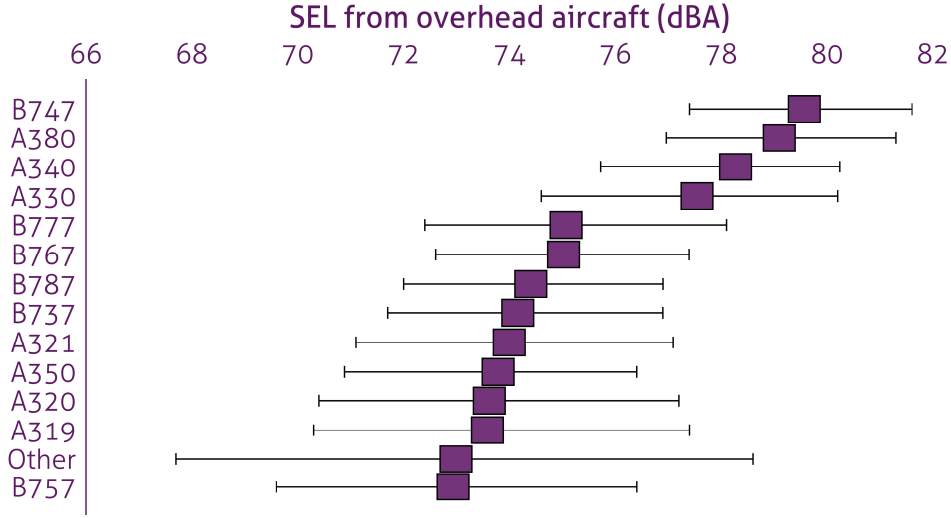
- The three loudest aircraft types are the B747 (68dB), A380 (67dB) and A340 (66dB) - the only quad engine aircraft operating into Heathrow.
- The average L_{Amax} for all the twin engine aircraft is in a range of around 61-63dB, the A330 being the sole exception at 66dB.
- There is typically a range of around 5 to 10dB in the L_{Amax} values of each aircraft type.
- The B787 and A350, the newest aircraft types in service (both in the medium twin engine category) are on average the quietest overhead aircraft, generating an average L_{Amax} of approximately 62.5 and 61.7dB respectively – comparable to the small twin engine aircraft types.

SEL

The plot in bottom right corner shows the average SEL of each aircraft type. The SEL takes into account of all energy within a noise event.

- The relationship of aircraft types is similar to that seen in the L_{Amax} plot although there are some small differences such as the difference between the B747 and the A380 is smaller when comparing the SEL values.
- There is a smaller range of values for the louder aircraft types – this is likely to be due to other noise sources having a smaller influence on the SEL compared to quieter aircraft noise events.

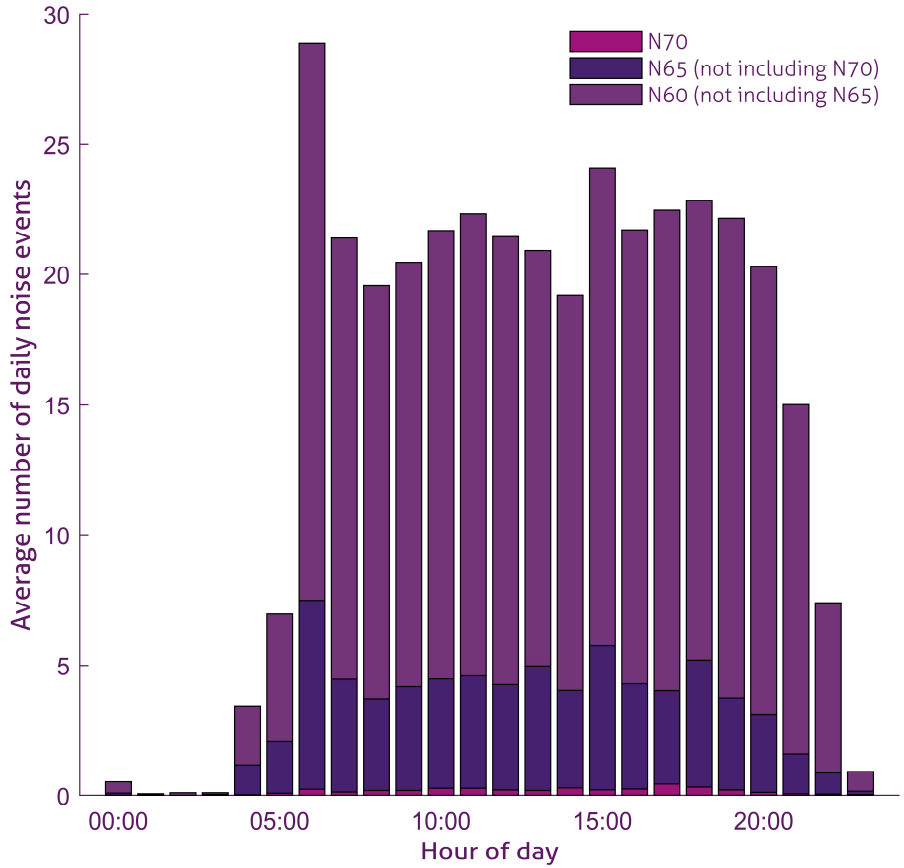




In accordance with CAA guidance, this analysis has used the 60 degree overhead cone.

How does the number of noise events above 60, 65 and 70 dB L_{Amax} noise events vary across a day (N60, N65 and N70)?

- It is recognised that the response to aircraft noise is related to more than average noise levels alone. The number of events and their individual levels are becoming increasingly recognised as a useful indicator of community response to aircraft noise.
- The N_{above} metrics describe the number of events in a period where the L_{Amax} exceeds a given value. For example, an $N65_{1hr}$ of 10 means that ten aircraft generated a maximum noise level greater than 65dBA in a single hour.
- The figure to the right shows the average hourly N60, N65 and N70 values across an **average 24hr day for days of 100% of westerly operations**.
- Between the hours of 07:00 and 21:00 there are typically, between 19 and 24 events with an L_{AMax} greater than 60dB being registered per hour.
- The busiest hour is between 06:00-07:00 where, on average, 28 events occur on a westerly day.
- On an average westerly day, the N65 during the 16h day period (07:00-23:00) was 323; the N60 during the 8h night (23:00-07:00) was 41.
- The N60 during the night period on westerly days was predominantly made up of early morning arrivals before 07:00.



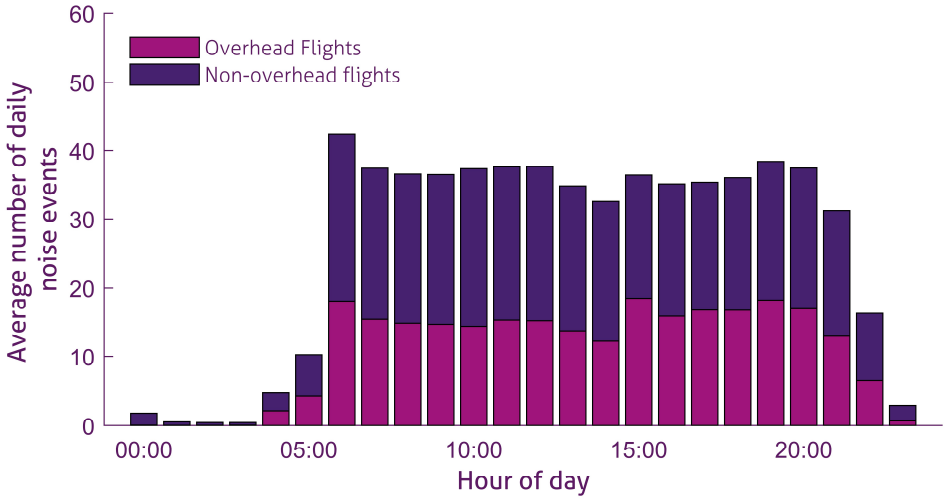
How does the number of aircraft noise events vary across a day?

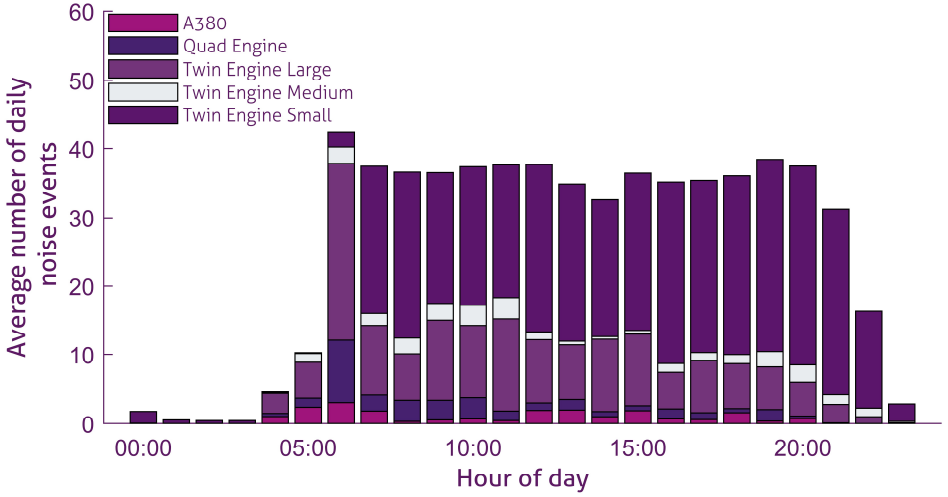
The top right figure shows the average number of noise events during each hour of the day for days of full westerly operations broken down by those that passed overhead or not.

- During the daytime period (07:00 to 23:00), there were typically up to 40 aircraft events recorded on average per hour at the noise monitor.
- Between 06:00 and 07:00 over 40 events were recorded on average.
- On average, the proportion of noise events measured by aircraft that pass overhead is relatively constant through the day, however it is expected that greater variation would be visible if runway alternation was taken into account .

The lower figure shows the same data broken down by aircraft size.

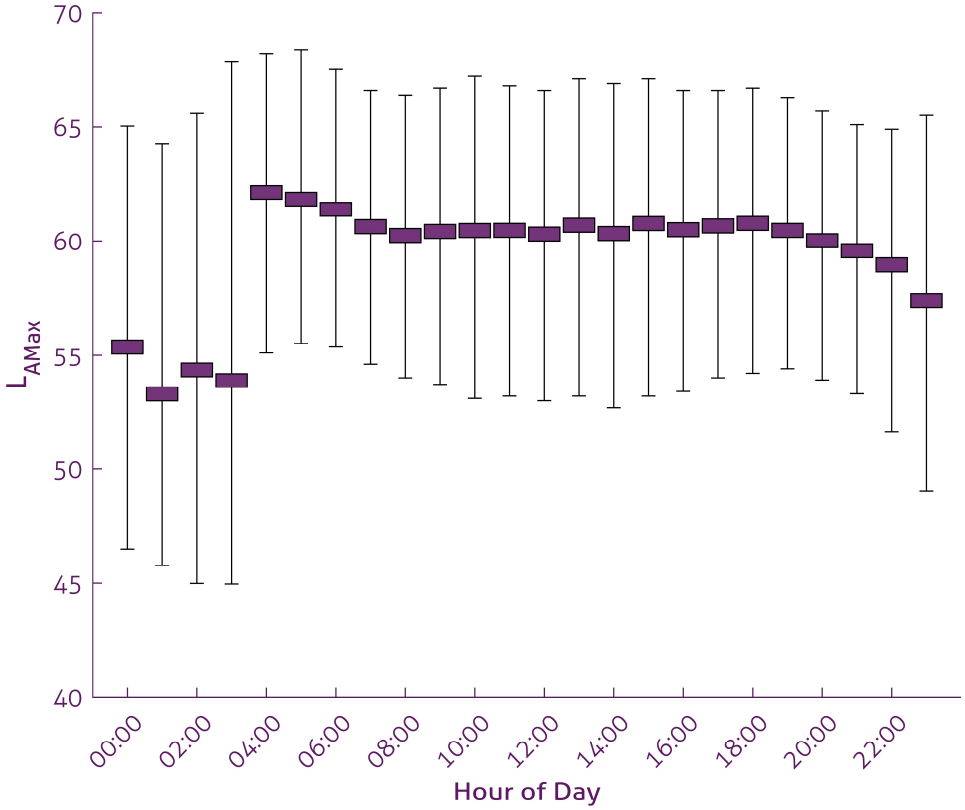
- Between 07:00 and 20:00, small twin engine aircraft are responsible for the majority of noise events and, in general, the proportion increases during these hours.
- Between 06:00 and 07:00, small twin engine aircraft were responsible for a small proportion of the noise events recorded. Events from medium to large twin engine and four engine aircraft are dominant.
- The number of larger aircraft in the hour between 06:00 and 07:00 is reflected in the increased number of N65 events in the N_{above} plots on the previous slide (p25).





