

MRI BMTU

Plant Noise Impact Assessment

Engie

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1.0

Introduction

1.0 Introduction

Cundall has been commissioned to undertake a noise impact assessment of items of rooftop plant servicing the redevelopment of Wards 43 and 44 within Manchester Royal Infirmary for bone marrow transplant (BMTU) services.

It is understood that the proposed development will be serviced by two new chiller units and four new air handling units (AHUs), all located at rooftop level.

In order to establish the prevailing noise climate at the nearest non-hospital receptors, a noise survey has previously been undertaken by RPS between 17 June and 19 July 2014. All results and subjective findings from the RPS report¹ have been reproduced in this report where relevant.

The purpose of this assessment is to evaluate the findings of the RPS, identify future items of noise-generated plant associated with the scheme and define limiting plant noise criteria in accordance with Manchester City Council (MCC) noise policy guidance.

In order to assist with the noise impact calculations, sound power level data for the proposed new plant items has been inputted into a 3D site model created using SoundPLAN version 8.2 acoustic software.

Note: Reproduction of RPS survey data has been authorised by Engie. Cundall cannot assume responsibility for the accuracy of third party survey information.

1.1 Revision P02 update (December 2021)

Since the issue of the initial Rev P01 Noise Impact Assessment Report by Cundall in April 2020, developments to the mechanical ventilation strategy have necessitated the installation of an additional AHU (ref: AHU5)

The purpose of this report update is to incorporate the additional noise sources from the new AHU and review the updated 3D noise model outcomes against Manchester City Council Noise Policy.

¹ Reference: B7477-ENV-P2 dated April 2nd 2015

2.0

Assessment criteria

2.0 Assessment criteria

This section of the report outlines the key legislation and guidance relevant to the assessment of noise for a development of this type.

2.1 Noise Policy Statement for England

The Noise Policy Statement for England (NPSE) was published by Defra in March 2010. This NPSE sets out the long-term vision of Government noise policy:

“Promote good health and a good quality of life through the effective management of noise within the context of Government policy on sustainable development.”

The NPSE long term vision is supported by the following aims:

“Through the effective management and control of environmental, neighbour and neighbourhood noise within the context of Government policy on sustainable development:

Avoid significant adverse impacts on health and quality of life;

Mitigate and minimise adverse impacts on health and quality of life; and

Where possible, contribute to the improvement of health and quality of life.”

2.2 National Planning Policy Framework

The revised National Planning Policy Framework was updated in July 2021 and sets out the Government's planning policies for England and how these are expected to be applied.

This revised Framework replaces the previous National Planning Policy Framework published in March 2012 and revised in July 2018. The NPPF states:

174. *Planning policies and decisions should contribute to and enhance the natural and local environment by;*
[...]

e) preventing new and existing development from contributing to, being put at unacceptable risk from, or being adversely affected by, unacceptable levels of soil, air, water or noise pollution or land instability. Development should, wherever possible, help to improve local environmental conditions such as air and water quality, taking into account relevant information such as river basin management plans;

185. *Planning policies and decisions should also ensure that new development is appropriate for its location taking into account the likely effects (including cumulative effects) of pollution on health, living conditions and the natural environment, as well as the potential sensitivity of the site or the wider area to impacts that could arise from the development. In doing so they should:*

a) mitigate and reduce to a minimum potential adverse impacts resulting from noise from new development – and avoid noise giving rise to significant adverse impacts on health and the quality of life;

b) identify and protect tranquil areas which have remained relatively undisturbed by noise and are prized for their recreational and amenity value for this reason; [...]

187. *Planning policies and decisions should ensure that new development can be integrated effectively with existing businesses and community facilities (such as places of worship, pubs, music venues and sports clubs). Existing businesses and facilities should not have unreasonable restrictions placed on them as a result of development permitted after they were established. Where the operation of an existing business or community facility could have a significant adverse effect on new development (including changes of use) in its vicinity, the applicant (or ‘agent of change’) should be required to provide suitable mitigation before the development has been completed.”*

2.3 Planning Practice Guidance

In March 2014 Planning Practice Guidance for noise was published. This online document advises on how planning can manage potential noise impacts in new development.

2.4 Local Authority noise policy guidance

Section 3.6.1.5.1 of the Manchester City Council (MCC) 'Planning & Noise - Technical Guidance' document (December 2015) relates to noise limits for building services plant and states:

"Many of the noise complaints Environmental Health receive about noise from plant, equipment and machinery specifically concern the character of the noise emitted. Any noise assessment needs to consider not only the overall level of noise emitted but also its particular characteristics. The noise assessment should be based on BS 4142: 2014 and any application for fixed plant, equipment or machinery must demonstrate that:

Externally mounted ancillary plant, equipment and servicing shall be selected and/or acoustically treated in accordance with a scheme designed so as to achieve a rating level of 5 dB (L_{Aeq}) below the typical background (L_{A90}) level at the nearest noise sensitive location."

2.5 BS 4142:2014

BS 4142:2014 +A1:2019 'Methods for rating and assessing industrial and commercial sound' (BS 4142) provides methods for rating and assessing sound of an industrial and/or commercial nature, which includes sound from industrial and manufacturing processes, fixed services plant, sound generated by the loading/unloading of goods and sound from mobile plant / vehicles associated with industrial / commercial premises (e.g. fork-lift trucks).

Typically, the greater the difference between the background and rating level, the greater the magnitude of impact, although BS 4142 emphasises that this is highly context-specific.

As a guideline, BS 4142 states that:

- *A difference (between the background and rating level) of around +10 dB or more is likely to be indicative of significant adverse impact, depending on context*
- *A difference (between the background and rating level) of around +5 dB or more is likely to be indicative of adverse impact, depending on context*
- *The lower the rating level relative to the background level, the less likely it is that the specific sound will have an adverse impact*
- *Where the rating level does not exceed the background level, this is an indication that the specific sound will have a low impact, depending on context*

3.0

Site context

3.0 Site context

The Manchester Royal Infirmary (MRI) site is located to the south of Manchester City Centre and is bounded by Grafton Street to the north, Upper Brook Street (A34) to the east, Hathersage Road to the south and Oxford Road to the west.

Upper Brook Street and Oxford Road are main routes into Manchester City Centre and are heavily trafficked throughout the daytime period and moderately trafficked throughout the night-time. Oxford Road, in particular, has a high percentage of bus movements which continue throughout the night-time period.

Multi-storey car parks and entrances to pick-up / drop-off zones within the MRI are accessed via Grafton Street and Hathersage Road.

The area surrounding the MRI is of mixed use and comprises of residential, commercial, educational buildings and places of worship.

The proposed area of development is located to the west of the site, and the approximate outline is highlighted red below.

