ARUP

British Land

1 Triton Square Life Sciences Fit-out

Planning plant noise emissions

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Ove Arup & Partners Limited
Parkin House
8 St. Thomas Street
Hampshire SO23 9HE
United Kingdom
arup.com

ARUP

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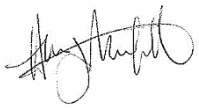
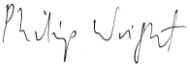
		Name	Ryan Van Wensveen MSc AMIOA	Harry Murfet BEng MSc CEng MIOA	Philip Wright PhD CEng MIOA
		Signature			
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Contents

Appendices

1. Introduction

This report sets out the planning noise emissions limits for the 1 Triton Square Life Sciences fit out. Plant noise emissions will be designed to comply with the overall emissions limits set out in condition 10 of the Full Planning permission ref 2016/6069/P dated 21 November 2017.

The original planning documentation set out noise limits for specific tenant plant areas. However, these limits are no longer considered applicable following subsequent updates to base build plant selections and proposals to add further fit-out plant outside of the original tenant plant areas.

Revised noise emissions limits for fit-out plant are defined in this report which ensure compliance with the overall noise emissions limits defined in condition 10 for the development. Predicted noise emissions from base build plant at the nearest noise sensitive properties have been updated based on noise data for the installed plant. On this basis the subsequent remaining allowable limits for the new fit-out plant are defined. The new major external fit-out plant items are identified and guidance limiting powers provided.

A glossary of acoustics terminology is provided in Appendix A.

2. Noise emissions limits

Plant noise emissions from new external plant will be designed to meet the planning noise emissions limits set in Arup base build planning report *Triton Square - Noise report for planning*[1] (Appendix B) when considered cumulatively with noise emissions from the base build plant.

Triton Square - Noise report for planning formed a part of the planning submission for the 1 Triton Square base build refurbishment. This document sets out the details of environmental noise surveys conducted as a basis for the plant noise limits which were established in accordance with London Borough of Camden (LBC) requirements. The document also defines the nearest noise sensitive receptors (NSR) as shown in Figure 1.

The original tenant plant noise limits set out in *Triton Square - Noise report for planning* are no longer considered applicable following updates to base build plant selections post planning submission, and considering additional proposed fit-out plant locations including the fume extract chimneys on core 2 and core 3 and the additional façade louvres on second, third, fourth and fifth floors. Section 3 sets out updated base build noise emissions predictions in line with final base build plant selections. Section 4 provides revised noise limits for new plant specific to the Life Sciences fit-out proposals.

[1] Arup, R02 Triton Square - Noise report for planning, December 2016

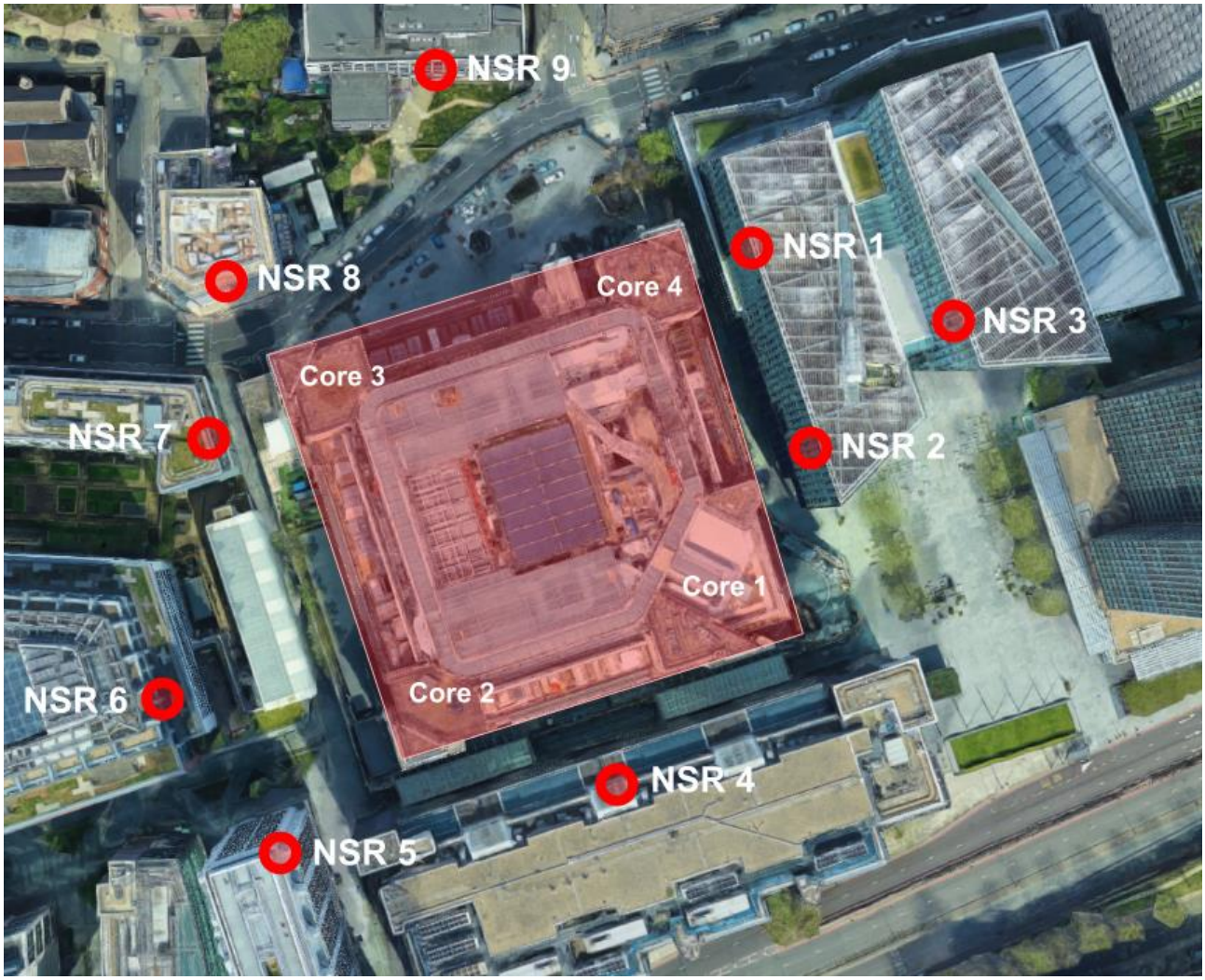

Figure 1 **Noise sensitive receptors**

Table 1 sets out the cumulative noise emission limits for the development at the nearest NSRs.

Table 1 Plant noise emission limits at nearby locations

Noise sensitive receptors	Building services noise emission limit at 1m external to sensitive façade, $dBL_{Ar, Tr}$		
	Type of noise	Weekday daytime (7am – 7pm)	Other times
Adjacent properties to the west, south and east (NSR 1-7)	Noise from plant	48	46
	Noise from plant that has a distinguishable continuous note or distinct impulses	43	41
	Noise from life safety and communications plant	54	54
Adjacent properties to the north (NSR 8 and 9)	Noise from plant	40	38
	Noise from plant that has a distinguishable continuous note or distinct impulses	40	38
	Noise from life safety and communications plant	47	47

Noise sensitive receptors	Building services noise emission limit at 1m external to sensitive façade, $dBL_{Ar, Tr}$		
	Type of noise	Weekday daytime (7am – 7pm)	Other times
Publicly accessible locations	Noise from plant	55	
	Noise from plant that has a distinguishable continuous note or distinct impulses	50	

3. Base build plant

Appendix C sets out the noise data for the installed external base build plant items. Locations of base build plant are shown in Figure 2. Based on the plant noise levels and locations, a 3D noise model has been built in SoundPlan software to determine the noise emissions from the base build plant and establish limiting noise levels for new fit-out plant items. SoundPlan uses sound propagation calculation methodology in accordance with the guidance set out in *ISO 9613-2:1996 Acoustics - Attenuation of sound during propagation outdoors Part 2: General method* and *BS 4142:2014+A1:2019 Methods for rating and assessing industrial and commercial sound.*