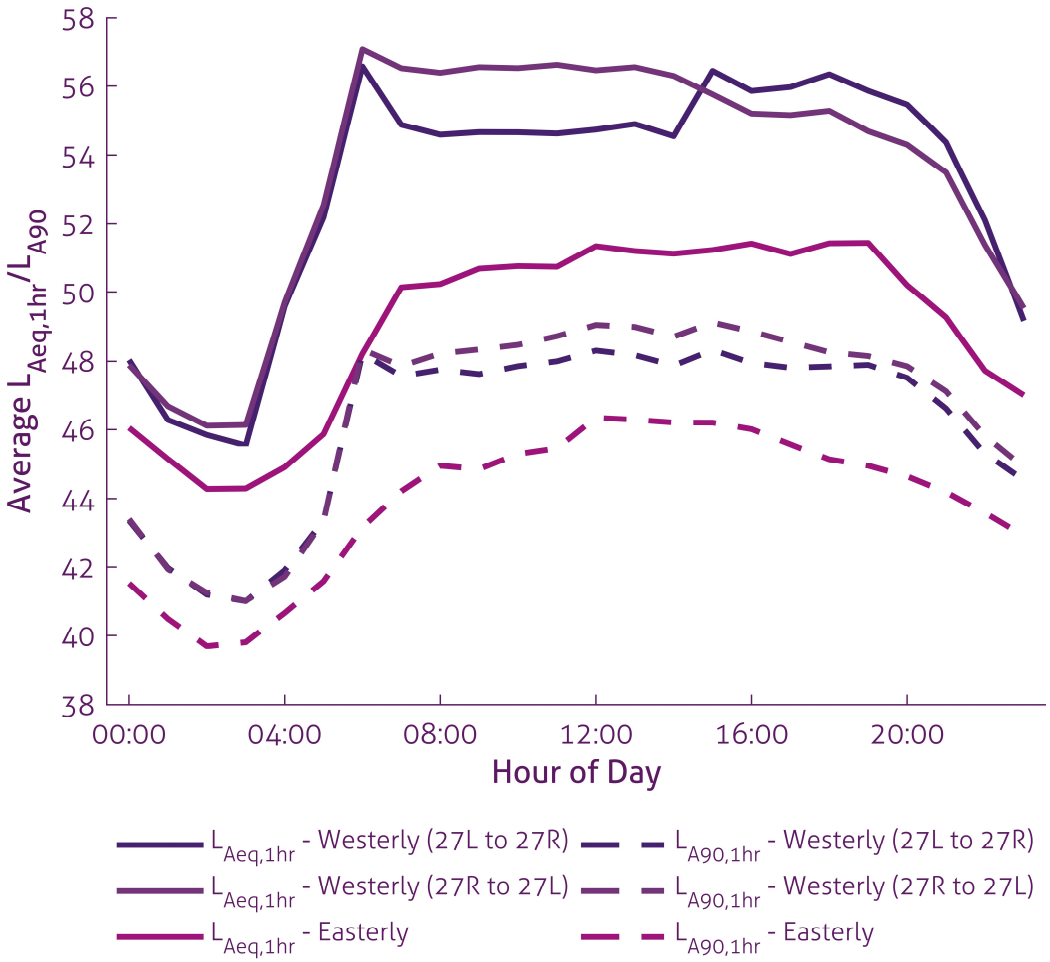
How does the average L_{Amax} vary across a day?

- The figure to the right shows the average and range of L_{Amax} values of aircraft noise events for each hour of the day. The range represents the 5th and 95th percentile in each hour.
- The average L_{Amax} values tend to be a function of the size of aircraft operating in a given hour.
- During the first four hours of the day (00:00-04:00), there are very few registered noise events. The average L_{AMax} during these hours does not exceed 56dB.
- After 04:00, the average L_{AMax} is 62dB and gradually decrease to 60dB by 08:00. After 08:00, the average L_{AMax} remains relatively constant until 19:00 after which the average level gradually decreases to 57dB.
- The average L_{AMax} is generally a function a the fleet mix and aircraft size. Page 25 shows the increased proportion of smaller aircraft passing over Camberwell between morning and evening hours.
- It should be noted there in any given hour, the range of L_{Amax} values can reach up to 9dB.



Do aircraft contribute to overall ambient noise levels?

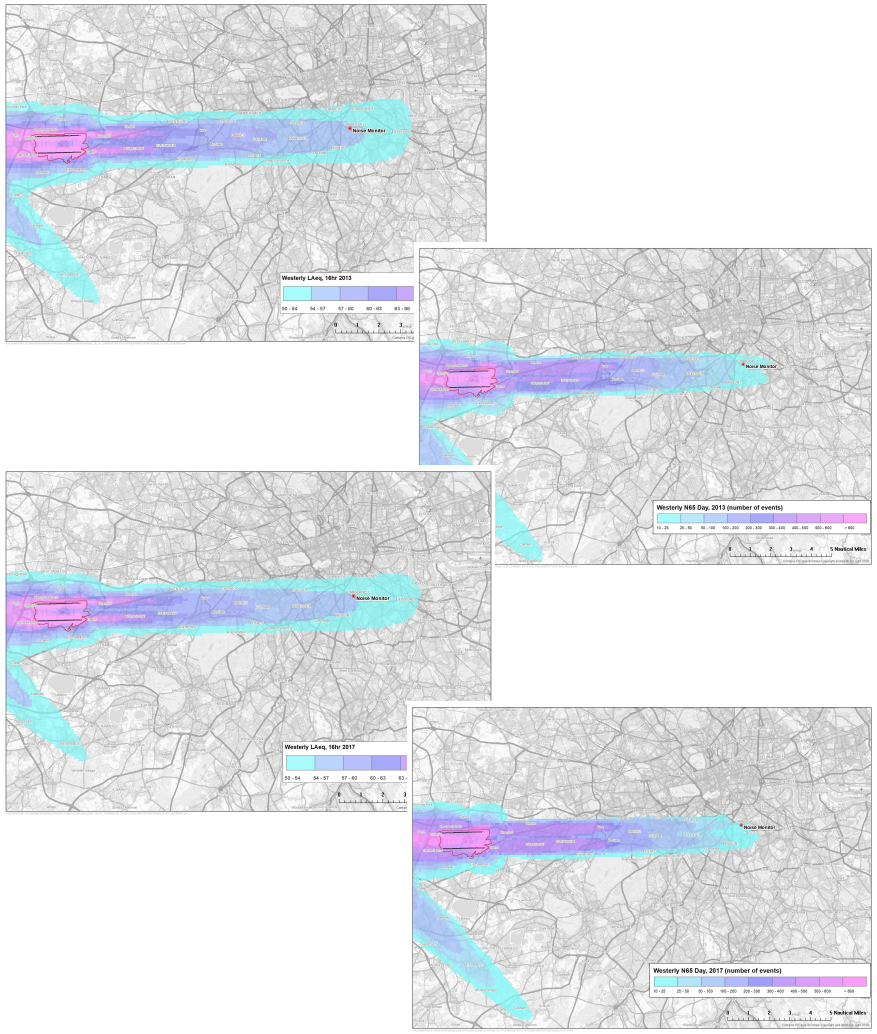
- The figure to the right shows the average (arithmetic mean) hourly $L_{Aeq,1hr}$ and $L_{A90,1hr}$ (an indication of background noise) on days where 100% of operations were either westerly or easterly. There are two westerly plots to show the effect of runway alternation of the noise levels at the Camberwell monitor.
- It should be noted that these metrics describe the overall noise environment including all noise sources, not just aircraft noise related to Heathrow.
- During days of full westerly operations between the hours of 07:00 and 21:00 average $L_{Aeq,1hr}$ values were around 3-7dB higher when compared with the same hour during a full easterly day.
- The highest average hourly noise level, 57dBA, occurs between 06:00 and 07:00 corresponding to the busiest period for arrivals into the airport.
- When on westerly operations, the average hourly noise level is up to 2dB higher when the northern runway is in use compared to the southern.
- On easterly operations the $L_{Aeq,1hr}$ reaches 52dB in the hour between 19:00 and 20:00. Aircraft noise is unlikely to contribute to the noise environment in Camberwell during periods of easterly operations.
- During the period the monitor was in place, the average daytime $L_{Aeq,16hr}$* between 07:00 and 23:00 was 55dB on westerly operations and 51dB on easterly operations from all noise sources.
- During the night, the average $L_{Aeq,8hr}$ between 23:00 and 07:00 was 51dB on westerly operations and 46dB on easterly operations.



* It should be noted that the $L_{Aeq,16hr}$ has been calculated using the average of the hourly values for easterly and westerly days during the monitoring period. This is different to the published annual contours which calculate the LAeq,16hr over a 92 day period over the summer.

Modelled long term average aircraft noise levels around the airport.

- While a noise monitor can provide an in-depth picture of the noise environment at a specific location, the data cannot be used to provide an understanding of the noise environment over a wider geographical area.
- The Heathrow AEDT model has been run using flight track data for **2013 and 2017** to investigate whether there are any differences in daytime ($L_{Aeq, 16hr}$ /N65) and nighttime ($L_{Aeq, 8hr}$ /N60) for an **average day and night of westerly operations** across the summer in each of these years.
- Note that these contours are specific to easterly and westerly operations and are not the same as the ERCD published annual contours which derive an overall average for the summer that combines westerly and easterly operations. The following maps only use days when there were full westerly operations across that day.
- Daytime $L_{Aeq, 16hr}$ values are presented in bands >50 dB, > 54dB and then in 3 dB increments to 69 dB.
- Night-time $L_{Aeq, 8hr}$ values are presented in 5dB bands starting at >40 dB to 65 dB.
- These are longer terms metrics averaged over 16 and 8hrs and do not directly reflect the shorter term fluctuations between individual events.
- It should be noted that aircraft noise modelling to average levels around 50 dB carries increasing uncertainty in the result. In areas where aircraft noise levels are in this range it should be noted that many non aircraft noise sources may be of similar (or even higher) levels. Interpretation of the modelled results at this noise level should bear this mind.