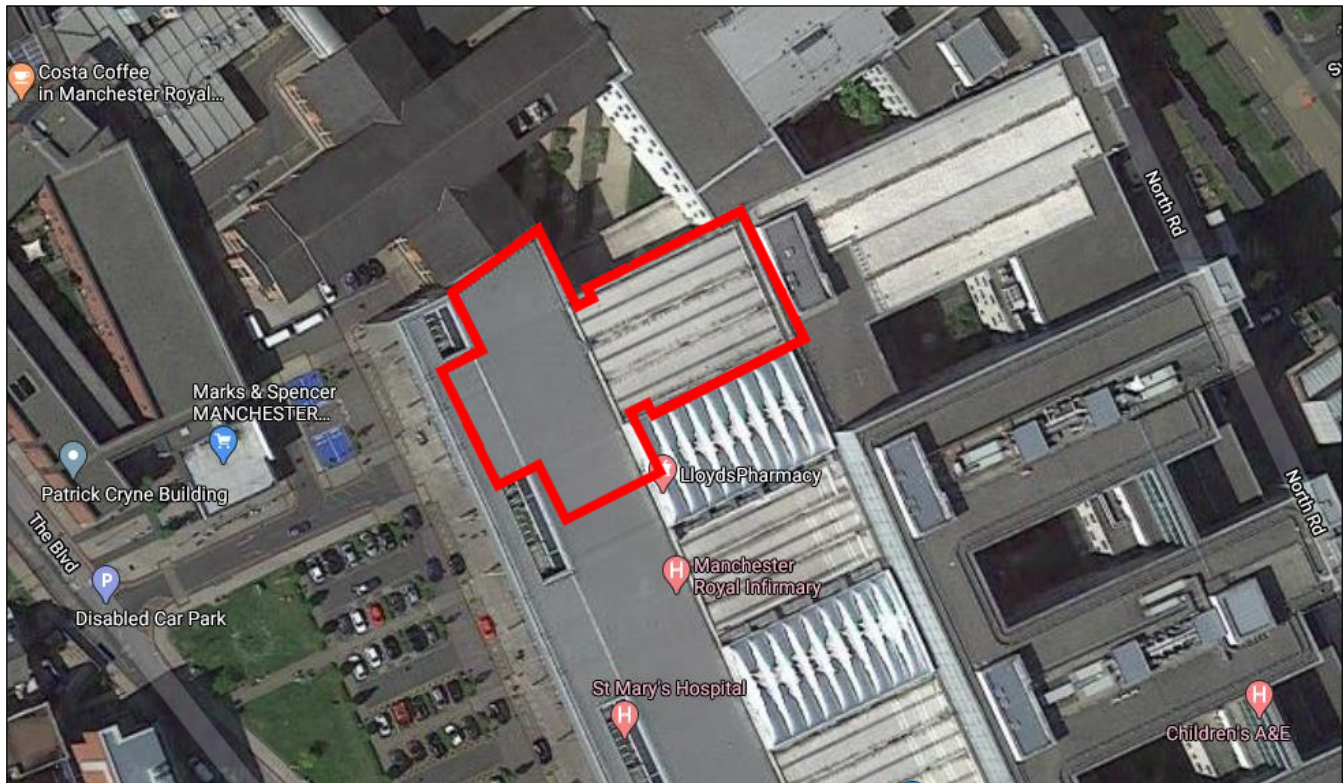


Figure 1 - Location of proposed redevelopment

From previous assessments of redevelopment at the MRI, the following sensitive receptors were identified as being closest to the boundary of the MRI campus, and therefore considered as being most exposed to potential sound impacts from the site:

- 1. Nick Everton House (78 Grafton Street)
- 2. The Grafton (60 Grafton Street)
- 3. Wilmslow Park (211 Hathersage Road)
- 4. Victoria Terrace (135-149 Hathersage Road)
- 5. Victoria Hall (281 Upper Brook Street)
- 6. Travelodge Manchester Upper Brook Street (227 Upper Brook Street)

An aerial photograph of the site showing the location of the nearest sound sensitive receptors and proposed locations for new rooftop plant is shown below.

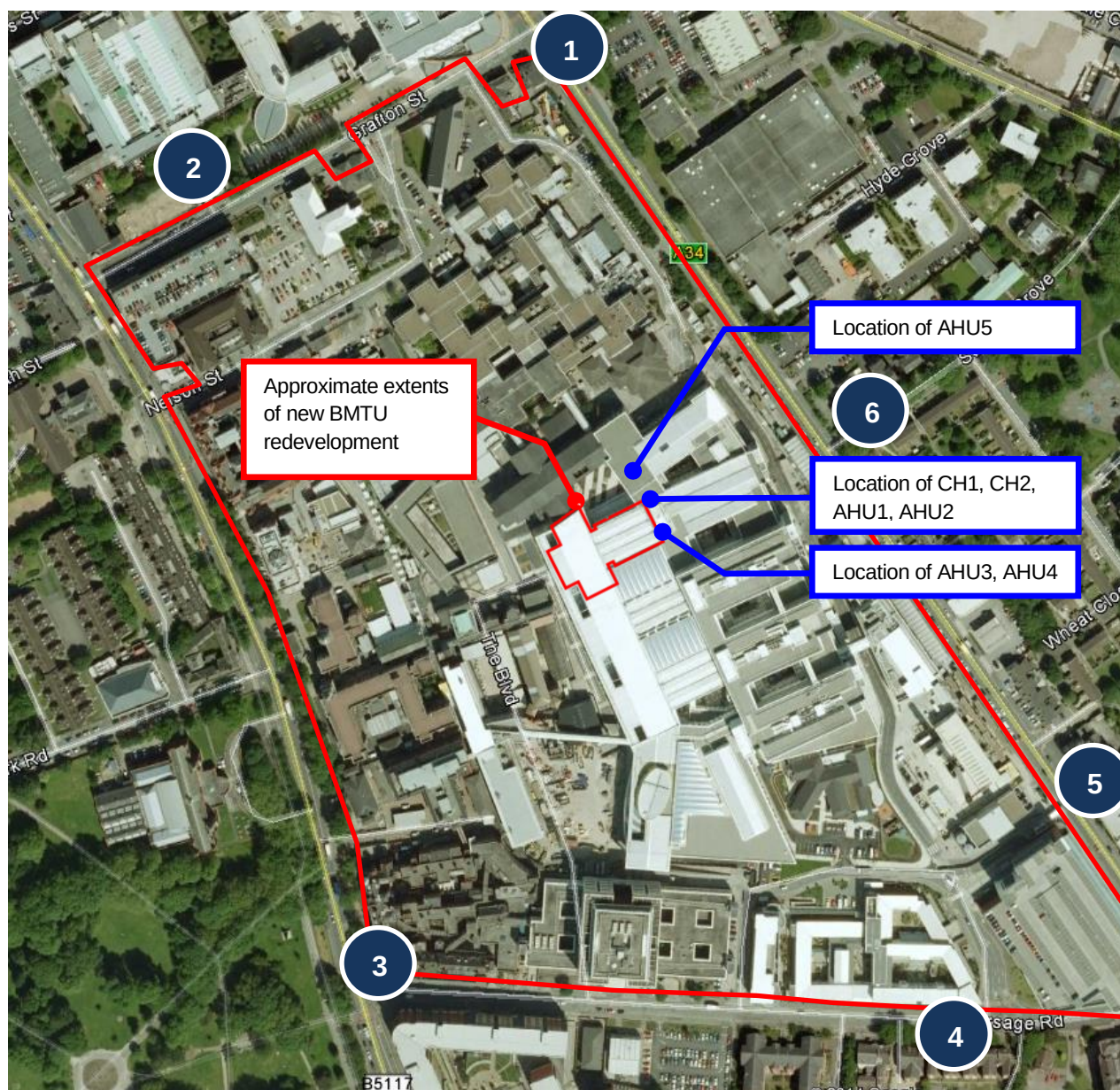


Figure 2 - Aerial photograph of approximate measurement locations

Key:

