

Phase 2 New Victoria: Office Development

Report on Acoustics and Vibration

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Table of contents

1.	Introduction	5
1.1	Introduction	5
1.2	The Site	5
1.3	The Proposed Development.....	5
1.4	Nearby Noise-Sensitive Receptors	5
1.5	Scope of This Report.....	6
2.	Planning Policy, Guidance & Standards	7
2.1	Overview.....	7
2.2	National Planning Policy and Guidance	7
2.3	Planning Practice Guidance	7
2.4	Local Planning Policy	8
2.5	Expected Requirements of Manchester City Council	9
2.6	Guidance on Suitable Indoor Noise Levels	11
2.7	Summary of Assessment Approach	12
3.	Environmental Noise Survey	14
3.1	Overview.....	14
3.2	Procedure	14
3.3	Equipment	15
3.4	Observations and Weather Conditions.....	15
3.5	Measurement Results	16
4.	Limits on Building Services Noise	18
4.1	Overview.....	18
4.2	Limits	18
5.	Outline Building Services Noise Impact Assessment.....	19
5.1	Overview.....	19
5.2	Methodology	19
5.3	Proposed Sound Sources and Assumptions.....	19
5.4	Outline Building Services Noise Predictions	22
5.5	Sound Character and Acoustic Feature Corrections.....	22
5.6	Outline Building Services Noise Assessment	22
5.7	Expected Noise Control Requirements	23
5.8	Out of Office Hours Operation.....	23
5.9	Conclusions	23
6.	Assessment of Activity Noise from Proposed Commercial Units	24
6.1	Overview.....	24
6.2	Assessment Criteria	24

6.3	Methodology	24
6.4	Proposed Sound Sources and Assumptions	25
6.5	Predicted sound levels	26
6.6	Summary	26
7.	Site Suitability: Noise Ingress into the Proposed Development	27
7.1	Overview	27
7.2	Noise Ingress with Ventilation via Openable Windows	27
7.3	Noise Ingress with Windows Closed	28
7.4	Summary	28
8.	Site Suitability: Ground-borne Vibration from Metrolink	29
8.1	Overview	29
8.2	Guidance on Vibration and GBN	29
8.3	Acoustic Design Criteria	30
8.4	Assessment Approach	31
8.5	Vibration Survey Results	32
8.6	Vibration and GBN within the Proposed Development	32
8.7	Conclusions	33
9.	Summary	34
	Appendix 1 Glossary	35
	Appendix 2 Additional Figures	38
	Appendix 3 Measurement Instrumentation	41
	Appendix 4 Detailed Survey Results	42
	Appendix 5 Detailed Noise Modelling Results	50

1. Introduction

1.1 Introduction

Sweco UK Limited have been appointed by Toriview Ltd to provide acoustic consultancy services in relation to the New Victoria Office development ('the Proposed Development') located at land adjacent to Corporation Street, Manchester, M3 1NX ('the Site'). This report presents preliminary acoustic assessments to accompany the planning application for the Proposed Development.

This report contains technical terminology relating to acoustics. For this reason, an introduction to acoustics and a glossary of terminology is presented in Appendix 1.

1.2 The Site

The Site is located within the Manchester City Council (MCC) planning authority area and in central Manchester adjacent to Corporation Street, Manchester, M3 1NX.

The Site is bounded by Manchester Victoria railway station to the west, Metrolink tram lines to the south, Corporation Street to the east and the Phase 1 New Victoria: residential development to the north (two residential blocks currently under construction).

The site primarily comprises hardstanding, a small number of temporary cabins are present on the site, supporting Phase 1 of New Victoria. The Site is currently partially fenced off restricting access, as it is located within the boundary of the construction compound for New Victoria Phase 1: residential development and currently accommodates site access, parking and storage facilities.

1.3 The Proposed Development

The Proposed Development comprises the following:

"Construction of a 10 Storey office building plus basement, comprising up to 18,101 (GEA) of office accommodation, ground floor commercial units, roof terrace, plant, cycle parking, hard and soft landscaping, access and servicing and other associated works."

As such, the Proposed Development would accommodate the following uses:

- Eight office-use floors, fitted out to typical Cat A standards;
- Commercial units (retail/café - bar) on the ground floor along with collaborative working spaces / gathering areas and the reception;
- Ancillary spaces such as the lobbies, WCs, cycle store and plant rooms; and
- External amenity areas in the form of roof terraces on Levels 08, 09 and 10..