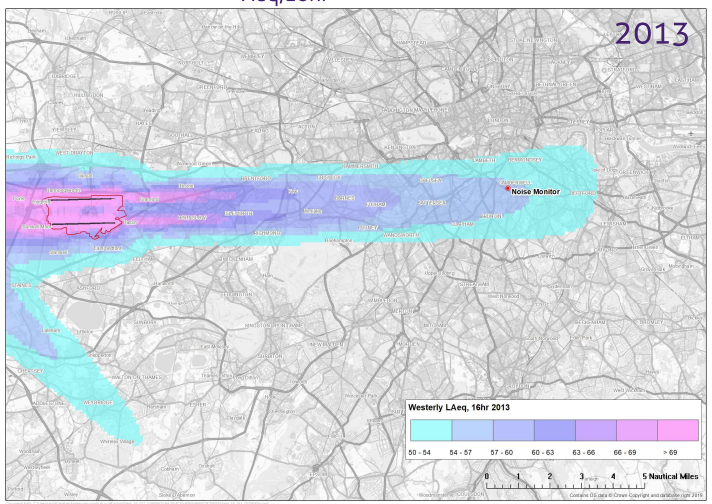
Average **daytime** aircraft noise levels – westerly operations

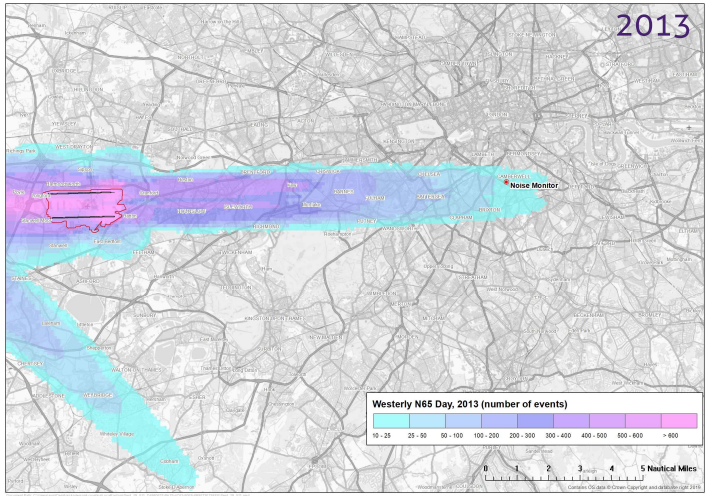
- The figures to the right show the 2013 and 2017 daytime $L_{Aeq, 16hr}$ bands in the left column and N65 bands in the right column for **an average westerly summer day when the airport is on 100% westerly operations**.
- The position of the noise monitor is marked by the orange dot.
- The N65 is defined as the number of aircraft noise events where the L_{Amax} exceeds 65dBA over the 16 hour day period between 7am and 11pm.

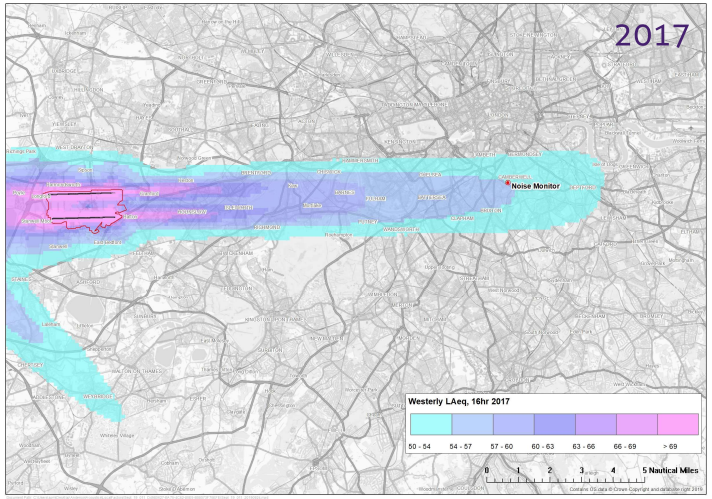
- Larger figures are shown in Appendix A.

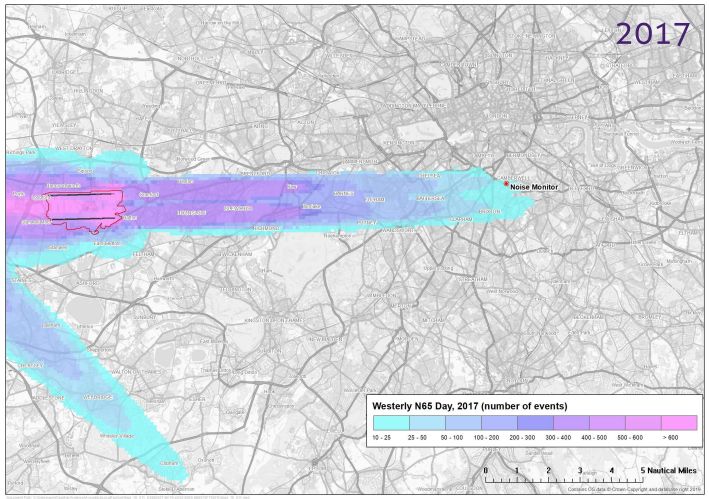
$L_{Aeq,16hr}$

N65, Daytime





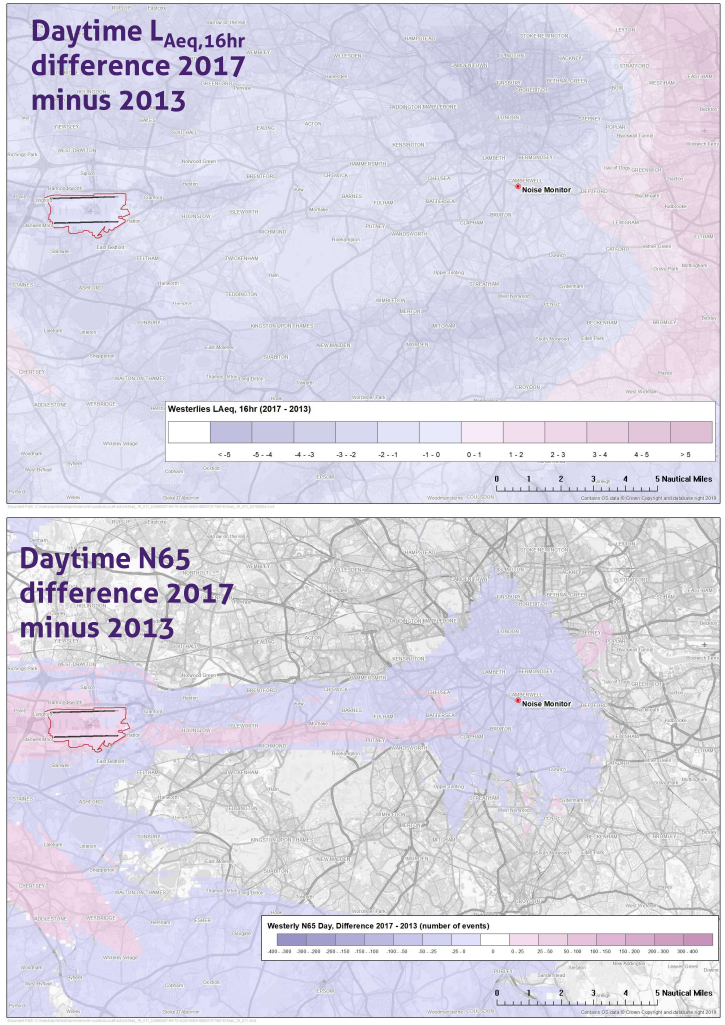




Differences in average **daytime** aircraft noise levels – westerly operations

- The difference in the modelled average $L_{Aeq,\ 16hr}$ and $N65_{16\ hr}$ contours around Heathrow between 2013 and 2017 are shown in the figures to the right. This is for **an average westerly summer day when the airport is on 100% westerly operations**
- The upper image shows the change in daytime $L_{Aeq,16hr}$ and the bottom image shows the change in daytime $N65_{16hr}$. Areas with a decrease in average exposure are shown in blue and those areas with an increase in average exposure shown in pink.
- At Camberwell, there was up to a 1dB decrease in average modelled daytime noise level $L_{Aeq,16hr}$ between 2013 and 2017.
- The modelling also indicates a decrease of up to 25 daytime N65 events.
- It should be noted that, all other variables remaining constant, a difference in 15% of noise events, would correspond to about a 1dB increase/decrease in $L_{Aeq,16hr}$ and a 100% increase would correspond to about a 3dB increase/decrease in $L_{Aeq,16hr}$.

- Larger figures are shown in Appendix A.



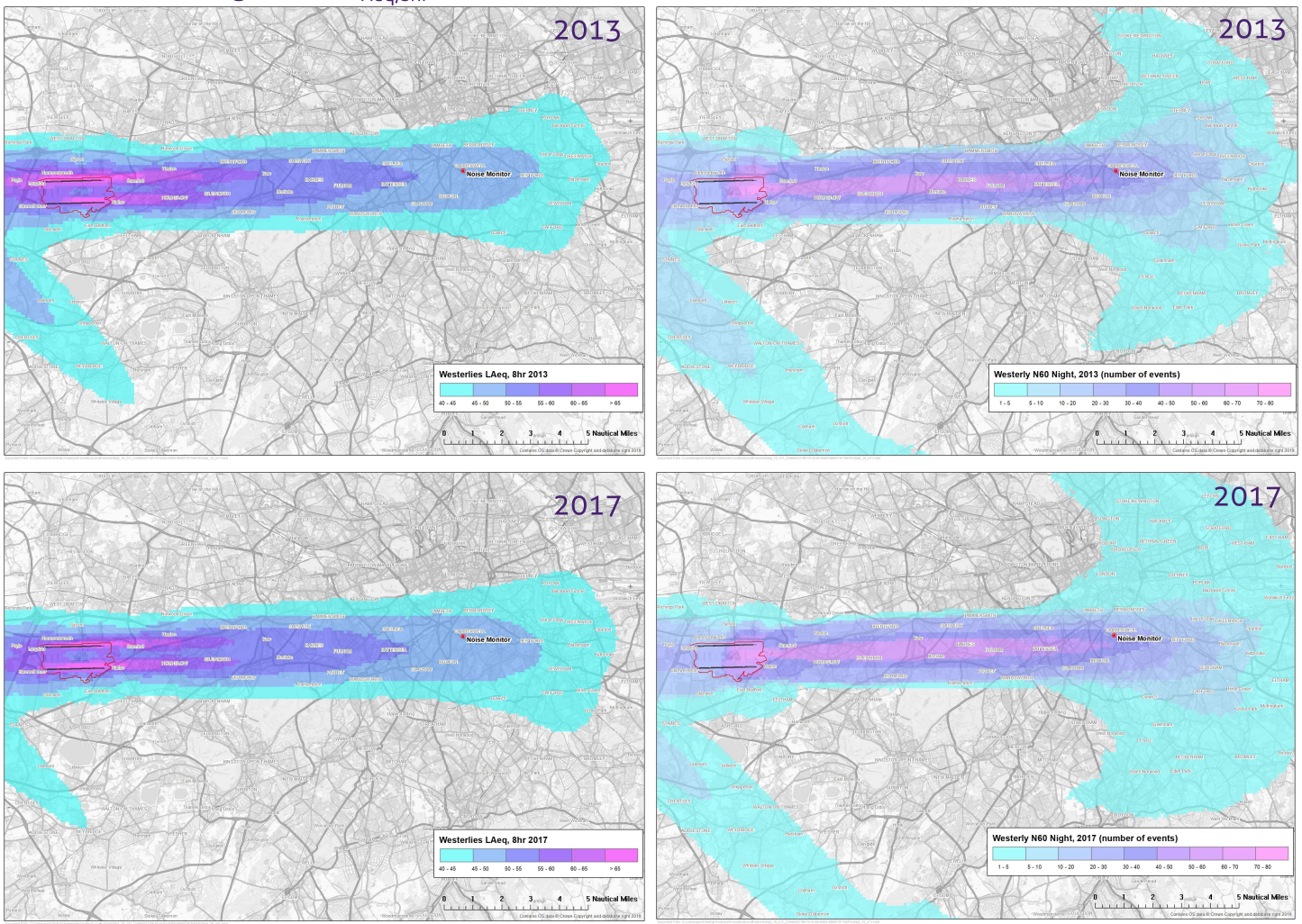
Average **night-time** aircraft noise levels – westerly operations

- The figures to the right show the 2013 and 2017 night-time $L_{Aeq, 8hr}$ bands in the left column and N60 bands in the right column. This is an average noise level on an average westerly summer night between 11pm and 7am when there are 100% westerly operations. Generated from **an average westerly summer day when the airport is on 100% westerly operations**
- The $L_{Aeq,8hr}$ contours are presented in 5dB intervals from >40 to > 65dB.
- The N60 is defined here as the number of aircraft noise events that exceed 60dBA over the 8 hour night period between 11pm and 7am.
- The figures to the right shows the average $N60_{8hr}$ values for 2013 and 2017 from 1 up to greater than 80 when the airport is on westerly operations.