1 Approximate measurement positions (Attended Measurements)

Site boundary

Note: Image reproduced from RPS report ref B7477-ENV-P2 dated 2nd April 2015

4.0

Background noise surveys

4.0 Background noise surveys

In order to assess the prevailing ambient noise climate across the site, attended daytime and night-time noise surveys were carried out by RPS between 17 June and 19 July 2014.

Weather conditions during all survey periods were reported as being typically dry (with the exception of 2 mm precipitation on 18th July) and with wind speeds < 5 m/s.

4.1 Measurement locations

To assess the existing prevailing noise climate at the nearest sound sensitive receptors (as agreed with MCC), RPS measurements were undertaken at six different positions as detailed in Table 1 below.

Measurement position	Description
MP1	Situated at crossroads between Upper Brook Street and Grafton Street, capturing existing noise impact at residential apartments at 'Nick Everton House' (78 Grafton Street)
MP2	Situated at corner of Portsmouth Street and Grafton Street, capturing existing noise impact at residential apartments at 'The Grafton' (60 Grafton Street)
MP3	Situated along Hathersage Road, capturing existing noise impact at residential apartments at 'Wilmslow Park' (211 Hathersage Road)
MP4	Situated along Hathersage Road, capturing existing noise impact at residential apartments at 'Victoria Terrace' (135-149 Hathersage Road)
MP5	Situated at corner of Upper Brook Street and Blockstock Street, capturing existing noise impact at residential apartments at 'Victoria Hall' (281 Upper Brook Street)
MP6	Travelodge Manchester Upper Brook Street hotel. (227 Upper Brook Street)

Table 1 - Measurement locations

A site plan showing the approximate location of the RPS measurement positions is shown in Figure 2.

4.2 Summary of measurement results

A summary of the average daytime and night-time ambient noise levels recorded is detailed in Table 2. The values are the average L_{Aeq} and the lowest L_{A90} dB values measured during each daytime or night-time period. Values have been rounded to the nearest integer.

Measurement Position	Period	Start Date / Time	Finish Date / Time	Average $L_{Aeq,T}$ (dB)	Lowest $L_{A90,5min}$ (dB)
MP1	Day	Tue 17 Jun - 09:40	Tue 17 Jun - 12:40	64	55
	Night	Tue 08 Jul - 00:05	Tue 08 Jul - 03:00	54	43
MP2	Day	Tue 17 Jun - 12:45	Tue 17 Jun - 15:40	61	56
	Night	Wed 18 Jun - 00:00	Wed 18 Jun - 03:00	56	54
MP3	Day	Wed 18 Jun - 13:00	Wed 18 Jun - 16:00	63	53
	Night	Fri 04 Jul - 00:00	Fri 04 Jul - 03:00	55	46
MP4	Day	Wed 02 Jul - 12:05	Wed 02 Jul - 15:00	72	56
	Night	Wed 09 Jul - 00:05	Wed 09 Jul - 03:00	58	41
MP5	Day	Mon 07 Jul - 12:40	Mon 07 Jul - 15:40	67	56
	Night	Wed 09 Jul - 00:00	Wed 09 Jul - 03:00	54	41
MP6	Day	Mon 07 Jul - 12:30	Mon 07 Jul - 15:30	60	51
	Night	Tue 08 Jul - 00:00	Tue 08 Jul - 03:00	62	47

Table 2 - Summary of L_{Aeq} and L_{A90} noise monitoring results

Table 3 below gives the spectral values (octave band centre frequencies between 125Hz – 4kHz) for the lowest measured $L_{A90,5min}$ dB levels in each daytime and night-time period and are reproduced from Table 4.3 of the RPS report.

Position	Period	Octave Band Centre Frequency							Broadband L_{A90} (dB)
		63Hz	125Hz	250Hz	500Hz	1kHz	2kHz	4kHz	
MP1	Day	64	55	51	50	51	47	38	55
	Night	53	48	43	42	38	33	23	43
MP2	Day	67	55	50	48	53	49	38	56
	Night	58	51	47	45	51	47	32	54
MP3	Day	62	54	52	50	48	45	37	53
	Night	55	50	48	44	40	36	28	46
MP4	Day	64	56	53	52	52	48	39	56
	Night	57	46	41	37	36	31	20	41
MP5	Day	66	58	54	51	52	48	39	56
	Night	56	48	42	38	36	32	24	41
MP6	Day	56	58	53	47	45	42	33	51
	Night	52	46	46	46	40	38	29	47

Table 3 - Summary of spectral data for lowest $L_{A90,5min}$ dB measurements

Full single-figure results provided within the RPS report are reproduced in Appendix I

4.2.1 Discussion

The following table provides a summary of the subjective assessment of the prevailing noise climate as noted in the RPS report.

Position	Period	Comments
MP1	Day	Noise climate dominated by local road traffic
	Night	
MP2	Day	Noise climate dominated by local road traffic and existing building services noise
	Night	
MP3	Day	Noise climate dominated by local road traffic
	Night	
MP4	Day	
	Night	
MP5	Day	
	Night	
MP6	Day	
	Night	
	Day	
	Night	

Table 4 - Summary of noise contributions during surveys

5.0

Limiting plant noise levels

5.0 Limiting plant noise levels

To meet the requirements of the MCC Planning Policy, noise attributable to external services plant associated with the development should be designed to 5 dB below the existing ambient (L_{Aeq}) noise climate when measured at 1 m from the nearest sound sensitive receptors and should not contain tonal elements.

Table 5 details the highest permissible average noise levels from fixed services plant when measured at 1 m from the nearest sound sensitive properties. These are based on the measured prevailing background levels as detailed in Table 3.

Measurement Position	Period	Broadband $L_{A90,5min}$ (dB)
MP1	Day	50
	Night	38
MP2	Day	51
	Night	49
MP3	Day	48
	Night	41
MP4	Day	51
	Night	36
MP5	Day	51
	Night	36
MP6	Day	46
	Night	42

Table 5 - Limiting plant noise levels (5 dB below levels in Table 3)

It is considered that achieving compliance with the above limits should be sufficient to demonstrate compliance with the Local Authority requirements.