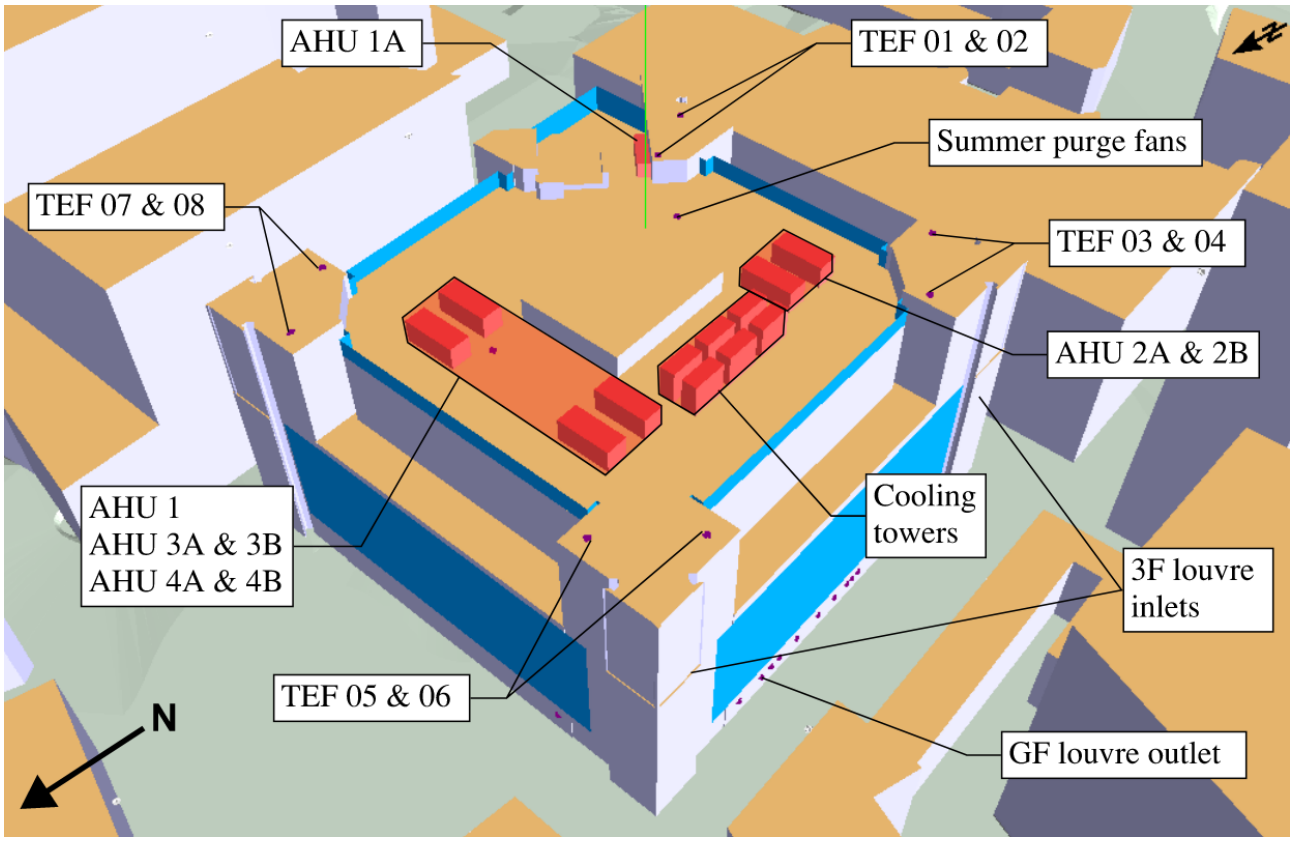

Figure 2 **Base build plant locations**

Table 2 sets out the predicted base build noise emissions at each NSR. Table 2 also sets out the effective noise emissions limits for fit-out plant such that cumulative planning plant noise emissions limits are met. This assessment is also based on onsite observations that the base build plant is free from distinguishable tones or distinct impulses.

Table 2 **Predicted base build noise emissions at each NSR and remaining consequent limits for fit-out plant**

NSR	Predicted noise emissions from base build plant, $L_{Aeq,T}$ (dB)	Resultant noise emissions limit for fit-out plant, $L_{Aeq,T}$ (dB)*	
		Weekday daytime (0700-1900)	Other times
1	35	48	46
2	37	48	45
3	36	48	45
4	30	48	46
5	41	47	44
6	36	48	46
7	38	48	45
8	34	39	36
9	30	40	37

* Limits are 5dB lower if plant has a distinguishable continuous note or distinct impulses

4. New plant noise emissions

Figure 3 shows the proposed external plant associated with the Life Sciences fit-out.

Two of the four fume extract fans and the AHUs will need to run 24 hours per day and seven days per week. Air Source Heat Pumps (ASHP) will be run on lower loads outside of typical weekday working hours when building occupancy is lower. Guidance sound power limits have been set accordingly based on reduced ASHP loads and noise emissions outside of typical working hours.

Based on the noise emissions limits set in Table 2 and results of the 3D modelling of new plant items, Table 3 sets out guidance limiting sound powers for the external plant associated with the fit-out. Limits are provided at louvres for future tenant fit-out of AHUs on floors 4 and 5, and for one further ASHP associated with potential future decarbonisation strategy. Further major plant items are not anticipated for tenant future fit-out of floors 4 to 7.

Based on initial plant selections the following attenuation is required:

- Specialist attenuators for fume extract fans
- Attenuation packages for ASHPs
- Ducted attenuators for on floor AHUs (levels 2 to 5)

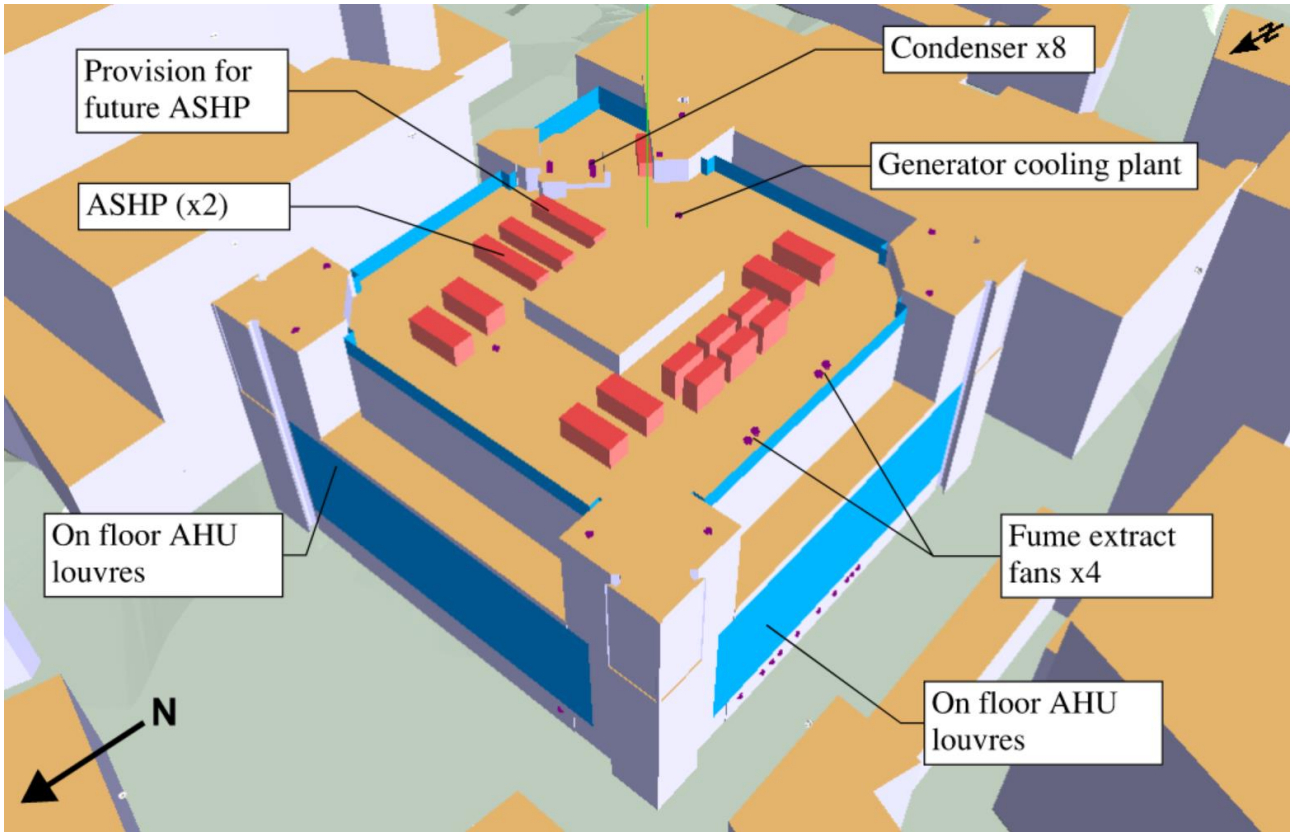

Figure 3 **Proposed external plant associated with the Life Sciences Fit-out**

Table 3 Guidance sound power limits for external plant associated with the life sciences fit-out of floors 1 to 3

External plant item	Sound power limit per item (dBA re 10^{-12} W)*
Fume extract fans	78
Air Source Heat Pumps (ASHP)	83
Condensers	75
On floor AHU louvres (level 2 to 5)	63
Generator rooftop cooling plant	73

* Limits are based on cumulative noise emissions being free from distinguishable continuous note or distinct impulses. Spectral data for early plant selections indicates this is likely the case, however if noise from selections is found to contain distinguishable continuous notes or distinct impulses they will be designed to meet the relevant lower limits set out in Table 1.

An emergency business continuity generator is located in the basement sharing inlet and outlet louvres at GF level with the base build generator. To meet the planning noise emissions limits, noise from louvres must be controlled to meet 55dBA at 3m.

Table 4 shows the predicted noise emissions with base build and fit-out plant running assuming all plant running at full load including fit-out plant with limiting sound powers as provided in Table 3. The noise emissions limits set out in Table 1 are met at all NSRs.

Table 4 Predicted cumulative noise emissions from base build and fit-out plant

NSR	Predicted noise emissions from base build and fit-out plant. $L_{Aeq,T}$ (dB)*	
	Weekday daytime (0700-1900)	Other times*
1	45	40
2	47	41
3	45	40
4	37	36
5	45	44
6	42	42
7	44	44
8	36	36
9	33	33

* Reasonable worst case based on fume extract fans running at full load and with one of the three new ASHP running at full load.

5. Conclusion

Plant noise emissions from new external plant associated with the 1 Triton Square Life Sciences fit-out are being designed to meet the overall planning noise emissions limits set for the base build refurbishment. The original tenant plant noise limits set out in the base build planning documentation are no longer considered applicable due to updated base build plant selections and changes to tenant plant locations. Therefore, revised limits for the new Life Sciences fit-out plant have been defined based on the final base build plant selections and the fit-out external plant proposals.

New major external fit-out plant items have been identified and guidance limiting sound powers have been provided which ensure compliance with the overall plant noise emissions limits for the development. As the design progresses, noise from evolving plant selections will be modelled to confirm compliance with the overall planning noise limits as the design develops.