- Larger figures are shown in Appendix A.

Night-time $L_{Aeq,8hr}$

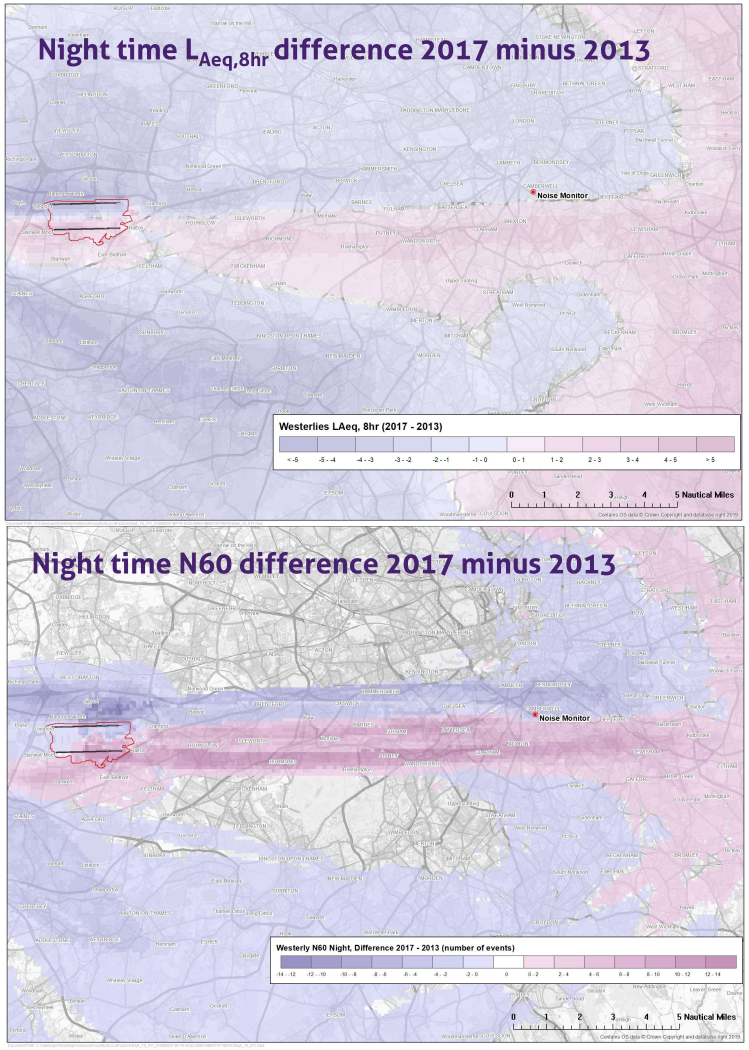
N60, night-time



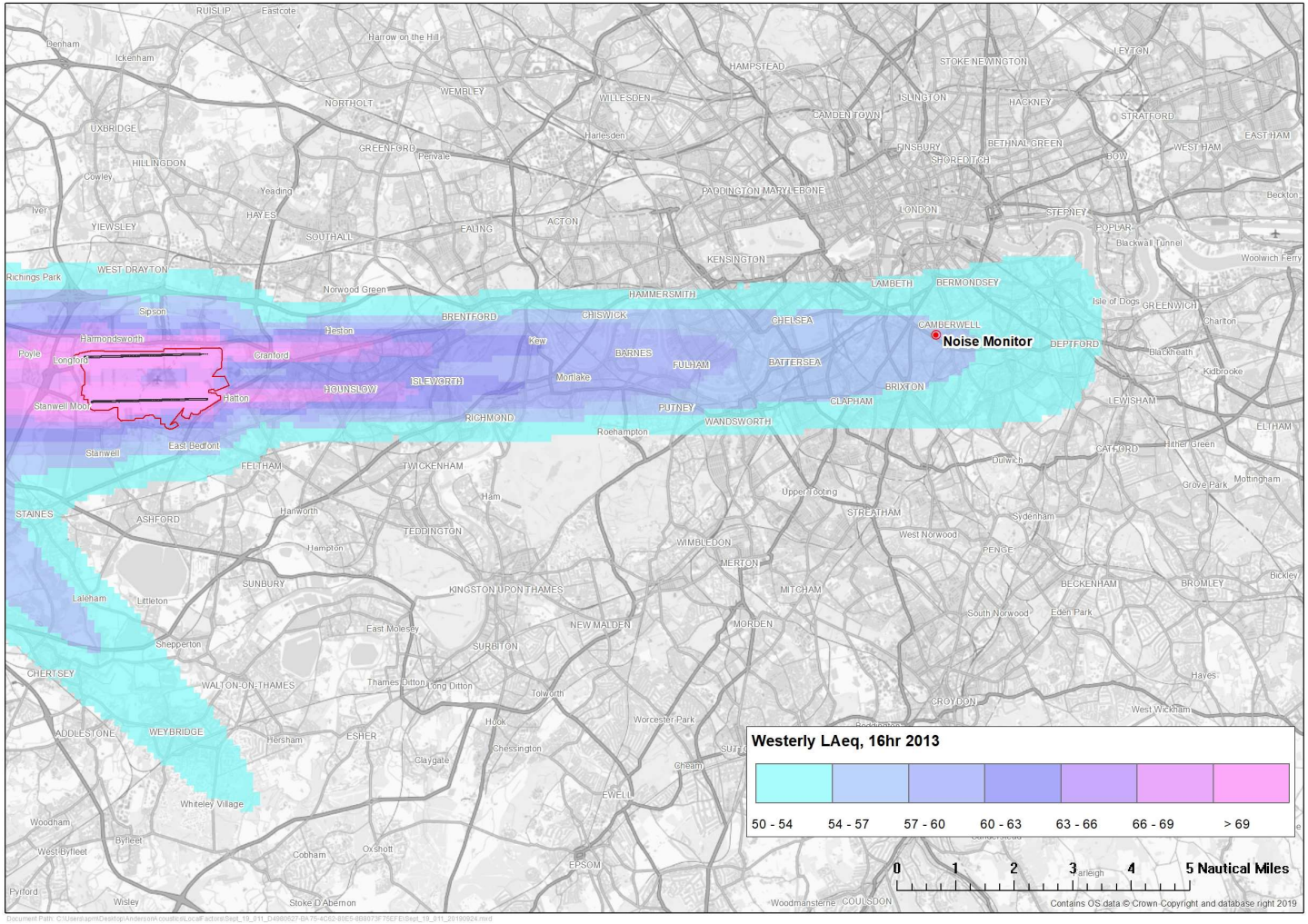
Differences in average **night-time** aircraft noise levels – westerly operations

- The difference in the modelled average $L_{Aeq, 8hr}$ (upper figure) and $N60_{(8\ hr)}$ (lower figure) values **on 100% westerly operations** around Heathrow between 2013 and 2017 are shown in the figures to the right.
- Areas with an average decrease are shown in blue and those areas with an average increase in pink.
- The results indicate an decrease in average night-time aircraft noise $L_{Aeq,8hr}$ decreased by less than one decibel and the N60 decreased by up to 2 at Camberwell from 2013 to 2017.

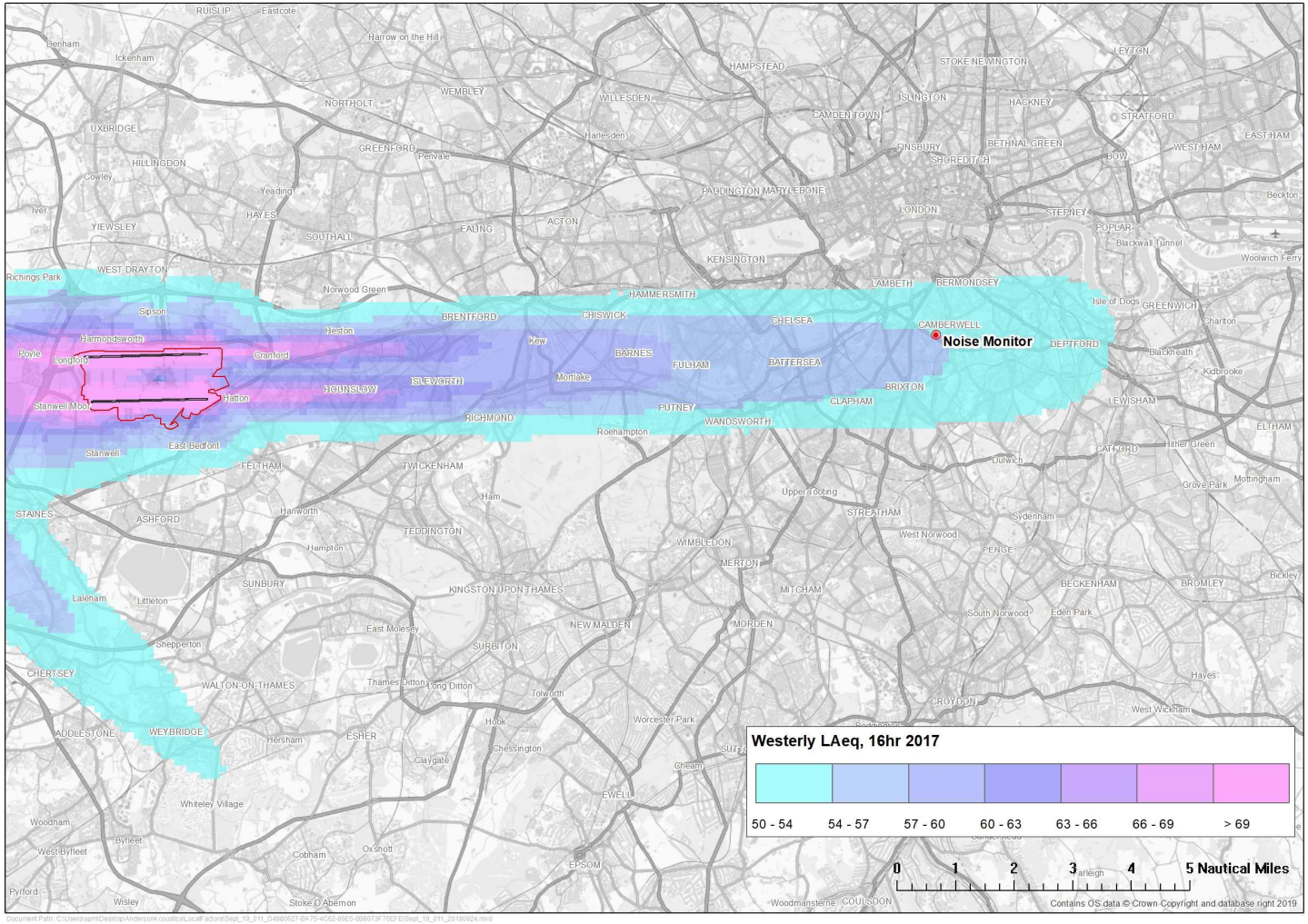
- Larger figures are shown in Appendix A.