6.0

Plant noise impact assessment

6.0 Plant noise impact assessment

It is understood that five air handling units (AHUs) and two chillers are intended to be installed in order to serve the proposed redevelopment. Data provided by Air Handling Systems Ltd. quotes the following sound power levels for AHUs;

Item reference	Spectral sound power level, L_{WA} (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
AHU 01 Supply Inlet	80	76	80	85	76	74	73	70
AHU 01 Extract Outlet	90	82	80	86	83	80	76	74
AHU 02 Supply Inlet	85	82	85	89	82	80	79	76
AHU 02 Extract Outlet	92	84	82	88	85	82	78	76
AHU 03 Supply Inlet	84	83	89	90	82	80	77	71
AHU 03 Extract Outlet	97	85	81	89	87	85	80	78
AHU 04 Supply Inlet	84	81	89	86	77	77	74	70
AHU 04 Extract Outlet	91	83	81	87	84	81	77	75
AHU 05 Supply Inlet*	84	83	89	90	82	80	77	71
AHU 05 Extract Outlet*	97	85	81	89	87	85	80	78

* worst-case assumed values

Table 6 – AHU noise data

It is also understood that the following atmosphere side attenuators have been specified for each AHU as follows;

Item reference	Accredited insertion loss (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
AHU 01 Supply Inlet	5	7	16	32	35	27	19	15
AHU 01 Extract Outlet	4	6	14	29	30	23	18	15
AHU 02 Supply Inlet	6	9	16	32	45	34	23	17
AHU 02 Extract Outlet	6	9	18	36	35	26	18	14
AHU 03 Supply Inlet	6	9	17	36	40	31	21	16
AHU 03 Extract Outlet	8	11	23	48	49	36	23	17
AHU 04 Supply Inlet	6	9	19	38	39	30	20	16
AHU 04 Extract Outlet	5	8	15	30	30	23	19	16
AHU 05 Supply Inlet	6	9	17	36	40	31	21	16
AHU 05 Extract Outlet	8	11	23	48	49	36	23	17

* worst-case assumed values

Table 7 – AHU attenuators

The manufacturer's data for sound pressure level of the two chillers is as follows;

Model no.	Spectral sound pressure level @ 1 m L _{pA} (dB)							
	63 Hz	125 Hz	250 Hz	500 Hz	1 kHz	2 kHz	4 kHz	8 kHz
Daikin EWAT175B-SSA1	68	73	72	70	69	67	64	58

Table 8 - Chiller noise data

The location of these items of rooftop plant has been based upon the following roof layout drawings provided by PW Building Services. These are also reproduced in Appendix III.

- VE.15.057_3099-M-AF-94-4-1_A0 Mechanical Services Fourth Floor – Sheet 1 of 4
- VE.15.057_3099-M-AF-94-4-2_A0. Mechanical Services Fourth Floor – Sheet 2 of 4
- VE.15.057_3099-M-AF-94-4-3_A0. Mechanical Services Fourth Floor – Sheet 3 of 4
- VE.15.057_3099-M-AF-94-4-4_A0. Mechanical Services Fourth Floor – Sheet 4 of 4

6.1 Assessment procedure

In order to determine plant noise propagation to the nearest effected residential properties, a model has been produced using SoundPLAN 8.2 acoustic modelling software. This model is capable of accurately determining sound propagation by taking into account variations in topography, barrier attenuation provided by existing landscaping and buildings, and distance attenuation.

Using the information as listed in Section 6.1, the noise propagation to the noise sensitive receptors listed in Section 3.0 has been calculated, and graphics indicating these levels in relation to the measured night-time background levels are presented in Appendix II. Since night-time levels are lower than daytime, it follows that achieving the criteria at night-time will say daytime emission limits achieved by default. The results are summarised in the table below.

Location	Worst Case Cumulative Sound Pressure Level, L _{Aeq} dB	Cumulative limiting noise level for all items of building services plant, L _{Aeq} dB	Assessment outcome
Nick Everton House	38	38	Equal to limiting noise level
The Grafton	38	49	-11 dB below noise level requirement
Wilmslow Park	33	41	-8 dB below noise level requirement
Victoria Terrace	34	36	-2 dB below noise level requirement
Victoria Hall	23	36	-13 dB below noise level requirement
Travelodge Manchester Upper Brook Street	40	42	-2 dB below noise level requirement

Table 9 - Plant noise assessment results

As can be seen from the results detailed in , the worst-case level of sound impact due to new building services plant associated with the redevelopment is predicted to be 5 dB below the lowest relevant measured L_{A90,15min} level, and as such satisfies the Local Authority requirements for plant noise emission limits.

7.0

Conclusions

7.0 Conclusions

An assessment of the potential sound impact due to the proposed new external plant associated with the bone marrow transplant unit redevelopment at the Manchester Royal Infirmary has been carried out.

This assessment has been based on plant noise level data and location plans supplied to Cundall by PW Building Services, and previous noise survey data of the site undertaken by RPS.

Calculations carried out in the acoustic modelling software SoundPLAN show that for all nearby noise-sensitive receptors, the current plan selections and layouts meet the plant noise emission limiting criteria as set out by the Local Authority.

8.0

Appendices

Appendix I RPS noise survey data

The tables below provide survey data from each measurement period, T (5 minutes). All survey results reproduced from RPS report ref B7477-ENV-P2 dated 2nd April 2015.

Measurement Position 1

Day: 17/06/2014				Night: 08/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}	Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
09:40	62.3	70.5	57.6	00:05	54.1	64.1	48.1
09:45	62.5	69.1	57.5	00:10	54.4	63.7	46.2
09:50	64.1	75.8	57.3	00:15	54.4	62.7	47.9
09:55	62.5	69.3	57.8	00:20	56.7	63.7	49.0
10:00	62.2	70.4	56.8	00:25	54.6	63.7	46.8
10:05	65.3	77.4	59.4	00:30	52.1	64.3	46.4
10:10	64.9	79.6	58.3	00:35	52.5	61.2	46.2
10:15	67.1	84.8	56.6	00:40	54.1	61.8	48.0
10:20	61.9	68.1	55.7	00:45	53.4	63.2	45.6
10:25	71.9	89.7	55.9	00:50	54.9	70.3	46.9
10:30	62.1	69.3	55.5	00:55	57.7	75.5	47.0
10:35	61.4	69.2	55.6	01:00	52.6	65.4	45.9
10:40	62.4	69.4	56.4	01:05	63.4	83.1	46.3
10:45	62.9	73.8	57.1	01:10	52.3	60.3	45.2
10:50	61.6	68.4	55.8	01:15	51.8	62.2	44.5
10:55	63.3	78.3	56.8	01:20	53.5	63.7	45.7
11:00	60.9	70.7	55.2	01:25	52.9	62.2	45.5
11:05	62.1	69.0	56.8	01:30	53.1	63.2	44.9
11:10	62.8	69.5	55.7	01:35	50.2	61.2	44.5
11:15	62.4	68.4	57.9	01:40	52.0	63.0	45.9
11:20	62.4	70.9	56.5	01:45	50.3	63.7	44.7
11:25	62.9	72.0	56.5	01:50	52.2	60.3	45.3
11:30	62.2	69.6	54.9	01:55	49.9	58.6	43.8
11:35	62.4	71.9	56.4	02:00	52.7	63.1	45.3
11:40	61.8	70.2	55.7	02:05	51.0	61.6	44.5
11:45	61.6	72.3	55.0	02:10	53.3	65.8	44.4
11:50	62.0	71.1	56.6	02:15	50.7	62.1	43.6
11:55	61.1	67.0	55.7	02:20	51.2	60.5	44.3
12:00	61.5	68.3	55.6	02:25	52.5	62.5	43.5
12:05	62.1	70.2	55.7	02:30	49.9	63.4	43.2
12:10	62.4	70.6	55.5	02:35	51.0	61.9	43.7
12:15	61.6	69.5	54.5	02:40	51.0	61.4	44.5
12:20	61.8	68.7	55.4	02:45	49.0	61.3	43.2