Appendix A

Acoustics Terminology

Acoustics Terminology

Decibel (dB)

The ratio of sound pressures which we can hear is a ratio of 10^6:1 (one million:one). For convenience, therefore, a logarithmic measurement scale is used. The resulting parameter is called the 'sound pressure level' (L_p) and the associated measurement unit is the decibel (dB). As the decibel is a logarithmic ratio, the laws of logarithmic addition and subtraction apply.

dB(A)

The unit used to define a weighted sound pressure level, which correlates well with the subjective response to sound. The 'A' weighting follows the frequency response of the human ear, which is less sensitive to low and very high frequencies than it is to those in the range 500 Hz to 4 kHz.
In some statistical descriptors the 'A' weighting forms part of a subscript, such as L_{A10}, L_{A90}, and L_{Aeq} for the 'A' weighted equivalent continuous noise level.

Equivalent continuous sound level, Leq

An index for assessment for overall noise exposure is the equivalent continuous sound level, L_{eq}. This is a notional steady level which would, over a given period of time, deliver the same sound energy as the actual time-varying sound over the same period. Hence fluctuating levels can be described in terms of a single figure level.

Frequency

Frequency is the rate of repetition of a sound wave. The subjective equivalent in music is pitch. The unit of frequency is the hertz (Hz), which is identical to cycles per second. A 1000 Hz is often denoted as 1 kHz, e.g. 2 kHz = 2000 Hz. Human hearing ranges approximately from 20 Hz to 20 kHz. For design purposes, the octave bands between 63 Hz to 8 kHz are generally used. The most commonly used frequency bands are octave bands, in which the mid frequency of each band is twice that of the band below it. For more detailed analysis, each octave band may be split into three one-third octave bands or in some cases, narrow frequency bands.

Sound pressure level

The sound power emitted by a source results in pressure fluctuations in the air, which are heard as sound. The sound pressure level (L_p) is 10 times the logarithm of the ratio of the measured sound pressure (detected by a microphone) to the reference level of 2×10^{-5} Pa (the threshold of hearing).
Thus L_p (dB) = $10 \log (P_1/P_{ref})^2$ where P_{ref}, the lowest pressure detectable by the ear, is 0.00002 Pascals (i.e. 2×10^{-5} Pa).
The threshold of hearing is 0 dB, while the threshold of pain is approximately 120 dB. Normal speech is approximately 60 dB(A) or more and a change of 3 dB is only just detectable. A change of 10 dB is subjectively twice, or half, as loud.

Statistical noise levels

For levels of noise that vary widely with time, for example road traffic noise, it is necessary to employ an index which allows for this variation. The L_{10}, the level exceeded for 10% of the time period under consideration and can be used for the assessment of road traffic noise (note that L_{Aeq} is used in BS 8233 for assessing traffic noise). The L_{90}, the level exceeded for 90% of the time, has been adopted to represent the background noise level. The L_1, the level exceeded for 1% of the time, is representative of the maximum levels recorded during the sample period. A weighted statistical noise levels are denoted L_{A10}, dB L_{A90} etc. The reference time period (T) is normally included, e.g. dB $L_{A10,\ 5min}$ or dB $L_{A90,\ 8hr}$.

Appendix B

Triton Square - Noise report for planning

British Land Co PLC

Triton Square

Noise report for planning

R02

Issue | 7 December 2016

Job number 246868-13

Ove Arup & Partners Ltd
13 Fitzroy Street
London
W1T 4BQ
United Kingdom
www.arup.com

ARUP

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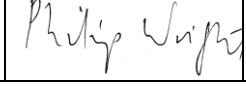
		Signature			
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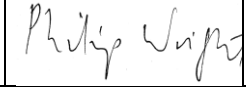
		Signature			
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Contents

Appendices

Ove Arup & Partners (Arup) have been appointed by British Land to provide acoustic design consultancy services for the proposed refurbishment and new-build project at Triton Square, London.

London Borough of Camden (LBC) require a noise assessment and report to support the planning application for the project. LBC require that the acoustic report should be prepared by a qualified acoustician outlining details of:

- The existing background noise levels measured over 24hrs.
- Proposed noise output.
- The measures proposed to reduce noise, fume emissions and vibration.
- Cumulative noise levels including all existing and proposed units.
- The method used to compile the report and examples of the calculations and assumptions made.
- The system manufacturer's specifications.

This report sets out this information. At the time of writing, the project has completed RIBA work stage 2.

1 Existing background noise

Arup undertook the following background noise measurements at locations shown in Figure 1:

- Attended measurements at pavement level around 1 Triton Square (Locations 1, 2, 3 and 4) on 5th May 2016.
- Unattended noise measurements at rooftop level of 1 Triton Square (Location A) between 1st April and 6th April 2016.
- Unattended noise measurements at rooftop level of St Annes (Location B) between 1st December and 6th December 2016.

Table 1 sets out the lowest background levels that were measured.

Sensitive location	**Lowest measured background levels ($L_{A90,5min}$), dB**		**Lowest measured ambient level ($L_{Aeq,5min}$), dB Daytime (7am – 7pm)**
	Weekday daytime (7am – 7pm)	**Other times**	
Adjacent properties to the west, south and east	53	51	54
Adjacent properties to the north	45	43	47
Publically accessible locations	55		59

Table 1 Lowest background levels measured

Appendix A provides more detail of these background noise measurements.

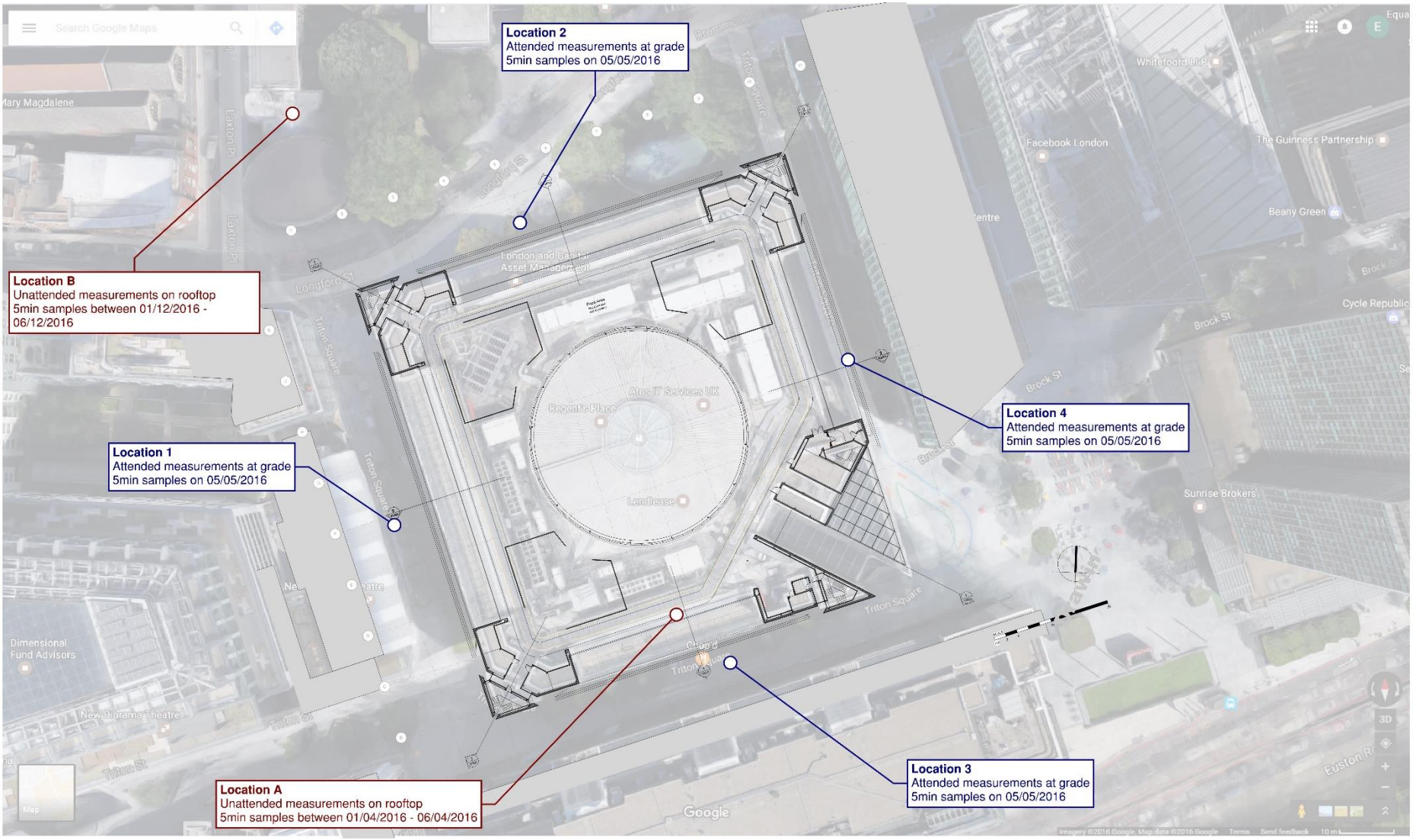

Figure 1 Noise measurement locations

2 Noise emission limits

External noise emissions will be controlled to meet Camden Council's requirements. These are set out in the council's development policy "DP28", an extract from which is shown below.

For non-tonal plant, noise emissions are to be at least 5dB below background noise levels at any time, at "sensitive" facades of nearby buildings. Elsewhere in the DP28 document it is stated that "noise sensitive development includes housing, schools and hospitals as well as offices, workshops and open spaces." Therefore the requirement can be considered in practice to apply to all of the adjacent buildings.