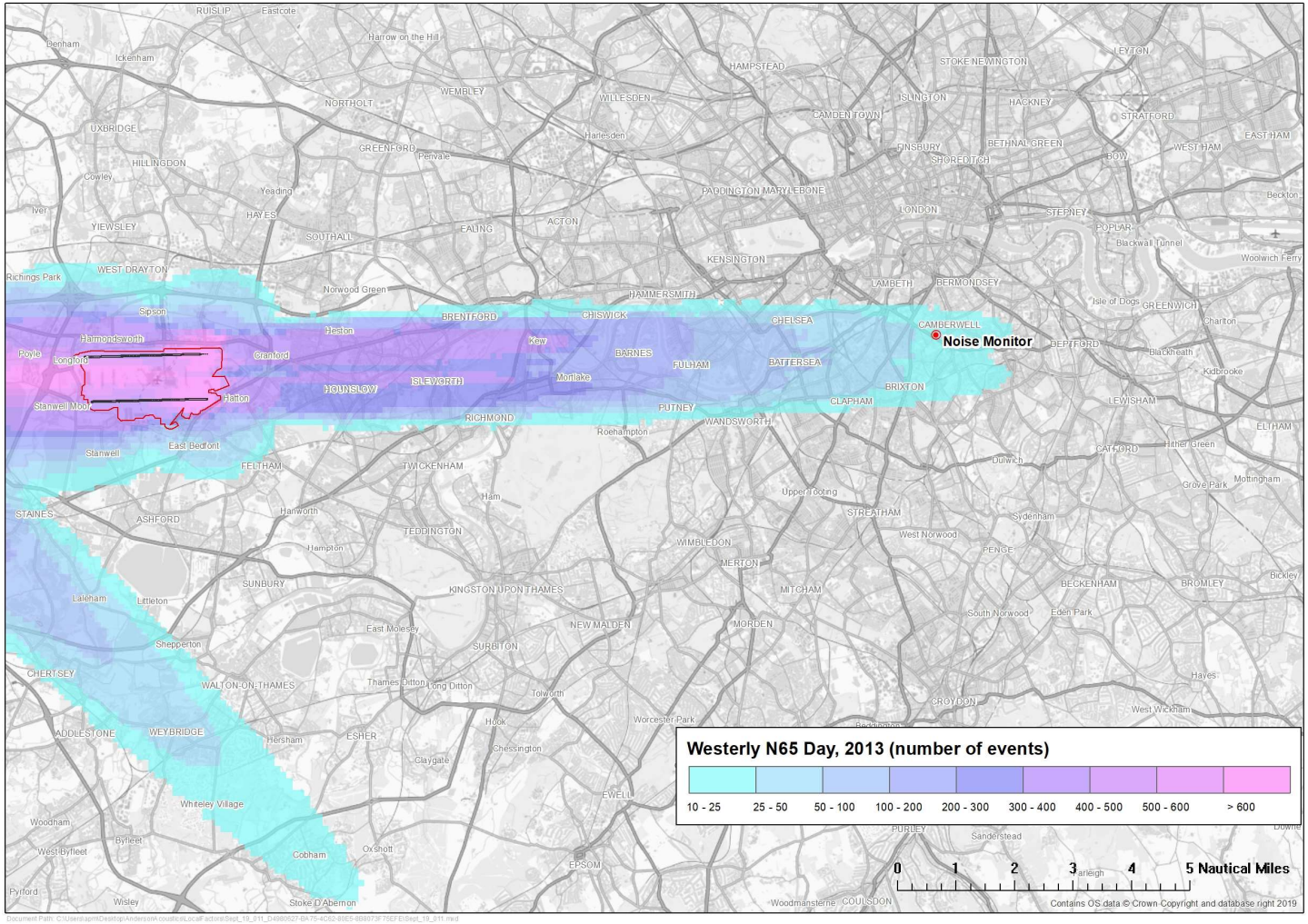
Appendix A: Average westerly day $L_{Aeq, 16hr}$ contours (2013)



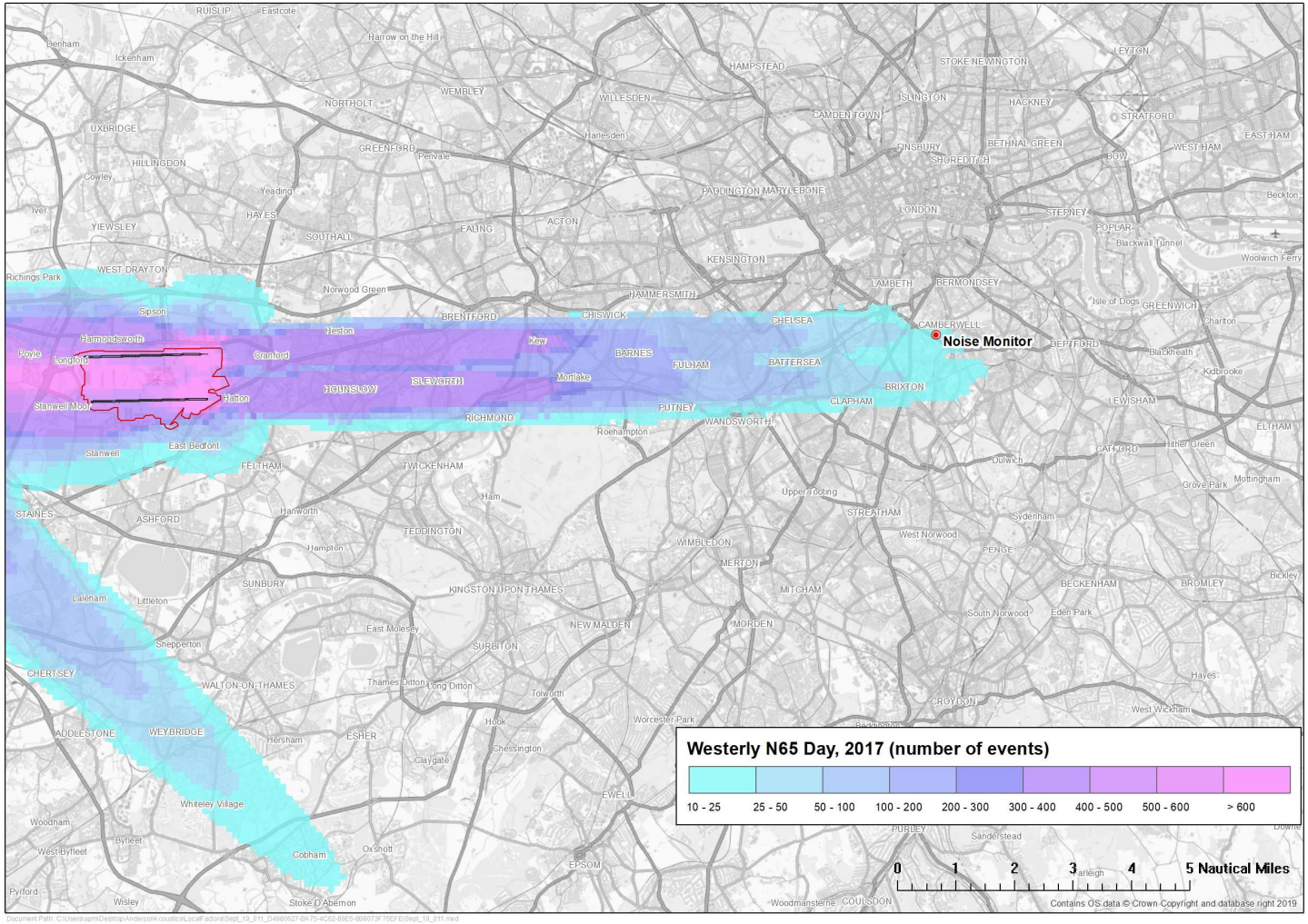
Appendix A: Average westerly day $L_{Aeq, 16hr}$ contours (2017)



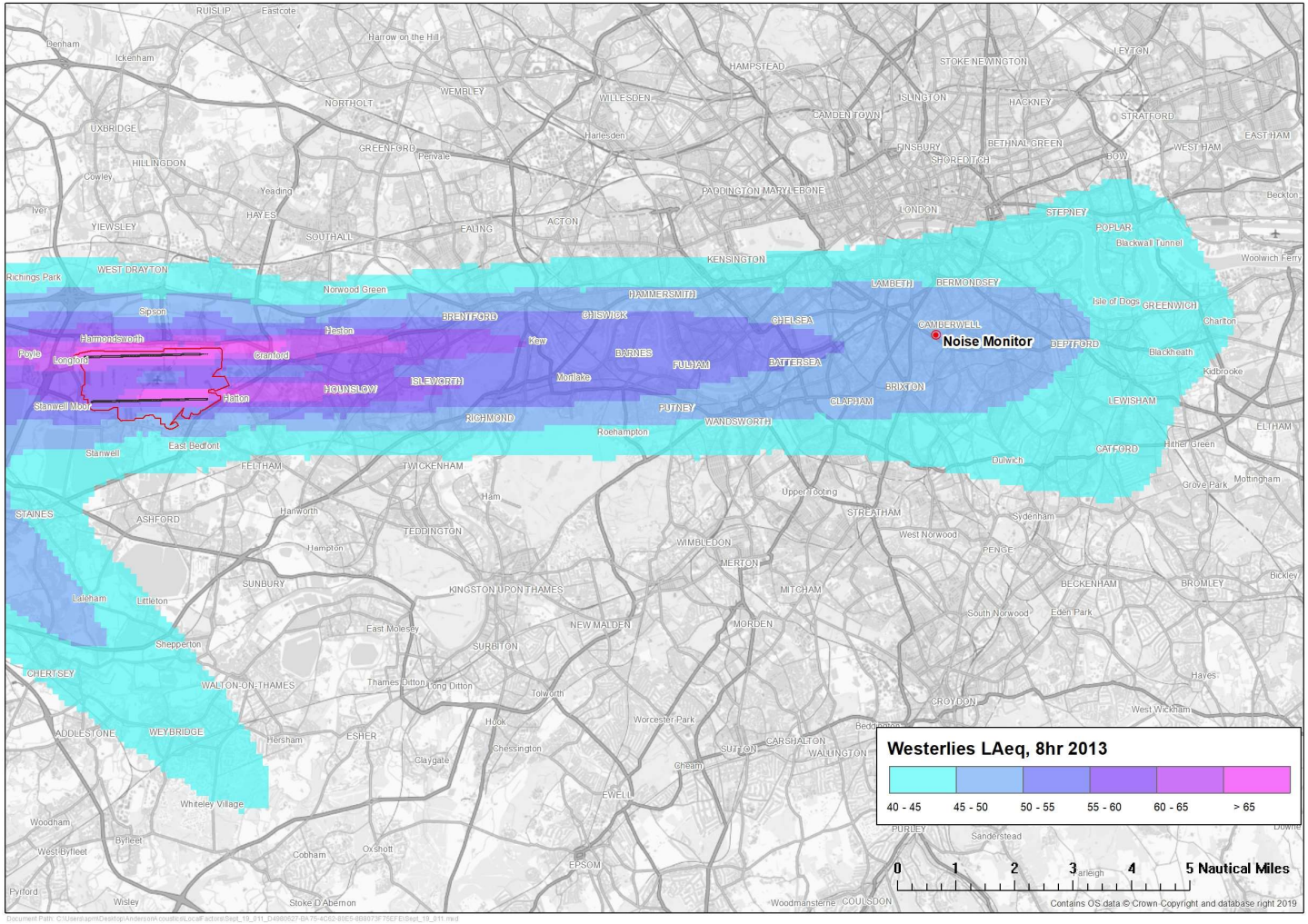
Appendix A: Average westerly day $N65_{16hr}$ contours (2013)