Measurement Position 2

Day: 17/06/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
12:45	60.9	67.6	56.9
12:50	59.2	66.9	56.2
12:55	59.9	67.8	56.7
13:00	60.0	69.2	56.5
13:05	65.0	83.3	57.0
13:10	61.8	77.6	56.7
13:15	60.2	66.8	56.9
13:20	59.1	68.4	55.7
13:25	59.1	66.1	55.9
13:30	61.0	76.4	55.8
13:35	59.3	67.7	55.9
13:40	58.9	65.2	55.9
13:45	61.5	69.0	57.5
13:50	67.1	88.8	56.5
13:55	61.9	79.0	56.3
14:00	59.0	69.0	56.2
14:05	60.7	76.7	56.4
14:10	59.3	66.6	56.4
14:15	58.8	67.2	56.0
14:20	59.9	71.7	56.7
14:25	60.1	65.8	56.8
14:30	59.8	66.4	56.8
14:35	59.5	65.5	56.5
14:40	64.1	85.8	56.8
14:45	59.7	67.7	56.4
14:50	63.6	73.4	57.1
14:55	60.2	70.6	56.2
15:00	60.7	68.3	56.9
15:05	59.1	65.5	56.3
15:10	58.6	67.0	56.1
15:15	59.0	65.3	56.4
15:20	59.8	74.1	56.5
15:25	60.1	65.8	56.7
15:30	59.0	64.4	56.5
15:35	59.4	67.1	56.3

Night: 18/06/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
00:00	57.9	65.4	54.7
00:05	57.6	68.3	54.5
00:10	56.9	64.2	54.4
00:15	56.0	61.9	54.3
00:20	56.7	62.9	54.4
00:25	55.7	62.9	54.3
00:30	56.9	66.9	54.3
00:35	56.9	66.3	54.5
00:40	56.1	64.9	54.5
00:45	55.8	64.1	54.2
00:50	55.8	64.6	54.2
00:55	55.8	65.3	54.4
01:00	56.5	64.1	54.5
01:05	57.2	65.8	54.5
01:10	57.6	73.1	54.7
01:15	55.9	64.4	53.9
01:20	55.2	61.6	53.9
01:25	55.9	62.7	54.2
01:30	55.5	65.9	54.1
01:35	55.7	64.8	54.0
01:40	54.7	58.2	54.0
01:45	56.3	65.4	54.2
01:50	55.6	65.5	54.0
01:55	55.2	63.3	54.3
02:00	56.5	69.4	54.1
02:05	57.2	68.0	54.1
02:10	56.3	65.6	54.3
02:15	55.4	62.3	54.2
02:20	55.4	62.7	54.0
02:25	55.6	64.9	53.8
02:30	56.2	66.1	54.0
02:35	56.2	64.6	54.3
02:40	56.3	66.8	54.0
02:45	55.3	62.4	53.9
02:50	55.1	63.0	53.9
02:55	54.7	63.6	53.8

Measurement Position 3

Day: 18/06/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
13:00	63.4	72.7	57.4
13:05	60.7	71.2	52.8
13:10	59.5	64.2	54.8
13:15	60.0	66.3	54.9
13:20	59.6	70.2	54.3
13:25	64.5	79.3	54.5
13:30	59.7	69.3	55.0
13:35	59.2	64.3	55.3
13:40	62.9	77.1	57.7
13:45	68.4	84.0	57.5
13:50	61.9	70.3	56.8
13:55	63.3	74.4	57.5
14:00	59.3	66.2	55.5
14:05	64.9	85.7	54.2
14:10	59.7	68.6	54.7
14:15	59.4	66.8	55.6
14:20	61.8	76.9	55.8
14:25	59.3	67.0	55.4
14:30	59.0	63.3	54.5
14:35	60.5	77.7	56.1
14:40	61.7	73.5	56.9
14:45	59.7	68.5	54.0
14:50	59.2	66.3	53.5
14:55	60.6	72.4	53.6
15:00	66.5	86.2	55.0
15:05	70.9	90.7	56.0
15:10	64.7	78.5	58.7
15:15	62.1	76.5	58.1
15:20	60.3	71.2	55.8
15:25	61.1	73.2	56.4
15:30	61.9	75.6	56.6
15:35	60.3	68.6	55.8
15:40	61.4	73.9	56.1
15:45	59.6	66.8	55.1
15:50	62.5	73.5	56.5
15:55	63.6	72.4	57.5

Night: 04/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
00:00	57.4	65.6	49.4
00:05	56.2	66.9	48.6
00:10	56.9	69.1	48.4
00:15	55.9	63.6	49.2
00:20	55.5	65.3	48.2
00:25	55.1	66.2	47.6
00:30	53.8	61.0	47.7
00:35	57.0	71.8	47.6
00:40	55.1	63.6	48.4
00:45	57.1	75.8	47.6
00:50	64.2	83.0	47.8
00:55	53.9	64.9	47.6
01:00	52.3	66.8	47.0
01:05	54.8	63.3	47.6
01:10	55.0	65.8	47.7
01:15	54.3	61.4	47.8
01:20	53.1	61.8	47.1
01:25	53.5	64.7	46.9
01:30	52.5	63.0	46.9
01:35	54.4	65.2	46.9
01:40	54.6	64.2	46.7
01:45	54.1	65.7	46.3
01:50	53.8	67.0	46.4
01:55	50.6	58.8	45.9
02:00	52.4	61.5	46.9
02:05	54.3	63.4	46.6
02:10	53.9	64.5	46.4
02:15	52.0	61.2	46.1
02:20	51.7	63.9	46.1
02:25	52.4	61.7	46.3
02:30	52.6	69.0	45.8
02:35	52.0	64.0	45.8
02:40	52.7	64.4	46.0
02:45	52.2	62.2	46.4
02:50	54.0	66.1	46.1
02:55	58.3	75.9	46.9