Table E: Noise levels from plant and machinery at which planning permission will not be granted

Noise description and location of measurement	Period	Time	Noise level
Noise at 1 metre external to a sensitive façade	Day, evening and night	0000-2400	5dB(A) <LA90
Noise that has a distinguishable discrete continuous note (whine, hiss, screech, hum) at 1 metre external to a sensitive façade.	Day, evening and night	0000-2400	10dB(A) <LA90
Noise that has distinct impulses (bangs, clicks, clatters, thumps) at 1 metre external to a sensitive façade.	Day, evening and night	0000-2400	10dB(A) <LA90
Noise at 1 metre external to sensitive façade where LA90>60dB	Day, evening and night	0000-2400	55dB$_{LAeq}$

Table 2: Camden Council's noise emissions requirements

Emergency generators used to maintain business continuity during power failures are subject to the same limits.

The LBC planning requirements do not apply to equipment that operates solely under emergency life safety conditions or for testing of such equipment.

The current LBC policy regarding noise from life-safety plant is that external noise emissions for emergency generators (life safety and communications only) is not to exceed the lowest daytime $L_{Aeq,15mins}$.

Table 3 sets out the noise emission limits for the development.

Sensitive location	**Building services noise emission limit at 1m external to sensitive façade, dBL$_{Ar, Tr}$**		
	Type of noise	**Weekday daytime (7am – 7pm)**	**Other times**
Adjacent properties to the west, south and east	Noise from plant	48	46
	Noise from plant that has a distinguishable continuous note or distinct impulses	43	41
	Noise from life safety and communications plant	54	54
	Noise from plant	40	38

Sensitive location	Building services noise emission limit at 1m external to sensitive façade, $dBL_{Ar, Tr}$		
	Type of noise	**Weekday daytime (7am – 7pm)**	**Other times**
Adjacent properties to the north	Noise from plant that has a distinguishable continuous note or distinct impulses	40	38
	Noise from life safety and communications plant	47	47
Publically accessible locations	Noise from plant	55	
	Noise from plant that has a distinguishable continuous note or distinct impulses	50	

Table 3 Plant noise emission limits at nearby locations

3 Proposed noise output

Figure 2 shows positions of rooftop plant and the nearest noise sensitive locations. Rooftop plant includes six cooling towers, ten AHUs, generator heat rejection, an exhaust flue and toilet extract fans. Areas are reserved for installation of plant items by tenants. Tenant plant will be subject to limiting sound power levels by the tenancy contract. Refer to Section 6 for a full list of rooftop plant.

Table 4 provides the calculated total noise emission from the 1 Triton Square development at these locations. This is based on provisional landlord plant selections at anticipated daytime duty. Where provisional plant selections are unavailable a typical selection has been used based on similar projects.

Sensitive location		Building services noise emission limit at 1m external to sensitive façade, $dBL_{Ar, Tr}$		Total noise level from rooftop plant (dB)	Level relative to night time limit (dB)
		Weekday daytime (7am – 7pm)	**Other times**		
NSR 1	10 Brock St	48	46	43	-6
NSR 2	10 Brock St	48	46	44	-9
NSR 3	10 Brock St	48	46	48	-4
NSR 4	2 Triton Square	48	46	36	-13
NSR 5	338 Euston Road	48	46	45	-5
NSR 6	20 Triton St	48	46	30	-17
NSR 7	20 Triton St	48	46	33	-14
NSR 8	St Anne's	40	38	31	-8
NSR 9	Westminster Kingsway College	40	38	29	-11

Table 4 Calculated noise emissions

The calculated levels are lower than all emission limits at all locations. The margin of at least 4dB at all locations allows suitable headroom for additional tenant plant. Guidance on the limits will be conveyed to tenants accordingly.

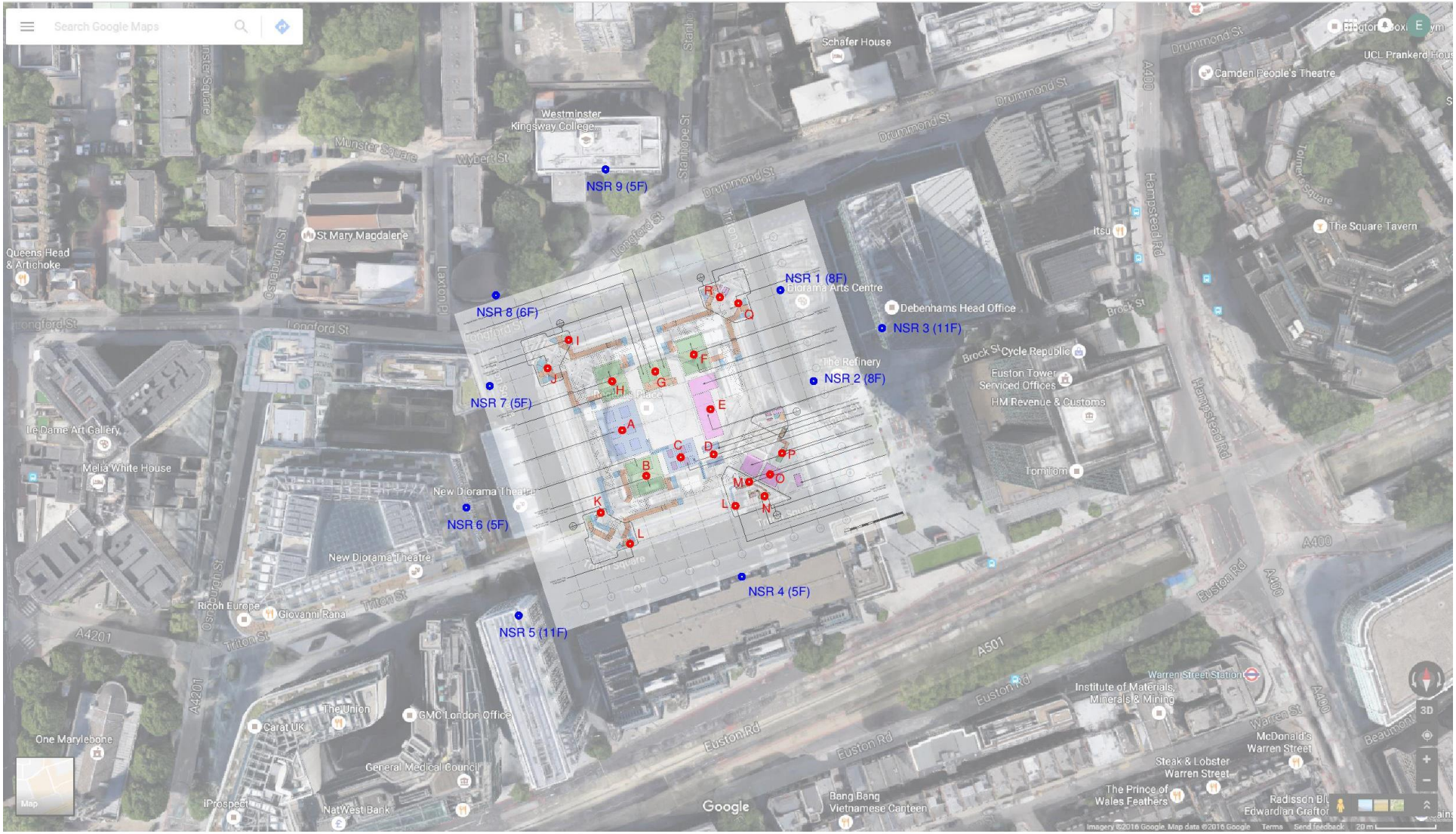

Figure 2 Rooftop plant locations and nearby sensitive locations

In addition to rooftop plant, louvres at pavement level provide air to landlord and tenant plant in the basement and ground floor. Ducts connecting to these louvres will include attenuation where necessary to ensure that the limits set out in Table 3 are not exceeded.

A landlord generator in the basement will serve life-safety systems. Airpaths and flues connecting with the external environment will be attenuated to ensure that noise from this plant does not exceed the lowest daytime $L_{Aeq,15mins}$ at the nearest sensitive locations

The basement includes space provision for a tenant generator to provide business continuity in case of power cut. The noise emissions limits will be communicated to tenants, and airpaths and flues connecting with the external environment will be attenuated to ensure that the limits set out in Table 3 are not exceeded.

4 Noise and vibration mitigation measures

The rooftop has a continuous solid plant screen around the perimeter. This will extend at least 3m above rooftop height.

An array of photovoltaic cells is located above the plant at rooftop at rooftop level. This will to some extent semi-enclose the rooftop plant, offering addition noise screening. The effect of this is difficult to predict and therefore as a worst case this effect has not been considered in the noise emission calculations.

Where necessary ducted connections to the external environment will be attenuated to meet the plant noise emission limits set out in this report.

Principal items of plant shall be installed on anti-vibration mounts to reduce any vibration transferred to the building fabric to an acceptable level. There is no direct structural connection to adjacent buildings.

5 Prediction method

The rooftop noise emission calculations follow the following algorithm:

[1] For each cluster of rooftop plant, establish a sound power level (SWL_{item}, see Table 7 below) and correct for quantity of plant, N, according to

$$SWL_{cluster} = SWL_{item} + 10\log_{10}(N)$$

[2] For each item of plant and each sensitive location measure the plan distance, r. Assume point-source hemi-spherical spreading to determine the sound pressure level (SPL) from the total SWL.

$$SPL_{cluster,source} = SWL_{cluster} - 20\log_{10}(r) - 11$$

[3] Logarithmically add the each SPL from each source $SPL_{cluster,NSR}$ at each sensitive location.

$$SPL_{totalNSR} = 10\log_{10}\left(\sum 10^{\left(SPLcluster,source/10\right)}\right)$$

[4] For each location, determine the average screening effect based on the building height at the sensitive location. Apply a barrier insertion loss according ISO 9613-2[1], assuming a barrier at the centre of a 60m path as per Table 5.

An example calculation sheet is shown in Appendix B.

Table 5 provides the barrier insertion losses derived from ISO 9613-2 to allow for screening effect of the building. Table 6 provides the relative height of each nearby sensitive location.