Building services equipment associated with the Proposed Development would mainly be located on the upper levels and at roof level. Local air handling plant is also proposed on each office floor of the building. Further details of the proposed building services systems are presented in Section 5.3.

1.4 Nearby Noise-Sensitive Receptors

Multiple sensitive receptors are located within the vicinity of the Site. The key noise-sensitive receptors have been identified as follows:

- New Victoria Phase 1: residential development: two residential blocks under construction and
- Indigo Hotel.

A variety of commercial and hospitality uses are also located within the vicinity of the Proposed Development. For the purposes of the assessment, however, only the above two identified receptors were considered to be noise-sensitive.

The nearest noise-sensitive receptors to the Proposed Development are shown in Figure A2-1 in Appendix 2.

1.5 Scope of This Report

The scope of this report has been developed through a review of national and local planning policy and through a review of the noise and vibration technical guidance produced by MCC. This is described further in Section 2.4.

This report aims to support the planning application by providing further detail with respect to the potential effects due to noise arising from the Proposed Development as follows:

- Details and results of environmental noise surveys carried out in the vicinity of the Site are presented.
- Limits that apply to noise from building services equipment at nearby sensitive receptors are presented within this report. An outline assessment of noise from the primary building services systems is also presented.
- Activity noise breakout from the proposed commercial units also has the potential to affect nearby existing noise-sensitive receptors. Indoor activity noise limits and provisional façade sound reduction requirements have been determined to minimise the potential for adverse effects due to this activity noise break-out.

In addition, this report presents an outline assessment of noise ingress into the Proposed Development. This assessment provides an indication of the building envelope constructions and ventilation strategies that would be suitable for achieving good noise conditions within the Proposed Development.

Vibration and re-radiated ground-borne noise from Metrolink tram movements and the potential effects on the Proposed Development have also been considered within this report. Details of a vibration survey are presented along with an assessment of the potential effects of vibration and ground-borne noise on the Proposed Development.

Mitigation measures have been considered where the Proposed Development would otherwise result in adverse effects due to noise. The mitigation measures that are expected to be required to control noise from the primary building services systems and activity noise are indicated with this report. The acoustic design of the building will need to be reviewed as the design progresses to ensure that no adverse effects occur.

2. Planning Policy, Guidance & Standards

2.1 Overview

This section presents national and local policies, standards, guidance and criteria that are relevant to the Proposed Development and the scope of this report.

2.2 National Planning Policy and Guidance

2.2.1 National Planning Policy Framework and Noise Policy Statement for England

Two national planning policy documents are relevant to the Proposed Development:

- The 'National Planning Policy Framework (NPPF)'¹; and
- The 'Noise Policy Statement for England (NPSE)'².

The NPPF sets out the Government's planning policies for England and describes how these are applied. The NPSE sets out the long-term vision of the Government's noise policy and the following noise policy aims:

- 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.

The NPSE relates the above terminology to concepts from toxicology, as applied by the World Health Organization, and defines the following:

- NOEL (No Observed Effect Level): No detectable effect on health and quality of life due to noise.
- LOAEL (Lowest Observed Adverse Effect Level): Threshold above which there are adverse effects on health and quality of life due to noise.
- **Noise policy aim:** Noise above this threshold to be mitigated and minimised.
- SOAEL (Significant Observed Adverse Effect Level): Threshold above which there are significant adverse effects on health and quality of life due to noise.
- **Noise policy aim:** Noise above this threshold to be avoided.

The NPSE should be taken into account in the preparation of local and neighbourhood plans and is a material consideration in planning decisions. It applies to all forms of noise (apart from noise in the workplace) and aims to provide clarity regarding current policies and practices to enable noise management decisions to be made within the wider context.

2.3 Planning Practice Guidance

In July 2019, the Government published updated national planning practice guidance (NPPG) for Noise³. The NPPG includes further guidance on the effect levels described in the Noise Policy Statement of England and examples of the outcomes at each effect level. It also presents further factors that need to be considered when assessing noise and the effect on future occupants of the

¹ *National Planning Policy Framework (NPPF)*, Ministry of Housing, Communities & Local Government, July 2021.