Measurement Position 4

Day: 02/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
12:05	66.3	73.3	58.3
12:10	81.6	98.0	56.9
12:15	64.8	75.3	55.8
12:20	64.3	75.5	57.3
12:25	65.5	72.7	56.9
12:30	66.7	74.3	59.5
12:35	66.9	76.9	58.3
12:40	66.1	73.7	57.1
12:45	64.9	75.9	55.8
12:50	65.6	73.5	58.2
12:55	78.7	95.8	58.4
13:00	67.5	76.4	58.4
13:05	67.3	85.5	57.6
13:10	68.3	76.5	60.4
13:15	80.3	99.8	59.1
13:20	78.8	98.3	58.3
13:25	66.6	78.1	58.6
13:30	66.9	78.8	58.2
13:35	65.5	74.2	56.8
13:40	66.2	73.5	57.3
13:45	66.2	74.4	58.5
13:50	66.7	75.5	59.6
13:55	66.1	74.4	57.5
14:00	67.0	75.8	60.0
14:05	65.6	73.1	56.8
14:10	65.9	74.5	59.2
14:15	66.5	75.0	57.9
14:20	66.3	72.9	59.9
14:25	66.4	74.3	59.5
14:30	66.8	74.7	60.0
14:35	65.9	73.2	58.0
14:40	66.5	74.0	59.6
14:45	67.2	74.7	59.9
14:50	66.3	73.8	60.1
14:55	66.5	74.8	59.2

Night: 09/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
00:05	61.5	72.6	45.6
00:10	58.0	71.3	43.8
00:15	59.0	73.0	43.1
00:20	62.2	77.6	44.1
00:25	59.1	73.1	44.6
00:30	59.9	73.1	44.6
00:35	59.9	72.7	43.1
00:40	57.2	71.2	41.8
00:45	59.9	73.9	43.2
00:50	60.0	71.6	43.6
00:55	57.9	71.6	42.6
01:00	59.1	71.1	42.6
01:05	58.3	70.3	43.9
01:10	59.9	71.8	42.5
01:15	59.0	73.5	42.8
01:20	58.3	71.9	42.7
01:25	59.3	74.0	44.1
01:30	54.4	69.5	42.0
01:35	61.4	75.5	43.2
01:40	54.4	67.8	41.4
01:45	52.5	65.4	41.8
01:50	55.5	70.3	41.5
01:55	56.9	73.0	42.2
02:00	63.0	80.8	40.7
02:05	58.8	71.5	40.6
02:10	57.5	72.6	41.0
02:15	55.7	74.6	41.5
02:20	53.6	65.9	40.8
02:25	54.1	70.8	40.9
02:30	59.2	72.7	41.8
02:35	56.5	71.7	41.5
02:40	53.8	71.5	41.4
02:45	55.6	70.8	41.2
02:50	54.7	74.1	41.4
02:55	54.4	73.9	41.3

Measurement Position 5

Day: 07/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
12:40	66.0	74.4	56.9
12:45	66.2	83.3	58.7
12:50	63.5	69.7	58.6
12:55	63.3	70.1	57.4
13:00	73.3	90.7	56.1
13:05	64.5	71.3	58.6
13:10	66.0	75.2	61.3
13:15	65.7	77.4	60.0
13:20	64.6	74.4	59.4
13:25	64.9	79.1	59.6
13:30	64.1	69.5	59.6
13:35	63.7	71.1	59.5
13:40	63.4	71.8	58.8
13:45	62.6	68.1	58.2
13:50	66.1	82.1	58.9
13:55	64.0	72.1	59.4
14:00	65.9	75.2	60.6
14:05	64.4	74.5	59.7
14:10	62.1	67.4	58.4
14:15	62.5	69.0	58.3
14:20	62.2	70.7	58.2
14:25	62.5	68.8	58.4
14:30	76.6	95.7	58.8
14:35	63.1	73.9	57.5
14:40	63.0	69.0	59.5
14:45	62.8	75.3	58.5
14:50	63.2	75.3	58.5
14:55	63.2	72.4	59.0
15:00	73.0	93.1	58.3
15:05	64.7	73.7	58.9
15:10	64.2	71.6	59.4
15:15	64.1	73.3	57.8
15:20	65.3	74.3	57.9
15:25	64.1	69.4	58.8
15:30	63.6	71.8	57.7
15:35	73.0	88.9	57.6