Sensitive location height of building, relative to 1 Triton Square	**Effective barrier height due to screening of 1 Triton Square**	**Barrier insertion loss (dB) in octave bands (Hz)**							
		63	**125**	**250**	**500**	**1k**	**2k**	**4k**	**8k**
3 floors lower	5m	-8	-10	-12	-14	-17	-20	-23	-25
Same height	1m	-5	-5	-5	-6	-7	-8	-10	-13
3 floors higher	No barrier	0	0	0	0	0	0	0	0

Table 5 Barrier insertion losses per building heights

Sensitive location		**Building height relative to 1 Triton Square**
NSR 1	10 Brock St	Same height
NSR 2	10 Brock St	Same height
NSR 3	10 Brock St	3 floors higher
NSR 4	2 Triton Square	3 floors lower
NSR 5	338 Euston Road	3 floors higher
NSR 6	20 Triton St	3 floors lower
NSR 7	20 Triton St	3 floors lower
NSR 8	St Anne's	3 floors lower
NSR 9	Westminster Kingsway College	3 floors lower

Table 6 Building heights at nearby sensitive locations

[1] ISO 9613-2:1996 Acoustics. Attenuation of sound during propagation outdoors. General method of calculation.

6 System manufacturer selections

Roof plant	Description	Qty	Landlord/ Tenant	Selection	Sound power level, dB(A)	Sound power level (dB) per octave band (Hz)							
						63	125	250	500	1k	2k	4k	8k
A	Cooling towers	6	Landlord	Provisional	73	88	81	72	69	64	63	61	60
B	AHU - office core 2	2	Landlord	Provisional	69	68	66	66	65	62	64	49	52
C	Plate heat exchange and pump	4	Landlord	Typical	67	60	60	60	60	60	60	60	60
D	Generator heat rejection	2	Landlord	Typical	68	69	83	65	55	55	50	46	41
E	Tenant plant area	1	Tenant										
F	AHU - office core 4	2	Landlord	Provisional	69	68	66	66	65	62	64	49	52
G	AHU - main atrium	3	Landlord	Provisional	69	68	66	66	65	62	64	49	52
H	AHU - office core 3	2	Landlord	Provisional	69	68	66	66	65	62	64	49	52
I	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
J	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
K	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
L	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
M	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
N	Toilet extract fan	2	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
O	Exhaust flue	2	Landlord	Limit	67	80	75	70	65	65	65	65	65
P	Tenant plant area	1	Tenant										
Q	AHU - main entrance reception	1	Landlord	Provisional	69	68	66	66	65	62	64	49	52
R	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56
S	Toilet extract fan	1	Landlord	Limit based on existing	74	80	83	76	72	67	63	58	56

Table 7 Sound power levels of plant selections

Appendix A

Background noise measurements

A1 Background noise measurements

Attended background spot measurements, taken at pavement level on 5th May 2016, are shown in Figure 3. The results are presented graphically for comparison with the unattended measurement results.

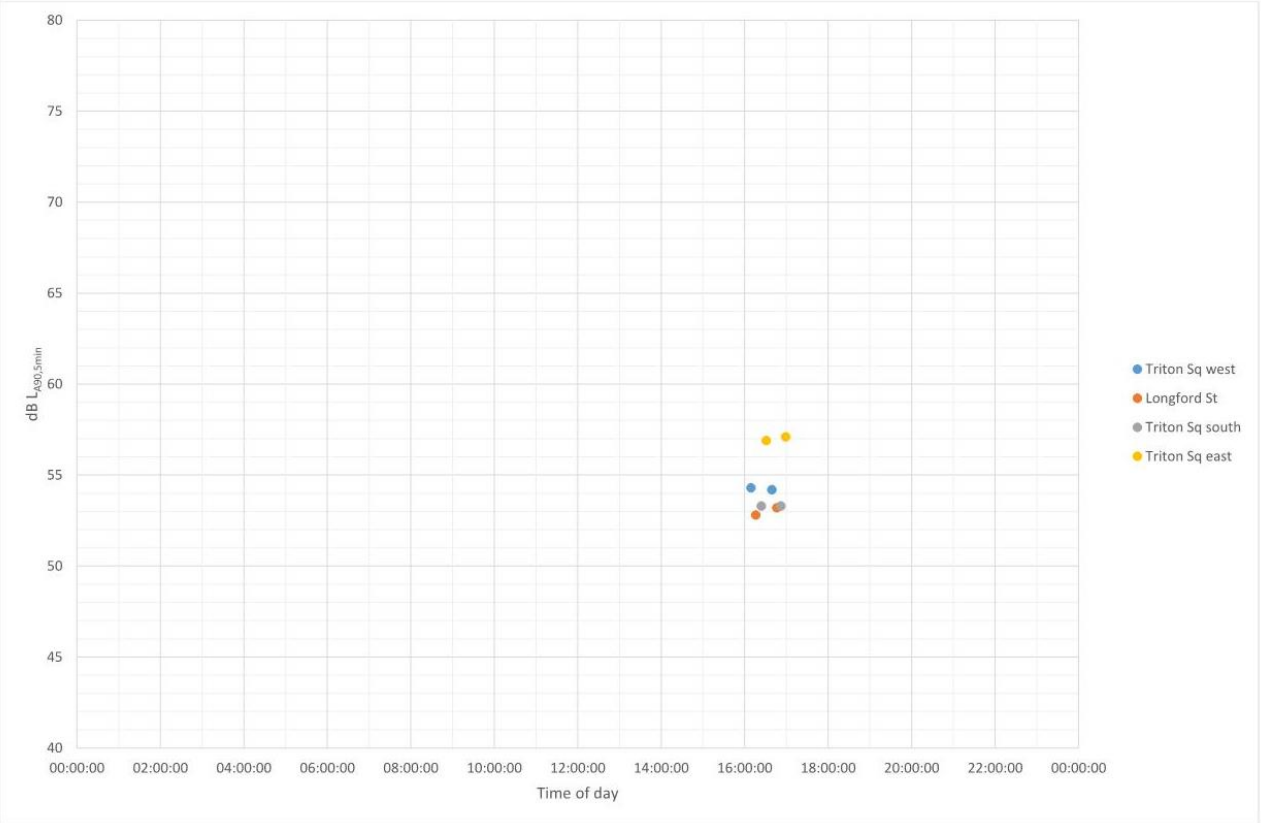

Figure 3 Background spot measurements

Unattended noise measurements were undertaken at rooftop level at 1 Triton Square between Fri 1st April and Wednesday 6th April 2016 at Location A (location indicated in Figure 1). The background and ambient noise levels are shown in Figure 4 and Figure 5.

Unattended noise measurements were undertaken at rooftop level at St Annes between Thu 1st December and Monday 5th December 2016 at Location B (location indicated in Figure 1). The background and ambient noise levels are shown in Figure 6 and Figure 7.