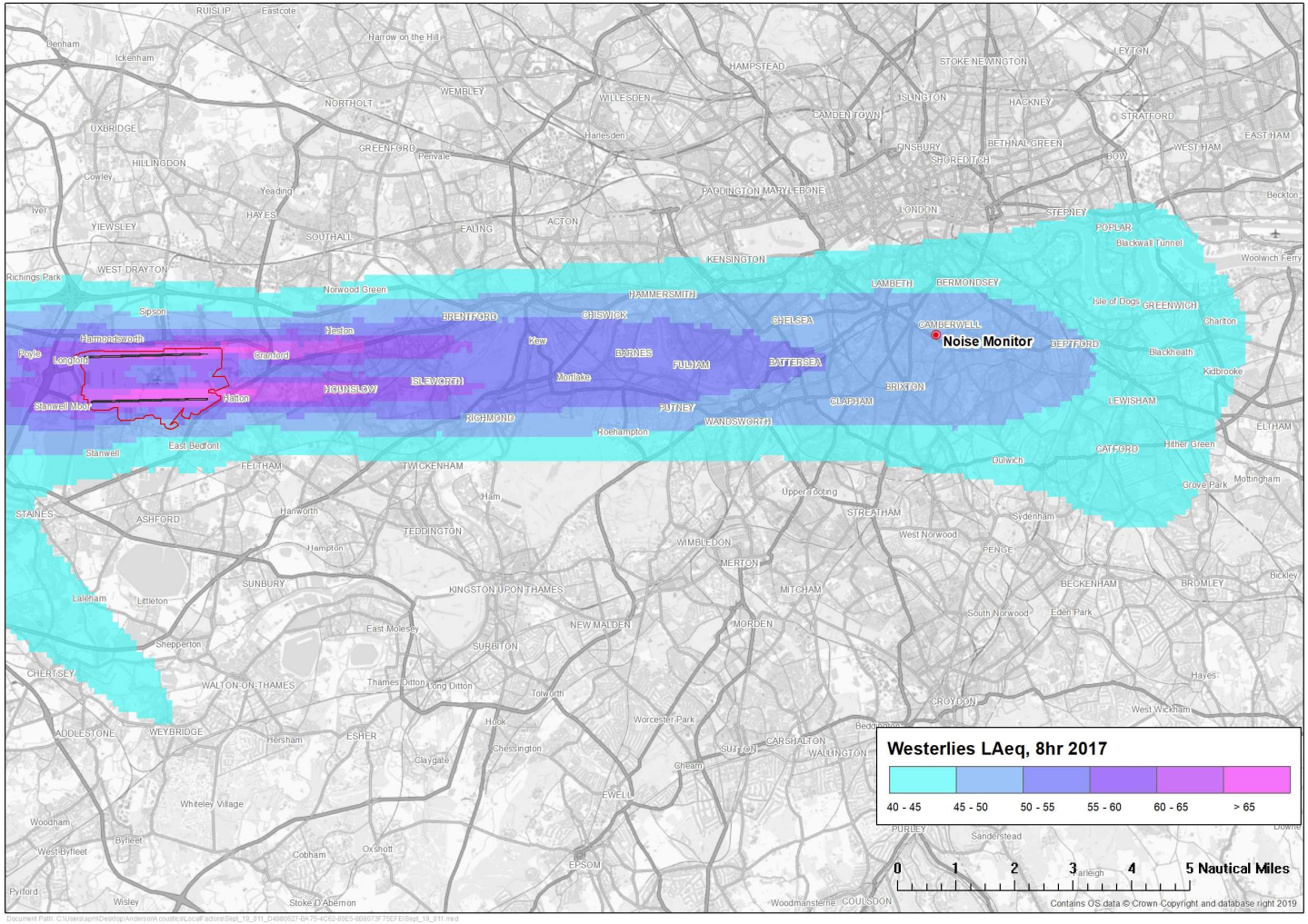
Appendix A: Average westerly day $N65_{16hr}$ contours (2017)



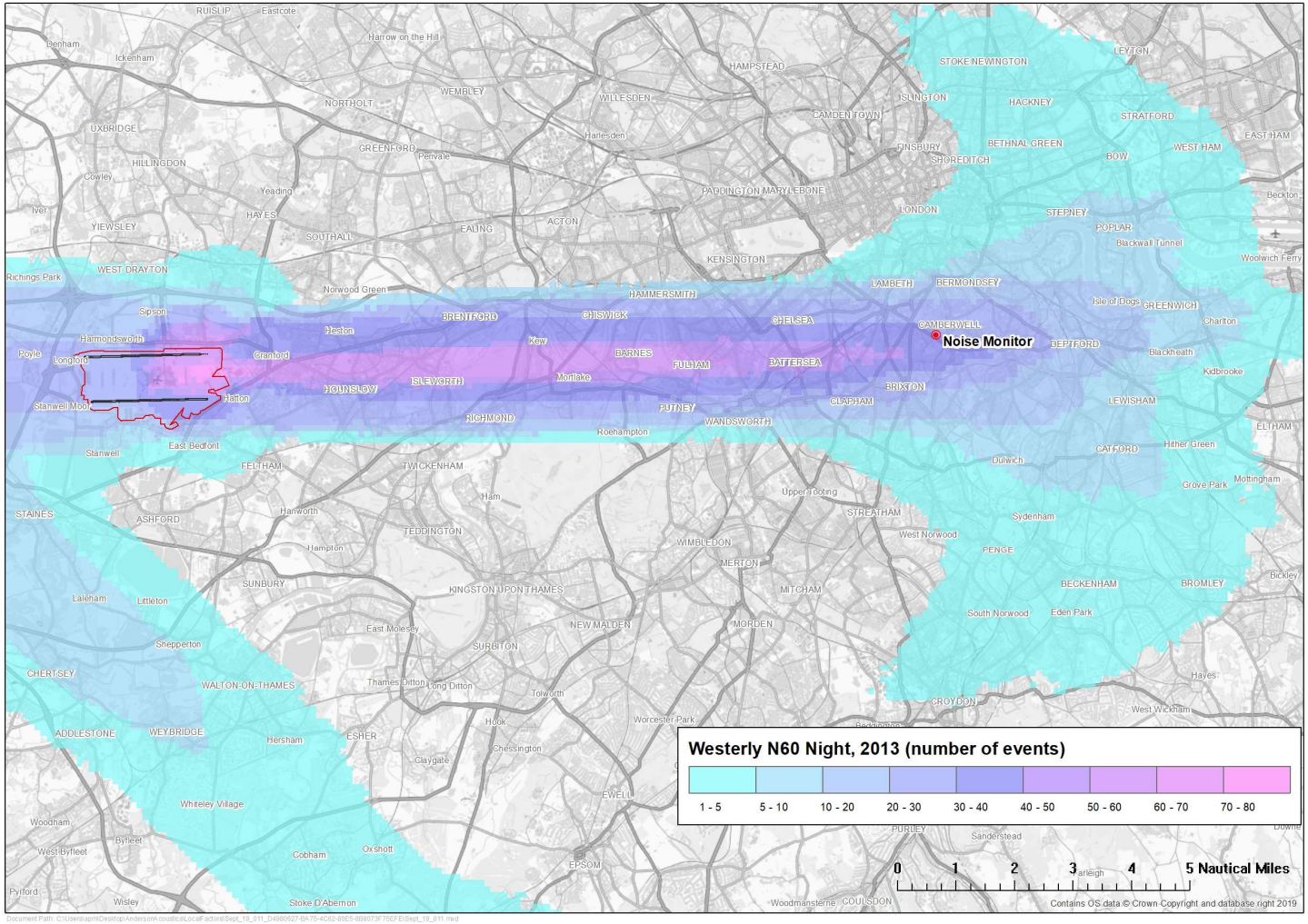
Appendix A: Average westerly night $L_{Aeq, 8hr}$ contours (2013)



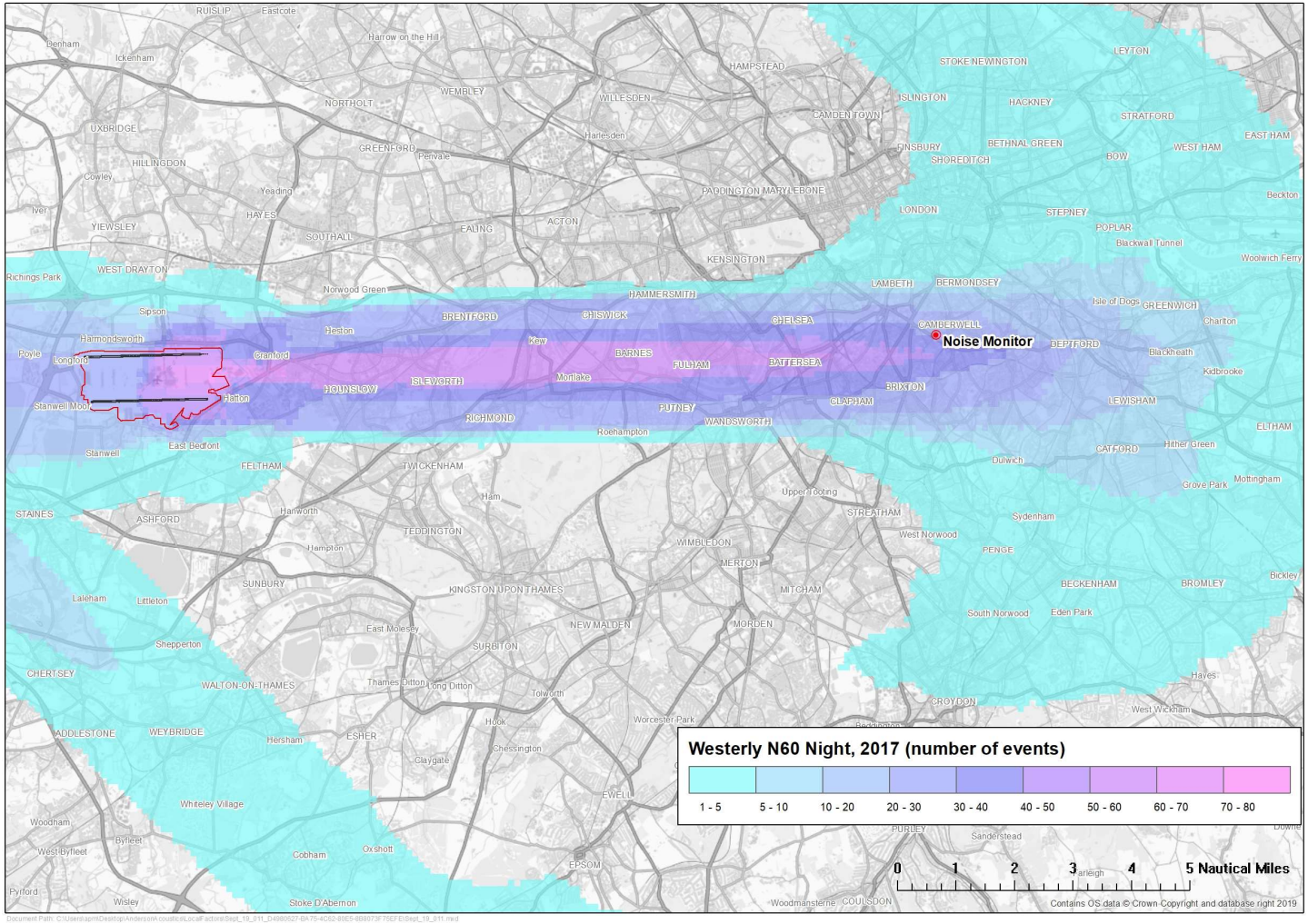
Appendix A: Average westerly night $L_{Aeq, 8hr}$ contours (2017)