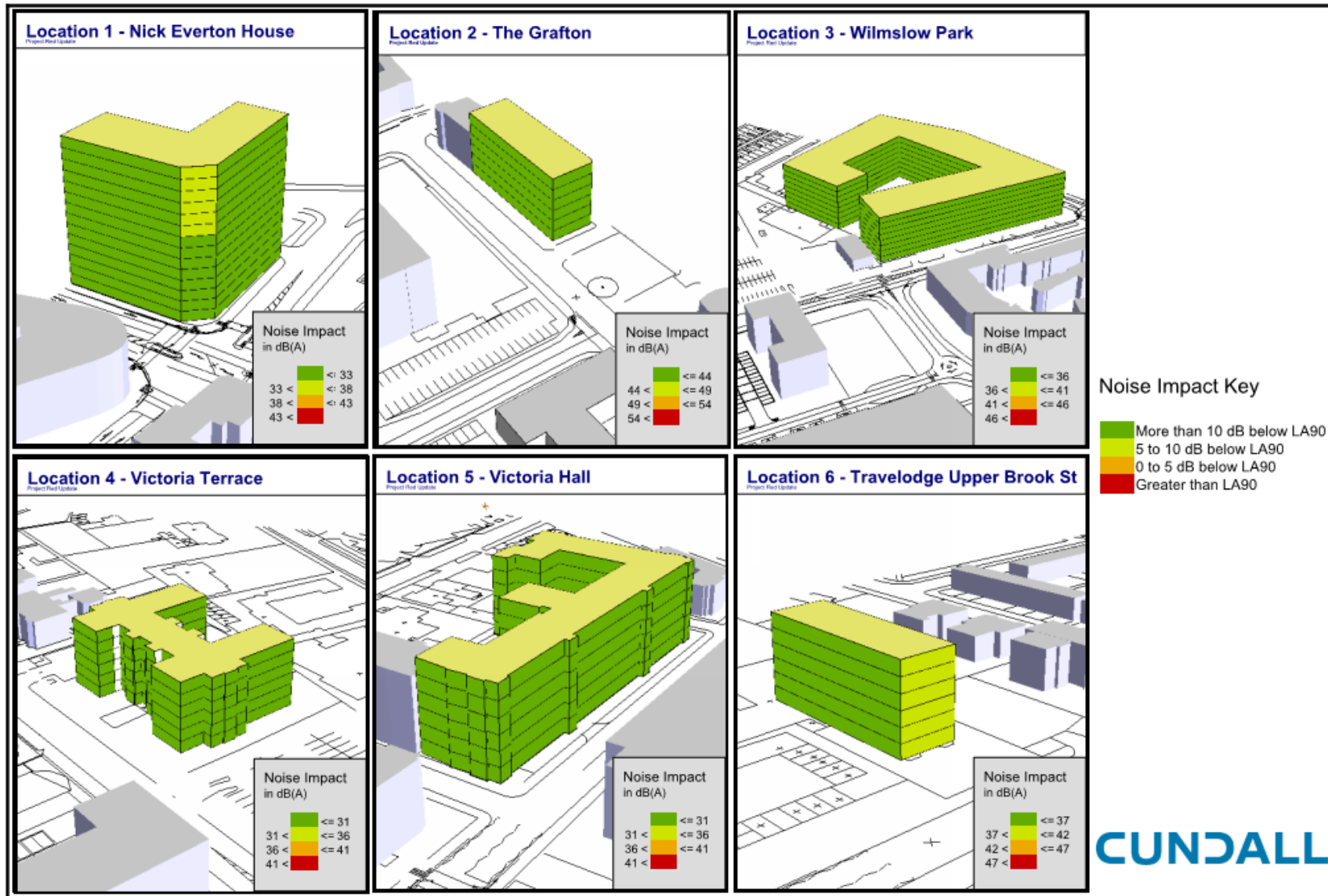
Night: 09/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
00:00	55.7	64.2	46.7
00:05	55.5	64.5	46.3
00:10	55.5	64.3	45.3
00:15	55.7	64.4	44.9
00:20	54.9	62.7	43.1
00:25	55.3	62.4	44.3
00:30	55.4	64.8	42.9
00:35	54.0	64.6	43.0
00:40	52.9	63.6	42.1
00:45	54.5	64.6	43.4
00:50	54.1	62.9	44.8
00:55	54.3	63.7	43.8
01:00	53.7	63.6	42.8
01:05	53.3	62.4	44.4
01:10	54.1	66.2	43.2
01:15	53.7	62.0	43.3
01:20	53.7	65.0	43.1
01:25	51.0	62.3	42.4
01:30	53.6	62.6	42.6
01:35	61.8	79.7	43.9
01:40	50.5	62.3	42.3
01:45	54.2	63.1	43.4
01:50	50.1	60.7	42.0
01:55	53.1	63.2	44.1
02:00	53.2	64.0	41.4
02:05	52.2	65.8	41.3
02:10	51.6	63.0	41.8
02:15	52.5	62.9	42.6
02:20	50.9	61.6	41.6
02:25	48.4	59.3	42.2
02:30	54.2	65.7	42.7
02:35	53.5	64.0	41.9
02:40	53.3	63.2	42.3
02:45	50.0	60.0	41.9
02:50	51.4	62.4	42.5
02:55	52.4	62.7	42.1

Measurement Position 6

Day: 17/06/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
12:30	56.0	64.6	51.1
12:35	56.2	64.2	51.2
12:40	56.9	65.5	51.1
12:45	55.7	60.7	51.3
12:50	62.9	78.8	50.8
12:55	56.3	62.5	50.9
13:00	59.4	76.2	51.0
13:05	62.1	81.5	51.6
13:10	65.9	77.2	52.4
13:15	58.8	72.3	52.8
13:20	69.9	78.9	54.3
13:25	57.3	64.8	53.4
13:30	57.4	63.5	53.7
13:35	58.2	63.0	54.5
13:40	57.1	62.9	53.5
13:45	58.0	70.3	53.5
13:50	56.9	63.5	53.2
13:55	55.9	63.7	52.9
14:00	56.4	64.7	52.8
14:05	56.3	62.9	52.7
14:10	57.2	63.9	52.8
14:15	56.2	61.2	52.6
14:20	57.2	64.3	53.5
14:25	56.3	62.0	53.0
14:30	58.0	70.9	53.0
14:35	55.9	61.1	52.9
14:40	57.0	64.7	53.0
14:45	56.4	62.6	53.0
14:50	55.9	61.8	52.7
14:55	56.7	63.0	53.5
15:00	59.9	76.3	53.4
15:05	56.9	65.9	53.2
15:10	56.9	62.8	53.7
15:15	57.5	64.1	53.3
15:20	59.4	66.8	53.4
15:25	58.1	66.5	53.8