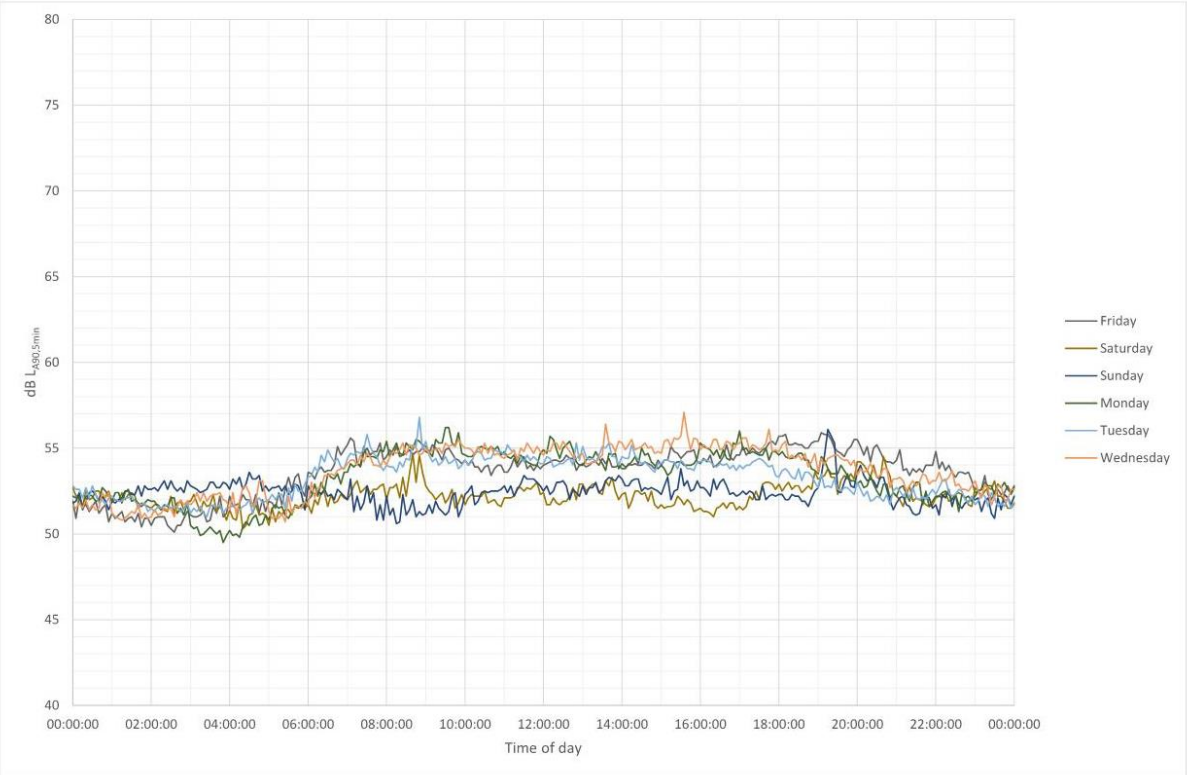

Figure 4 Unattended background noise measurements at 1 Triton Square

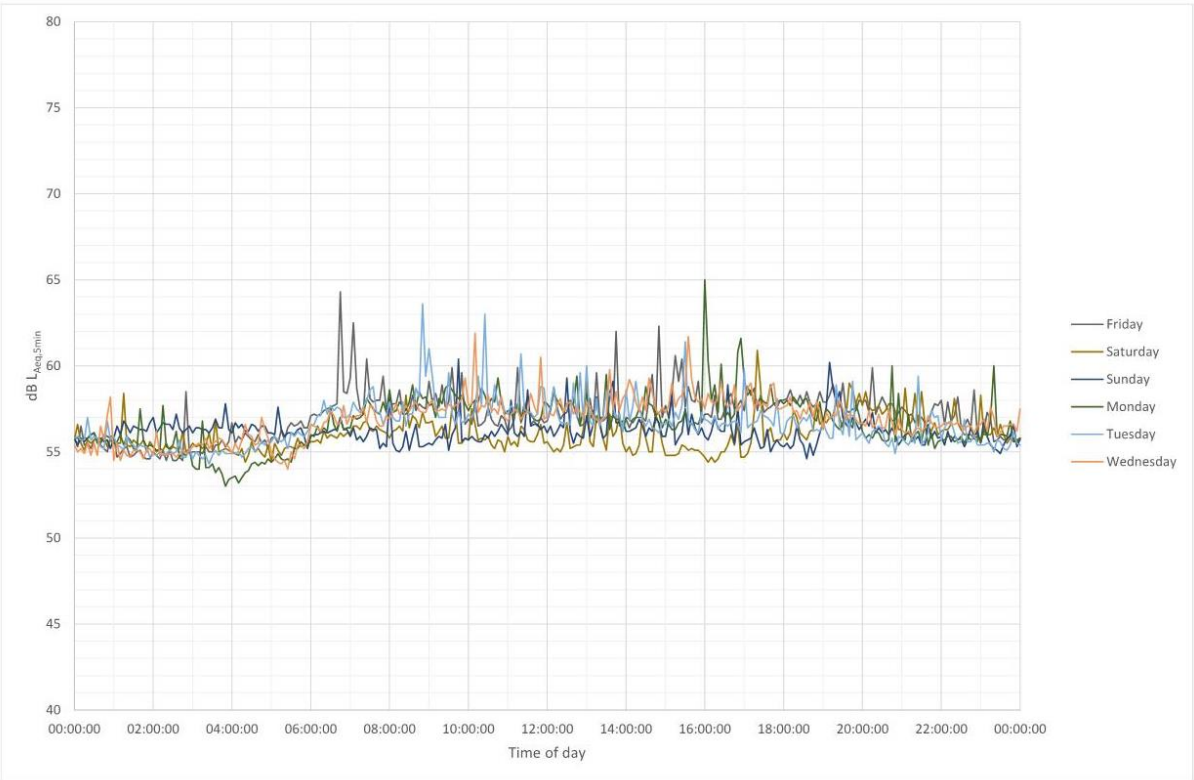

Figure 5 Unattended ambient noise measurements at 1 Triton Square

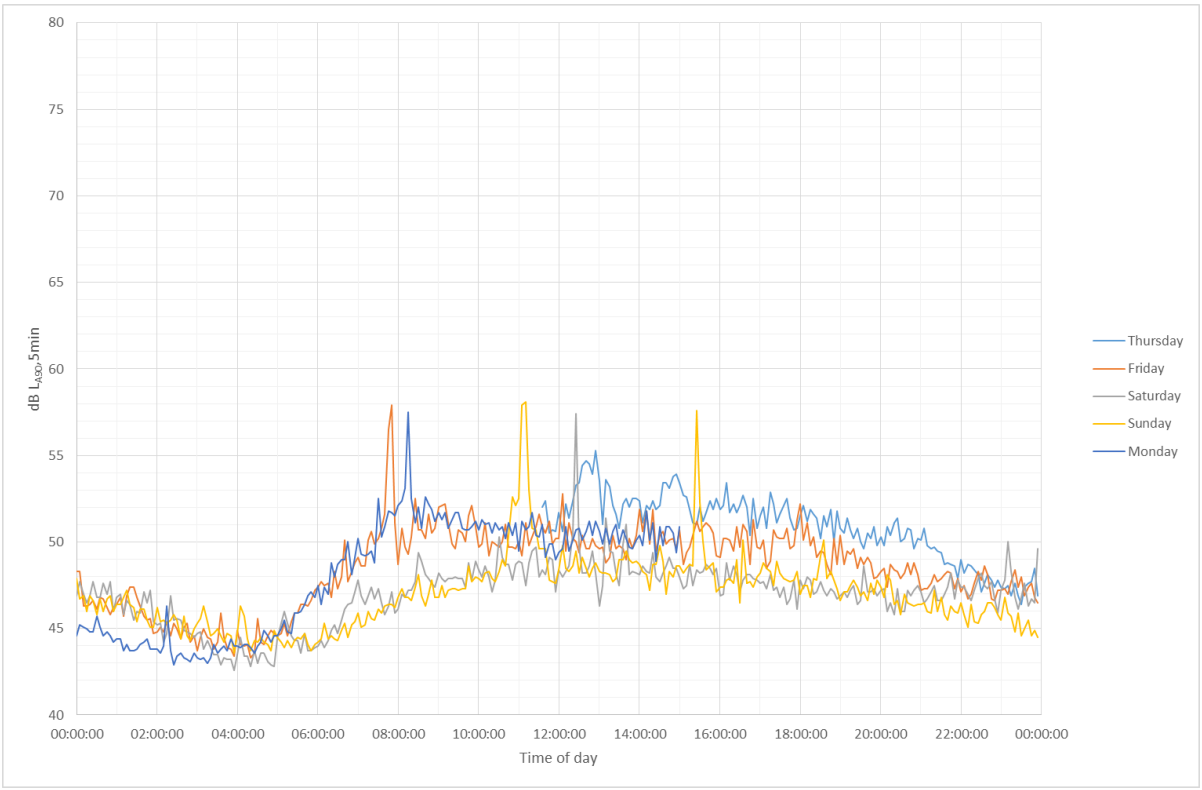

Figure 6 Unattended background noise measurements at St Annes

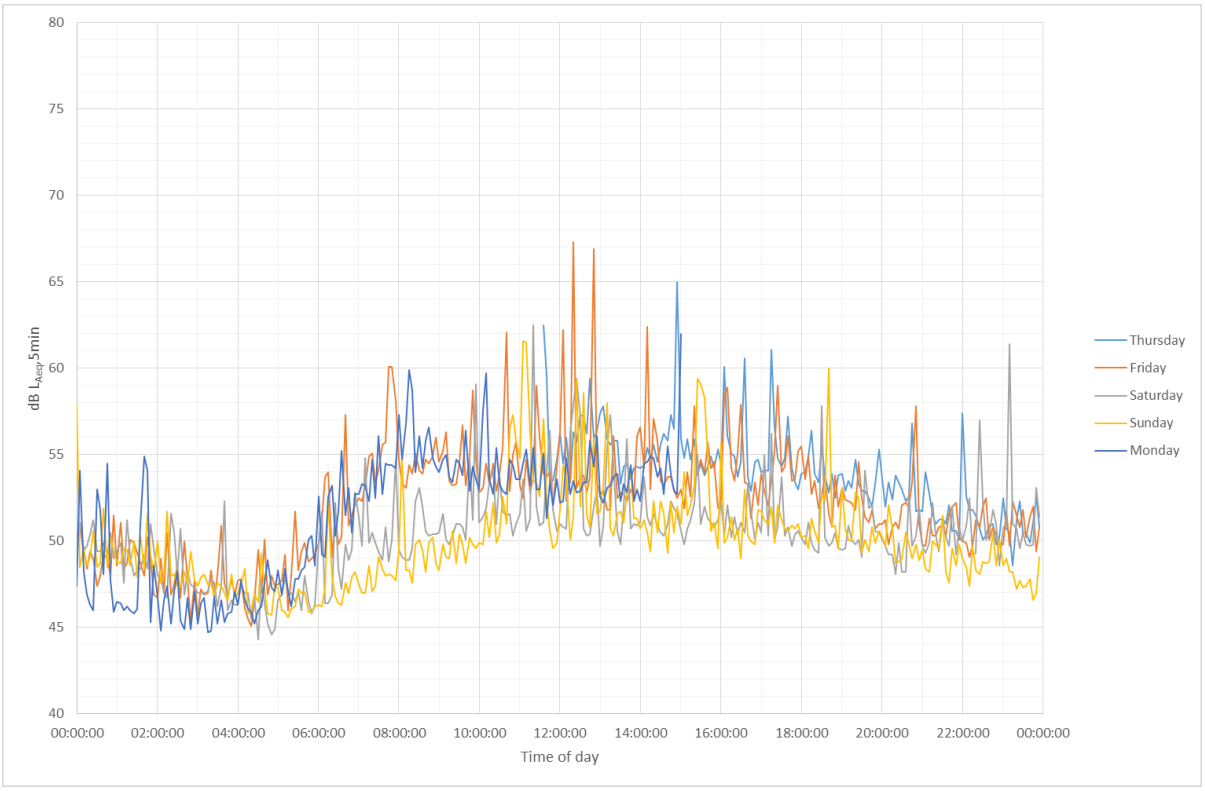

Figure 7 Unattended ambient noise measurements at St Annes

Appendix B

Typical plant noise emission calculation

ARUP strutt

Job No.	Job Title			
246868-13	Triton Square			
Date Created	By	Date Revised	Rev	Sheet
05 Dec 2016	EE	06 Dec 2016	43	1
Date Reviewed	By	Review Type	Review Status	