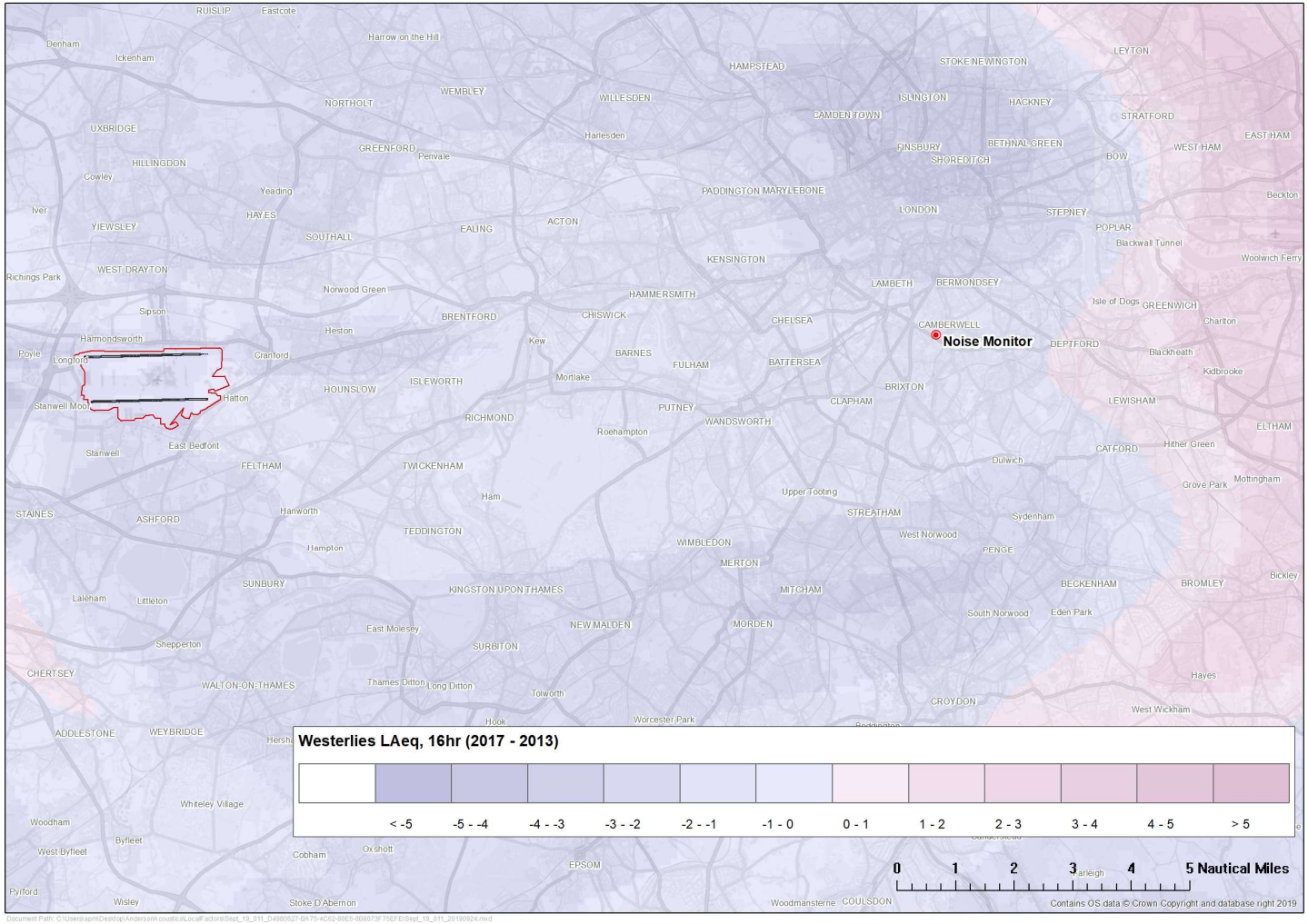
Appendix A: Average westerly night $N60_{8hr}$ contours (2013)



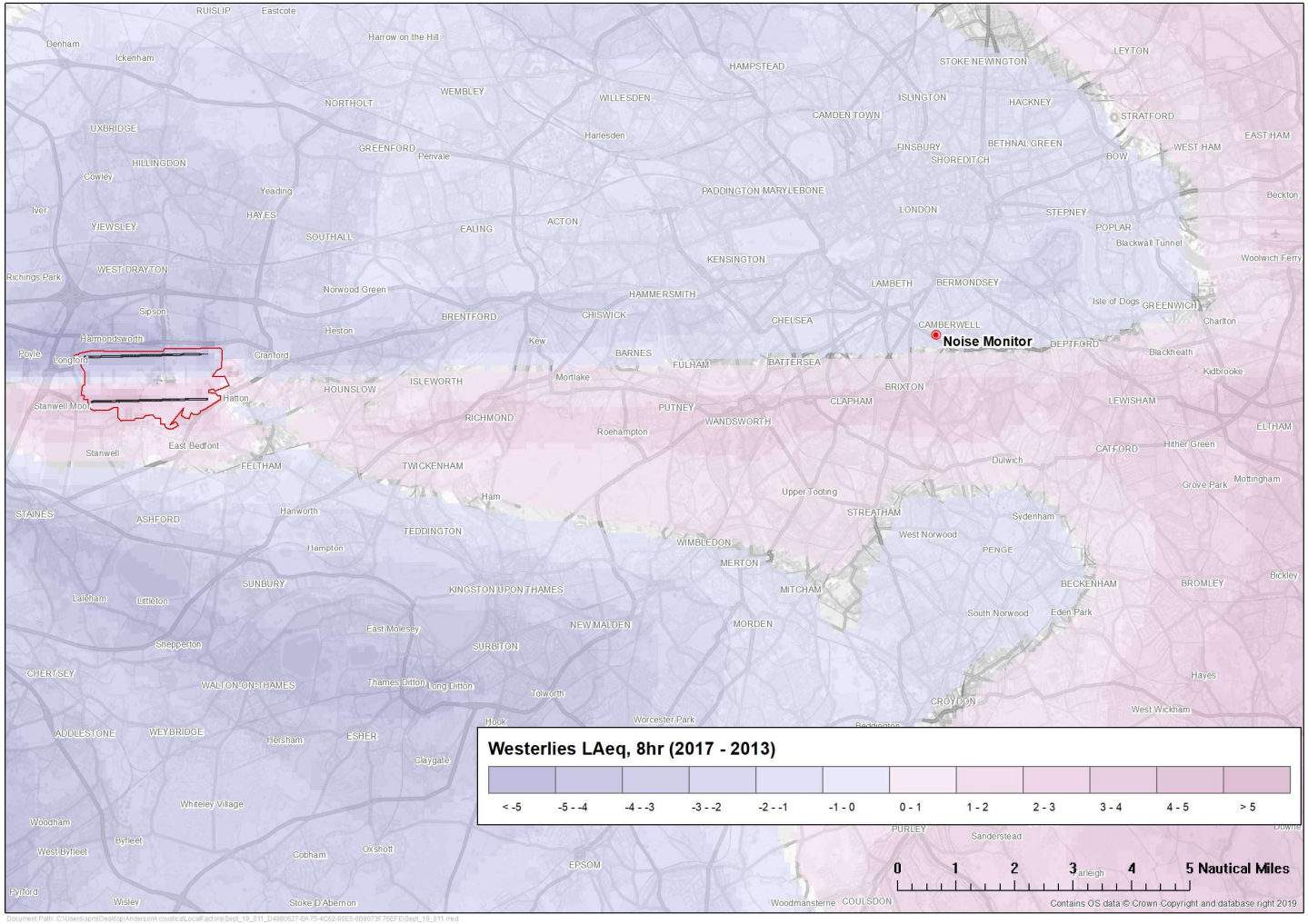
Appendix A: Average westerly night $N60_{8hr}$ contours (2017)



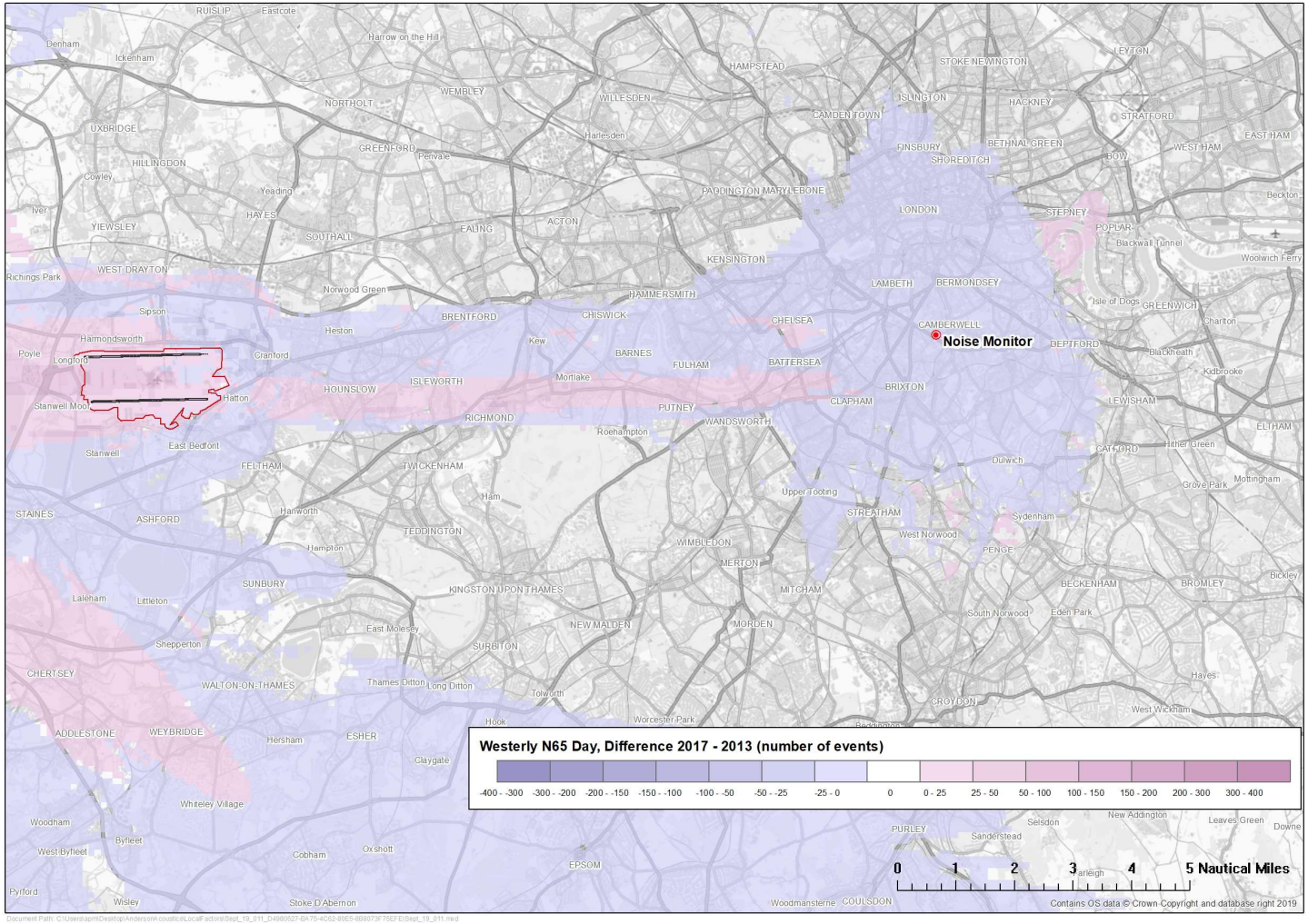
Appendix A: Average westerly day $L_{Aeq, 16hr}$ difference (2017 minus 2013)