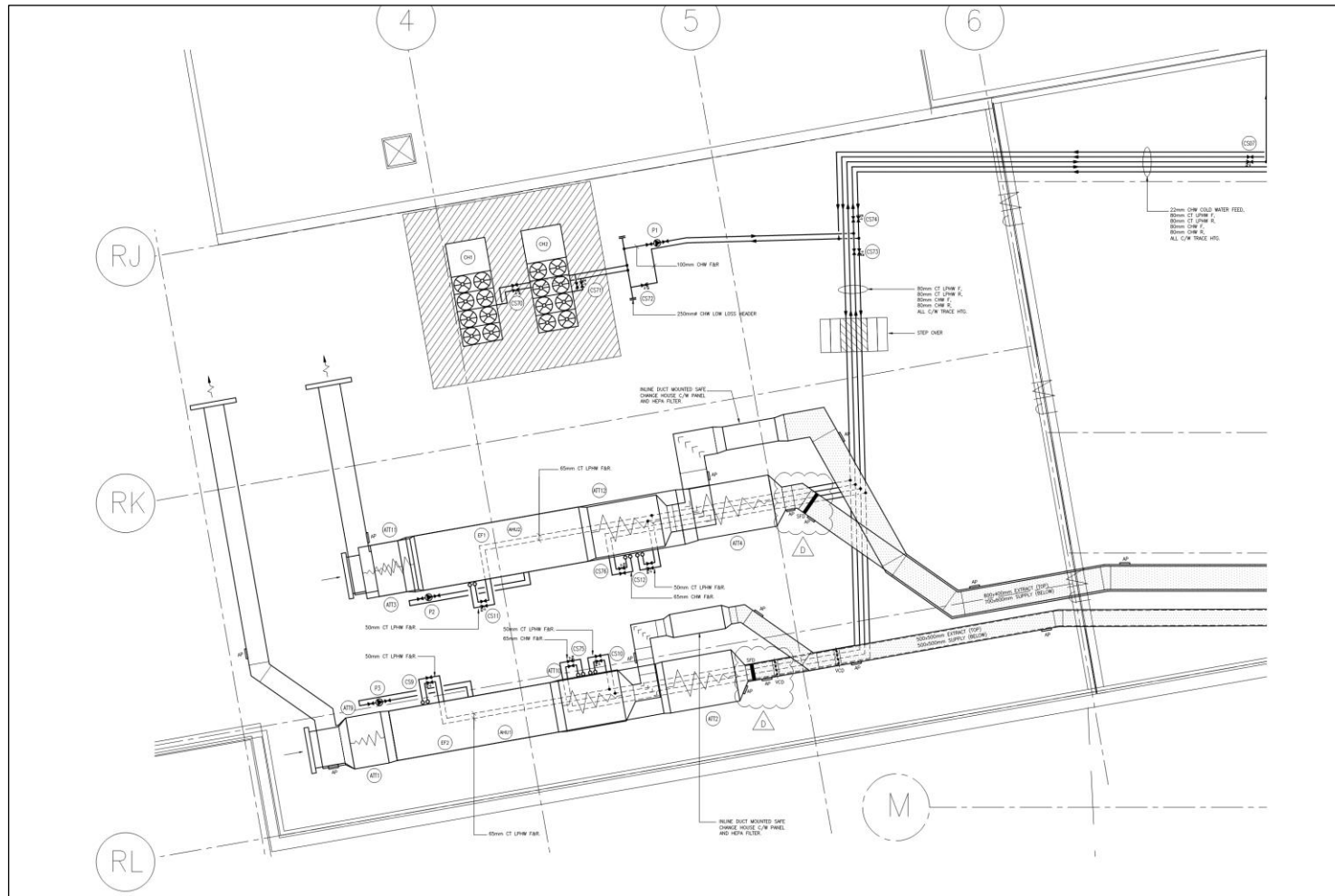
Night: 08/07/2014			
Start Time	L _{Aeq,5min}	L _{AF,max}	L _{A90,5min}
00:00	62.1	77.3	49.4
00:05	64.1	80.2	48.1
00:10	65.1	82.4	48.1
00:15	65.5	84.5	48.1
00:20	63.6	75.4	48.8
00:25	62.8	73.5	48.4
00:30	63.1	76.4	48.1
00:35	61.9	77.6	47.5
00:40	63.5	74.0	48.9
00:45	61.5	73.7	47.5
00:50	64.4	76.4	49.1
00:55	62.6	76.8	47.8
01:00	61.2	75.3	47.6
01:05	61.0	74.4	47.3
01:10	60.3	75.4	47.4
01:15	62.1	75.0	48.1
01:20	62.1	76.8	49.0
01:25	61.7	73.2	47.9
01:30	61.9	75.4	47.4
01:35	60.8	73.8	47.3
01:40	61.6	76.3	47.5
01:45	58.3	73.4	47.4
01:50	62.8	75.3	46.9
01:55	55.9	73.7	47.1
02:00	62.4	80.9	47.7
02:05	60.6	73.5	46.9
02:10	58.1	73.4	47.0
02:15	56.2	73.5	46.9
02:20	61.2	79.7	47.0
02:25	61.2	76.3	46.9
02:30	59.4	76.8	46.5
02:35	57.8	75.1	46.9
02:40	60.4	74.2	47.8
02:45	57.2	71.3	46.7
02:50	60.7	74.0	46.9
02:55	58.6	73.8	47.2

Appendix II Noise modelling map results

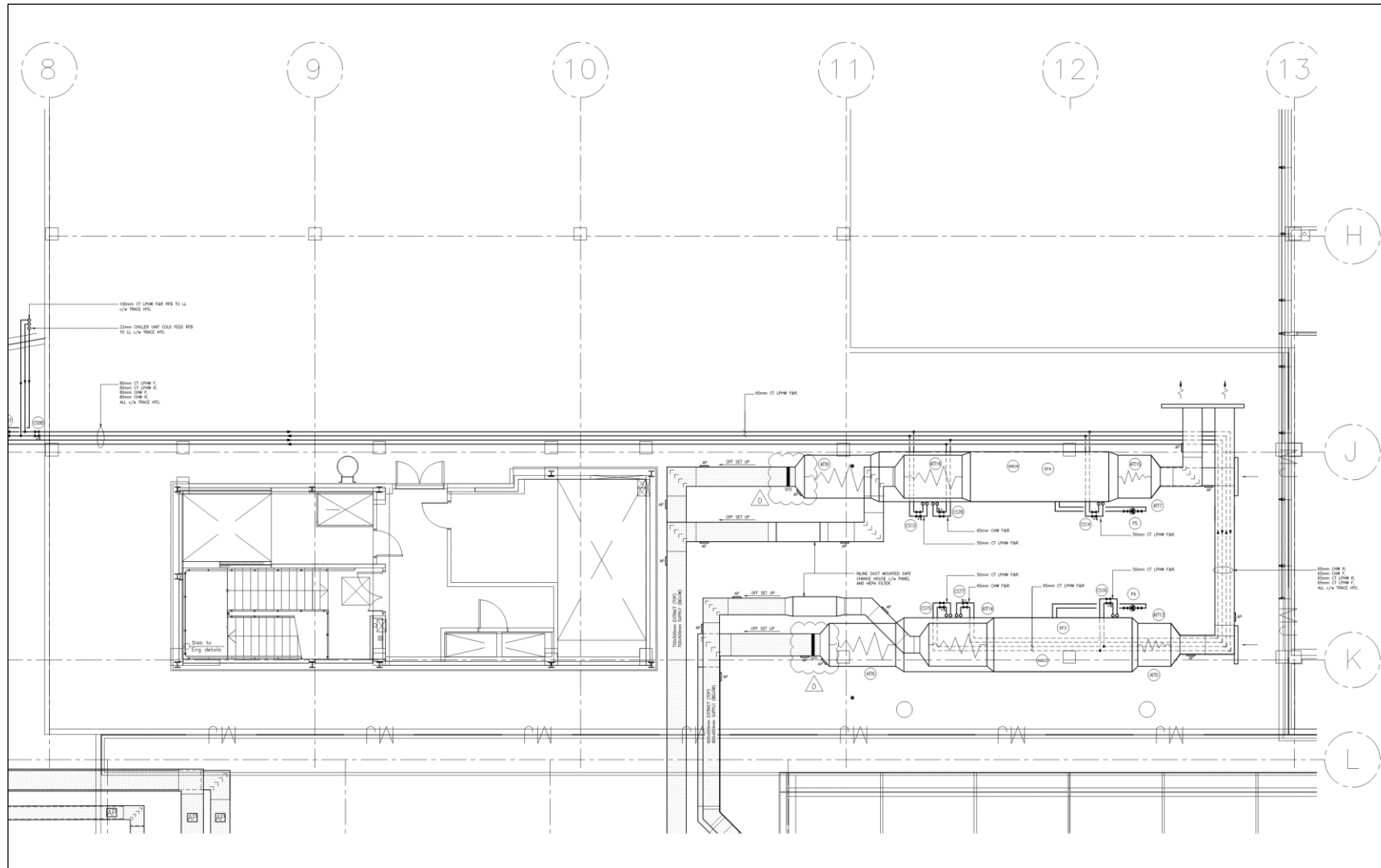


Appendix III Rooftop plant layouts

CH1, CH2, AHU1 and AHU2



AHU03 and AHU04



[illegible]

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