Triton Square - Summary of plant noise

Item / Description		Rating/Broadband/Input				Octave Band Centre Frequency, Hz							
		Rating	dB	dB(A)		63	125	250	500	1k	2k	4k	8k
		Is NSR lower than roof?	**Average Effective barrier height (m)**	**Plant noise limit (cont, non-tonal)**									
NSRs	**Address**			**Weekday 7am - 7pm**	**Other**	**Use**							
NSR 1	10 Brock St	Same height	1.0	48.0	46.0	Commercial							
NSR 2	10 Brock St	Same height	0.0	48.0	46.0	Commercial							
NSR 3	10 Brock St	3 floors higher	1.0	48.0	46.0	Commercial							
NSR 4	2 Triton Square	3 floors lower	5.0	48.0	46.0	Commercial							
NSR 5	338 Euston Road	3 floors higher	0.0	48.0	46.0	Commercial							
NSR 6	20 Triton St	3 floors lower	5.0	48.0	46.0	Commercial							
NSR 7	20 Triton St	3 floors lower	5.0	48.0	46.0	Commercial							
NSR 8	St Anne's	2 floors lower	5.0	42.0	40.0	Residential							
NSR 9	Westminster Kingsway College	3 floors lower	5.0	48.0	46.0	Educational							
ISO 9613.2 Barrier effects													
Barrier Attenuation - Theory: ISO 9613.2, Source H		1.0 m	30.0 m	30.0 m		-5	-5	-5	-6	-7	-8	-10	-13
Barrier Attenuation - Theory: ISO 9613.2, Source H		5.0 m	30.0 m	30.0 m		-8	-10	-12	-14	-17	-20	-23	-25
Roof plant	**Description**	**Qty**	**Landlord/Tenant**	**Selection**		**Sound Power (each)**							
A	Cooling towers	6	Landlord	Provisional		88	81	72	69	64	63	61	60
B	AHU - office core 2	2	Landlord	Provisional		68	66	66	65	62	64	49	52
C	Plate heat exchange and pump	4	Landlord	Typical		60	60	60	60	60	60	60	60
D	Generator heat rejection	2	Landlord	Typical		69	83	65	55	55	50	46	41
E	Tenant plant area	1	Tenant	Limit		90	85	80	80	75	75	75	75
F	AHU - office core 4	2	Landlord	Provisional		68	66	66	65	62	64	49	52
G	AHU - main atrium	3	Landlord	Provisional		68	66	66	65	62	64	49	52
H	AHU - office core 3	2	Landlord	Provisional		68	66	66	65	62	64	49	52
I	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
J	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
K	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
L	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
M	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
N	Toilet extract fan	2	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
O	Exhaust flue	2	Landlord	Limit		80	75	70	65	65	65	65	65
P	Tenant plant area	1	Tenant	Limit		90	85	80	80	75	75	75	75
Q	AHU - main entrance reception	1	Landlord	Provisional		68	66	66	65	62	64	49	52
R	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
S	Toilet extract fan	1	Landlord	Limit based on existing		80	83	76	72	67	63	58	56
Total level at NSRs		**Total level (dB)**	**Limit (dB)**	**Margin under limit**									
NSR 1	10 Brock St	42 (A)	46 (A)	-4 (A)									
NSR 2	10 Brock St	42 (A)	46 (A)	-4 (A)									
NSR 3	10 Brock St	46 (A)	46 (A)	-1 (A)									
NSR 4	2 Triton Square	35 (A)	46 (A)	-11 (A)									
NSR 5	338 Euston Road	43 (A)	46 (A)	-3 (A)									
NSR 6	20 Triton St	30 (A)	46 (A)	-16 (A)									
NSR 7	20 Triton St	33 (A)	46 (A)	-14 (A)									
NSR 8	St Anne's	31 (A)	38 (A)	-7 (A)									
NSR 9	Westminster Kingsway College	28 (A)	38 (A)	-10 (A)									

Distance to NSR

NSR 1	NSR 2	NSR 3	NSR 4	NSR 5	NSR 6	NSR 7	NSR 8	NSR 9
70.0	66.0	93.0	63.0	71.0	58.0	46.0	62.0	87.0
76.0	64.0	93.0	46.0	63.0	61.0	60.0	78.0	103.0
65.0	51.0	80.0	44.0	75.0	73.0	68.0	82.0	99.0
59.0	41.0	71.0	41.0	85.0	84.0	78.0	90.0	101.0
46.0	35.0	63.0	56.0	94.0	88.0	73.0	81.0	88.0
36.0	41.0	63.0	75.0	105.0	92.0	69.0	69.0	69.0
50.0	52.0	77.0	74.0	93.0	77.0	55.0	59.0	69.0
63.0	67.0	92.0	77.0	85.0	64.0	41.0	48.0	72.0
72.0	82.0	105.0	97.0	94.0	66.0	30.0	29.0	58.0
81.0	89.0	112.0	94.0	84.0	54.0	21.0	29.0	69.0
95.0	83.0	112.0	52.0	44.0	45.0	56.0	80.0	114.0
98.0	81.0	111.0	39.0	44.0	56.0	71.0	93.0	125.0
73.0	77.0	49.0	23.0	81.0	90.0	91.0	106.0	120.0
69.0	69.0	41.0	23.0	92.0	99.0	99.0	111.0	121.0
64.0	40.0	68.0	31.0	89.0	95.0	92.0	105.0	114.0
62.0	34.0	61.0	35.0	96.0	101.0	98.0	109.0	115.0
54.0	26.0	53.0	43.0	102.0	107.0	100.0	109.0	111.0
15.0	36.0	49.0	91.0	127.0	113.0	87.0	81.0	63.0
20.0	42.0	55.0	93.0	126.0	109.0	82.0	75.0	57.0

SWL Distance attenuation (based on hemispherical point source)

NSR 1	NSR 2	NSR 3	NSR 4	NSR 5	NSR 6	NSR 7	NSR 8	NSR 9
-45	-44	-47	-44	-45	-43	-41	-44	-47
-46	-44	-47	-41	-44	-44	-44	-46	-48
-44	-42	-46	-41	-45	-45	-45	-46	-48
-43	-40	-45	-40	-47	-46	-46	-47	-48
-41	-39	-44	-43	-47	-47	-45	-46	-47
-39	-40	-44	-45	-48	-47	-45	-45	-45
-42	-42	-46	-45	-47	-46	-43	-43	-45
-44	-45	-47	-46	-47	-44	-40	-42	-45
-45	-46	-48	-48	-47	-44	-38	-37	-43
-46	-47	-49	-47	-46	-43	-34	-37	-45
-48	-46	-49	-42	-41	-41	-43	-46	-49
-48	-46	-49	-40	-41	-43	-45	-47	-50
-45	-46	-42	-35	-46	-47	-47	-48	-50
-45	-45	-40	-35	-47	-48	-48	-49	-50
-44	-40	-45	-38	-47	-48	-47	-48	-49
-44	-39	-44	-39	-48	-48	-48	-49	-49
-43	-36	-42	-41	-48	-49	-48	-49	-49
-32	-39	-42	-47	-50	-49	-47	-46	-44
-34	-40	-43	-47	-50	-49	-46	-45	-43

ARUP strutt

Job No.	Job Title			
246868-13	Triton Square			
Date Created	By	Date Revised	Rev	Sheet
05 Dec 2016	EE	05 Dec 2016	4	3
Date Reviewed	By	Review Type	Review Status	

NSR 1

Item / Description		Rating/Broadband/Input Rating	dB	dB(A)	Octave Band Centre Frequency, Hz 31.5	63	125	250	500	1k	2k	4k	8k
Roof Plant		**Quantity**			**Source quantity correction**								
A	Cooling towers	6 x			7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8	7.8
B	AHU - office core 2	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
C	Plate heat exchange and pump	4 x			6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0	6.0
D	Generator heat rejection	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
E	Tenant plant area	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
F	AHU - office core 4	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
G	AHU - main atrium	3 x			4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8	4.8
H	AHU - office core 3	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
I	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
J	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
K	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
L	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
M	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
N	Toilet extract fan	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
O	Exhaust flue	2 x			3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0	3.0
P	Tenant plant area	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
Q	AHU - main entrance reception	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
R	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
S	Toilet extract fan	1 x			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
					Total SWL (includes quantity correction)								
A	Cooling towers			80.4 (A)		95.8	88.8	79.8	76.8	71.8	70.8	68.8	67.8
B	AHU - office core 2			71.8 (A)		71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
C	Plate heat exchange and pump			73.0 (A)		66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
D	Generator heat rejection			70.8 (A)		72.0	86.0	68.0	58.0	58.0	53.0	49.0	44.0
E	Tenant plant area			83.2 (A)		90.0	85.0	80.0	80.0	75.0	75.0	75.0	75.0
F	AHU - office core 4			71.8 (A)		71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
G	AHU - main atrium			73.6 (A)		72.8	70.8	70.9	69.9	66.9	69.0	53.8	57.0
H	AHU - office core 3			71.8 (A)		71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
I	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
J	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
K	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
L	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
M	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
N	Toilet extract fan			77.3 (A)		83.0	86.0	79.0	75.0	70.0	66.0	61.0	59.0
O	Exhaust flue			75.5 (A)		83.0	78.0	73.0	68.0	68.0	68.0	68.0	68.0
P	Tenant plant area			83.2 (A)		90.0	85.0	80.0	80.0	75.0	75.0	75.0	75.0
Q	AHU - main entrance reception			68.8 (A)		68.1	66.0	66.1	65.1	62.1	64.2	49.0	52.2
R	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
S	Toilet extract fan			74.3 (A)		80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0