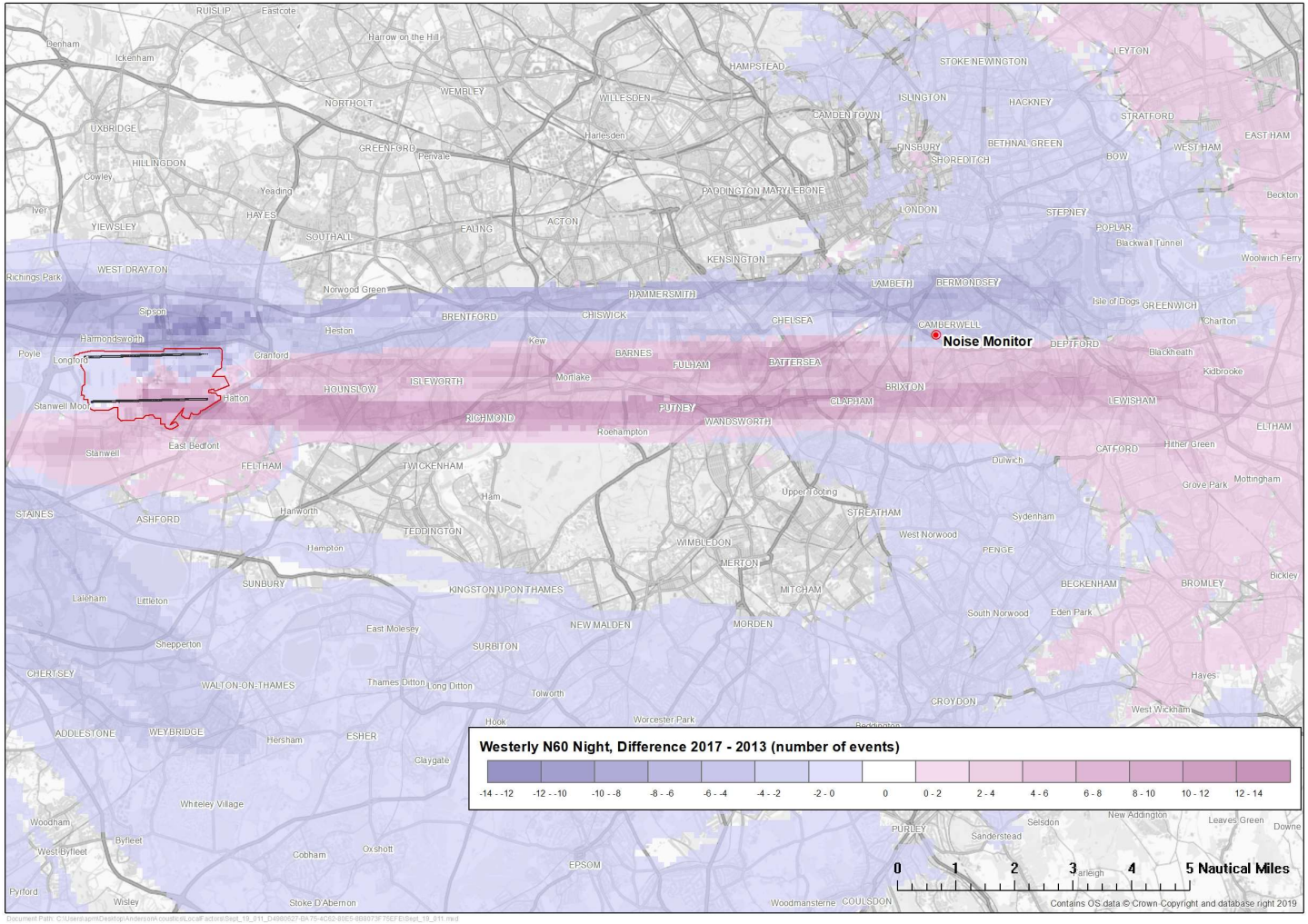
Appendix A: Average westerly night $L_{Aeq, 8hr}$ difference (2017 minus 2013)



Appendix A: Average westerly day $N65_{16hr}$ difference (2017 minus 2013)



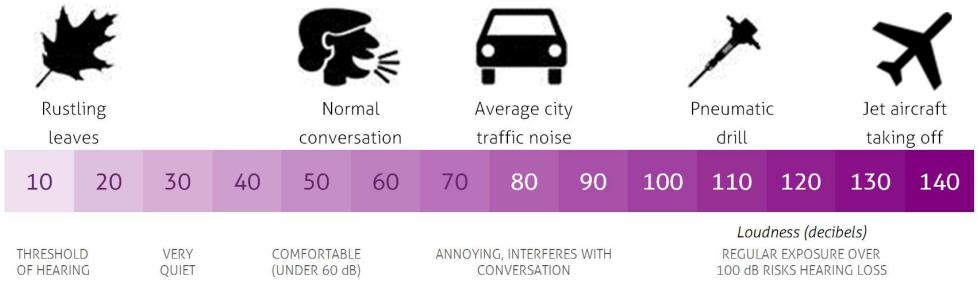
Appendix A: Average westerly night $N60_{8hr}$ difference (2017 minus 2013)



Appendix A: Noise Terminology

How is noise measured?

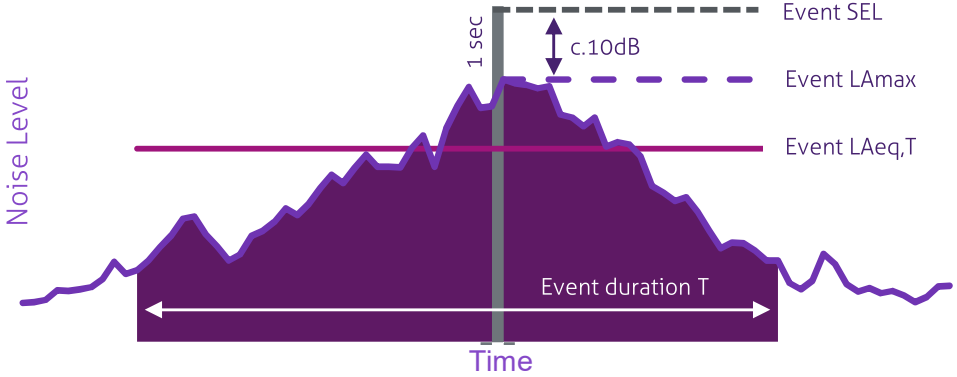
There is a million to one ratio between the threshold of hearing and the highest tolerable sound pressure. Noise is therefore measured using a logarithmic scale, to account for this wide range, called the decibel (dB). Typical noise levels of everyday sounds are shown in the figure below.



The human ear is capable of detecting sound over a range of frequencies from around 20 Hz to 20 kHz, however its response varies depending on the frequency and is most sensitive to sounds in the mid frequency range of 1 kHz to 5 kHz. Instrumentation used to measure noise is therefore weighted across the frequency bands to represent the sensitivity of the ear. This is called 'A weighting' and is represented as dB(A). All units in this report use this A-weighting.

How is aircraft noise measured?

As an aircraft passes over a location, noise levels slowly increase from ambient levels, reach a maximum and decrease back down to ambient levels. An example flyover is shown below.



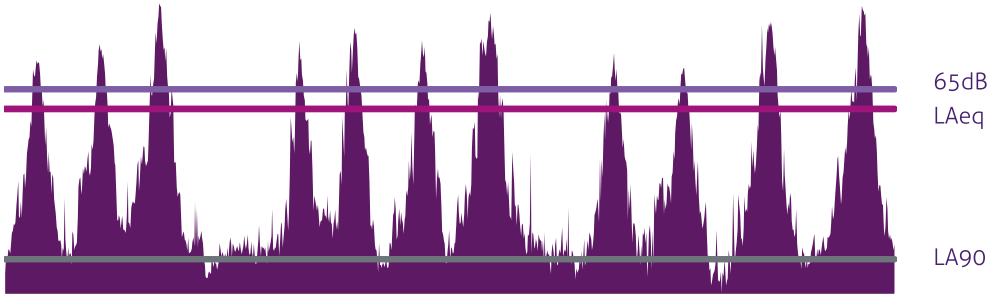
There are a number of metrics that can then be used to characterise a noise event all of which can be derived from modelling:

- The L_{Amax} is the highest sound pressure level during the event, it is an instant value, this is used typically with noise limits;
- The $L_{Aeq,t}$ is the continuous sound pressure level that would generate the same energy as that of the fluctuating noise level during the event of period T. It is in effect the average noise level over the time of the event;
- The SEL (sound exposure level or single event level), is the sound pressure that would arise for if all the energy of the event were to be delivered in 1 second.

Appendix A: Noise Terminology

How is long term noise exposure measured?

The L_{Amax} and SEL are useful at describing the noise level of individual events but how is aircraft noise exposure measured over time? The standard approach is based on long term averages such as the L_{Aeq} in the UK. The L_{Aeq} for a period of aircraft overflights is demonstrated in the figure below.



Although the L_{Aeq} plays a role in policy and planning assessment it does not adequately describe community experience. Supplementary noise metrics have been developed to better reflect community experience in simpler language. For example, the N65 describes the number of events which exceed 65dB which, in the above example, would be 11 over the period displayed.

The L_{A90} is a useful indicator of background noise in the absence of aircraft or other distinctive noise events. The L_{A90} is defined as the noise level which is exceeded for more 90% of monitored period and is demonstrated by the grey line in the figure above.

How does noise vary with distance?

As we move away from a sound source, the level we hear reduces since the sound energy is spread over a larger and larger area. If we assume a source emits sound equally in all directions, we can generate some rules regarding sound levels at different distances. For example, if the distance between a source and the receiver is doubled, the sound level will reduce by 6dB or if it is increase by a factor of 10 the level will reduce by 20dB.

Ratio of Distances	Level difference
1	0dB
1.25	2dB
1.5	3.5dB
2	6dB
5	14dB
10	20dB

Appendix A: Noise Terminology

How is noise level related to loudness?

Loudness is a subjective measure that describes the perceived strength of a sound. It is related to sound level but also related to other parameters such as frequency and duration. The table below provides an indication of the how the perceived loudness of a sound changes with an increase or decrease in sound level. For example, an increase of 10dB corresponds to a doubling of perceived loudness. It should be noted that the table below should only act as a guide to the relationship between level and perceived loudness – since loudness is a subjective measure, the same sound will not create the same loudness perception by all individuals

Level difference (dB)	Loudness Perception
+20dB	x 4
+10dB	x 2
+6dB	x 1.5
+3dB	x 1.2
±0dB	0
-3dB	÷ 1.2
-6dB	÷ 1.5
-10dB	÷ 2
-20dB	÷ 4

How does average noise level relate to number of events?

Average noise levels are determined by not only the level of individual aircraft events but also the frequency of which they occur. Due to the logarithmic nature in which noise is measured, a doubling of noise energy relates to a 3dB increase in average noise level. Therefore, if the number of events is doubled over a given time period (assuming the levels of the events are the same), the $L_{Aeq, T}$ will increase by 3dB. Further factors are shown in the table below.

Number of Events	Noise level difference
x4	+6dB
x2	+3dB
0	0
÷2	-3dB
÷4	-6dB