					Total SWL (includes quantity correction)							
A	Cooling towers			80.4 (A)	95.8	88.8	79.8	76.8	71.8	70.8	68.8	67.8
B	AHU - office core 2			71.8 (A)	71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
C	Plate heat exchange and pump			73.0 (A)	66.0	66.0	66.0	66.0	66.0	66.0	66.0	66.0
D	Generator heat rejection			70.8 (A)	72.0	86.0	68.0	58.0	58.0	53.0	49.0	44.0
E	Tenant plant area			83.2 (A)	90.0	85.0	80.0	80.0	75.0	75.0	75.0	75.0
F	AHU - office core 4			71.8 (A)	71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
G	AHU - main atrium			73.6 (A)	72.8	70.8	70.9	69.9	66.9	69.0	53.8	57.0
H	AHU - office core 3			71.8 (A)	71.1	69.0	69.1	68.1	65.1	67.2	52.0	55.2
I	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
J	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
K	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
L	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
M	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
N	Toilet extract fan			77.3 (A)	83.0	86.0	79.0	75.0	70.0	66.0	61.0	59.0
O	Exhaust flue			75.5 (A)	83.0	78.0	73.0	68.0	68.0	68.0	68.0	68.0
P	Tenant plant area			83.2 (A)	90.0	85.0	80.0	80.0	75.0	75.0	75.0	75.0
Q	AHU - main entrance reception			68.8 (A)	68.1	66.0	66.1	65.1	62.1	64.2	49.0	52.2
R	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
S	Toilet extract fan			74.3 (A)	80.0	83.0	76.0	72.0	67.0	63.0	58.0	56.0
					Barrier attenuation							
	Based on 1m effective barrier at centre of 60m distance				-4.9	-5.1	-5.4	-6.0	-6.9	-8.4	-10.3	-12.7
		SWL Distance attenuation			**Resdiual Level at NSR**							
A	Cooling towers		-44.9		46.0	38.8	29.5	25.9	20.0	17.5	13.6	10.2
B	AHU - office core 2		-45.6		20.6	18.3	18.1	16.5	12.6	13.2	-3.9	-3.1
C	Plate heat exchange and pump		-44.3		16.9	16.7	16.4	15.8	14.9	13.4	11.5	9.1
D	Generator heat rejection		-43.4		23.7	37.5	19.2	8.6	7.7	1.2	-4.7	-12.1
E	Tenant plant area		-41.2		43.9	38.7	33.4	32.8	26.9	25.4	23.5	21.1
F	AHU - office core 4		-39.1		27.1	24.8	24.6	23.0	19.1	19.7	2.6	3.4
G	AHU - main atrium		-42.0		26.0	23.7	23.5	21.9	18.0	18.6	1.5	2.3
H	AHU - office core 3		-44.0		22.2	19.9	19.7	18.1	14.2	14.8	-2.3	-1.5
I	Toilet extract fan		-45.1		30.0	32.8	25.5	20.9	15.0	9.5	2.6	-1.8
J	Toilet extract fan		-46.2		28.9	31.7	24.4	19.8	13.9	8.4	1.5	-2.9
K	Toilet extract fan		-47.5		27.6	30.4	23.1	18.5	12.6	7.1	0.2	-4.2
L	Toilet extract fan		-47.8		27.3	30.1	22.8	18.2	12.3	6.8	-0.1	-4.5
M	Toilet extract fan		-45.3		29.8	32.6	25.3	20.7	14.8	9.3	2.4	-2.0
N	Toilet extract fan		-44.8		33.3	36.1	28.8	24.2	18.3	12.8	5.9	1.5
O	Exhaust flue		-44.1		34.0	28.8	23.5	17.9	17.0	15.5	13.6	11.2
P	Tenant plant area		-43.8		41.3	36.1	30.8	30.2	24.3	22.8	20.9	18.5
Q	AHU - main entrance reception		-42.6		20.5	18.3	18.1	16.5	12.5	13.2	-3.9	-3.2
R	Toilet extract fan		-31.5		43.6	46.4	39.1	34.5	28.6	23.1	16.2	11.8
S	Toilet extract fan		-34.0		41.1	43.9	36.6	32.0	26.1	20.6	13.7	9.3
Total level at NSR				42 (A)	50.9	50.2	43.0	39.6	33.9	31.0	26.8	24.2

Strutt Version 5.16.20 (Confidential) J:\LONDON\Projects\246868-13 Project Mint\4 Internal Project Data\7 Calculations\20161205 Stage 2 Plant Emissions - EE\20161205 Stage 2 plant emissions v2.xlsx [NSR 1]

Appendix C

Base build plant

Base build plant noise data

Table 5 Base build plant noise data

Description	Qty	Data source	Sound Power (dB) at octave band centre frequency (Hz)							
			63	125	250	500	1k	2k	4k	8k
Cooling towers	6	FAT test results	96	84	74	69	67	69	71	71
AHU 2A and 2B (see AHU data table 5 and 6)	1	Technical data sheet	77	80	66	55	46	45	50	60
Summer purge fans	2	Technical data sheet	75	71	71	59	47	52	54	57
AHU 4A and 4B (see AHU data table 5 and 6)	1	Technical data sheet	79	81	67	58	47	47	52	61
AHU – 1A	1	Technical data sheet	62	65	63	51	44	47	41	35
AHU 3A and 3B (see AHU data table 5 and 6)	1	Technical data sheet	80	82	67	57	46	47	51	59
Toilet extract fan (TEF 06) (see Fan data table 5 and 6)	1	Technical data sheet	75	74	53	36	33	31	29	33
Toilet extract fan (TEF 05) (see Fan data table 5 and 6)	1	Technical data sheet	73	80	58	43	36	38	34	40
Toilet extract fan (TEF 04) (see Fan data table 5 and 6)	1	Technical data sheet	82	77	57	36	33	35	32	33
Toilet extract fan (TEF 03) (see Fan data table 5 and 6)	1	Technical data sheet	73	80	58	43	38	38	34	40
Toilet extract fan (TEF 02) (see Fan data table 5 and 6)	1	Technical data sheet	78	72	51	34	31	28	26	30
Toilet extract fan (TEF 01) (see Fan data table 5 and 6)	1	Technical data sheet	85	83	66	45	41	44	43	43

Description	Qty	Data source	Sound Power (dB) at octave band centre frequency (Hz)							
			63	125	250	500	1k	2k	4k	8k
AHU 1A (see AHU data table 5 and 6)	1	Technical data sheet	74	68	65	50	48	38	45	57
Toilet extract fan (ER-RL-WC-08) (see Fan data table 5 and 6)	1	Technical data sheet	82	77	57	38	33	35	32	33
Toilet extract fan (ER-RL-WC-07) (see Fan data table 5 and 6)	1	Technical data sheet	76	80	63	49	44	45	39	46
3F inlet lourve (north) (see AHU data table 5 and 6)	1	Technical data sheet (AHU-BF.EN)	64	68	50	32	33	39	41	31
3F inlet louvre (south) (see AHU data table 5 and 6)	1	Technical data sheet (AHU-BF.SW AHU-BF.OF AHU-BF.AU)	76	78	64	45	50	53	57	53
GF outlet louvre (see AHU data table 5 and 6)	1	Technical data sheet (AHU-BF.SW AHU-BF.OF)	75	76	61	51	56	59	61	49

Table 6 Base build AHU and Fan sound power

Plant item	Sound Power (dB) at octave band centre frequency (Hz)							
	63	125	250	500	1k	2k	4k	8k
AHU 2A Supply	78	88	88	90	87	85	82	80
AHU 2A Extract	80	88	86	87	81	84	75	75
AHU 2B Supply	76	85	87	89	87	84	81	79
AHU 2B Extract	79	88	86	86	81	82	75	73
AHU 3A Supply	84	91	89	91	86	87	81	78
AHU 3A Extract	80	89	87	86	81	83	75	74
AHU 3B Supply	77	87	87	90	86	84	81	79
AHU 3B Extract	83	89	88	90	84	87	79	77
AHU 4A Supply	78	87	87	90	87	84	81	80
AHU 4A Extract	83	89	89	91	85	88	80	78
AHU 4B Supply	77	87	87	90	86	84	81	79
AHU 4B Extract	83	90	90	91	85	88	80	78
AHU 1A Supply	79	77	89	86	90	80	77	78
AHU 1A Extract	79	78	89	86	89	80	77	78
AHU-BF.SW outlet (attenuated)	71	72	57	47	52	55	57	45
AHU-BF.OF outlet (attenuated)	72	74	59	48	53	56	58	46
AHU-BF.SW inlet (attenuated)	72	74	55	38	47	50	54	43
AHU-BF.OF inlet (attenuated)	72	75	56	42	47	50	53	44
AHU-BF.AU inlet (attenuated)	71	67	62	38	32	29	35	52
AHU-BF.EN inlet (attenuated)	64	68	50	32	33	39	41	31
Toilet extract fan (TEF 01)	91	95	86	76	72	73	69	62
Toilet extract fan (TEF 02)	84	84	71	65	62	57	52	49
Toilet extract fan (TEF 03)	79	92	78	74	69	67	60	59
Toilet extract fan (TEF 04)	88	89	77	67	64	64	58	52
Toilet extract fan (TEF 05)	79	92	78	74	67	67	60	59
Toilet extract fan (TEF 06)	81	86	73	67	64	60	55	52
Toilet extract fan (TEF 07)	82	92	83	80	75	74	65	65
Toilet extract fan (TEF 08)	88	89	77	69	64	64	58	52

Table 7 Base build AHU and Fan attenuator insertion losses

	Octave band centre frequency							
	63	125	250	500	1k	2k	4k	8k
AHU 1-4 atmosphere side supply and extract attenuator insertion loss (dB)	8	13	27	39	45	45	35	24
Toilet extract fan (01-08) attenuator insertion loss (dB)	6	12	20	31	31	29	26	19