² *Noise Policy Statement for England (NPSE)*, Department for Environment, Food & Rural Affairs, March 2010.

³ <https://www.gov.uk/guidance/noise--2>

Proposed Development, such as the need to provide alternative ventilation methods when relying on the closed windows to provide suitable indoor acoustic conditions in sensitive rooms.

2.4 Local Planning Policy

2.4.1 Manchester Local Plan

The Manchester Local Plan is the adopted development plan for Manchester and guides development within the city. The Local Plan comprises the Core Strategy, an Interactive Proposals Map, extant Unitary Development Plan policies, and two Development Plan Documents (for Waste and for Minerals).

The Core Strategy was adopted by MCC on 11 July 2012 and outlines the Council's vision for Manchester in 2027. The Core Strategy contains the following policies relevant to this report:

Policy SP 1: Spatial Principles (extract)

"Core Development Principles:

Development in all parts of the City should:-

- *Make a positive contribution to neighbourhoods of choice including:*
 - *creating well designed places that enhance or create character.*
 - *making a positive contribution to the health, safety and wellbeing of residents considering the needs of all members of the community regardless of age, gender, disability, sexuality, religion, culture, ethnicity or income.*
 - *protect and enhance the built and natural environment.*
- *Minimise emissions, ensure efficient use of natural resources and reuse previously developed land wherever possible.*
- *Improve access to jobs, services, education and open space by being located to reduce the need to travel and provide good access to sustainable transport provision."*

Policy C 10: Leisure and the Evening Economy

"New development and redevelopment that supports the evening economy, contributes to the vitality of district centres and supports a balanced and socially inclusive evening/night-time economy will be permitted, subject to the following considerations:

- *Cumulative impact – in areas where there is already a concentration of bars (A4), hot food takeaways (A5) and other night-time uses which are detrimental to the character or vitality and viability of the centre, there will be a presumption against further facilities.*
- *Residential amenity – the proposed use should not create an unacceptable impact on neighbouring uses in terms of noise, traffic and disturbance.*
- *Balance - new uses in Manchester centres should support both the day-time and evening/night-time economies whilst not undermining the role of the primary shopping area..."*

Policy DM 1: Development Management

"All development should have regard to the following specific issues...:-

- *Appropriate siting, layout, scale, form, massing, materials and detail.*
- *Impact on the surrounding areas in terms of the design, scale and appearance of the Proposed Development. ...*

- *Effects on amenity, including privacy, light, noise, vibration, air quality, odours, litter, vermin, birds, road safety and traffic generation. This could also include proposals which would be sensitive to existing environmental conditions, such as noise. ...*
- *Design for health.*
- *Adequacy of internal accommodation and external amenity space. ...*

Subject to scheme viability, developers will be required to demonstrate that new development incorporates sustainable construction techniques as follows:-

... (b) For new commercial developments to demonstrate best practice which will include the application of the BREEAM (Building Research Establishment Environmental Assessment Method) standards. By 2019 provisions similar to the Code for Sustainable Homes will also apply to all new non-domestic buildings."

The Local Plan also includes Saved Policies from the Unitary Development Plan (UDP). The Citywide Development Control Policies document contains policies DC26.1 to DC26.6 specifically relating to noise. These policies, in summary, state that MCC intend to use the development control process to reduce the impact of noise on people living and working in the City. In particular, consideration will be given to the effect of new development proposals which are likely to be generators of noise.

Conditions will (where appropriate) be used to control the impacts of developments, and the Council expect to see assessments of the likely noise impact of developments that could generate potentially unacceptable levels of noise.

2.5 Expected Requirements of Manchester City Council

The expected requirements of MCC have been determined with reference to the previous planning conditions relating to acoustics (Extant Consent, MCC ref. 111777/FO/2016/C1) and the MCC Planning & Noise: Technical Guidance. These are described further below.

2.5.1 Planning History and Previous Planning Conditions

A planning application (ref. 111777/FO/2016/C1) was submitted to Manchester City Council in April 2016, seeking the erection of two residential buildings (the Phase 1 New Victoria: residential development) and one office building (the Phase 2 New Victoria: office development) along with associated works and improvements to the public realm. This application was granted in September 2016 subject to various planning conditions. The planning conditions from the Extant Consent that are relevant to the acoustic design of the Phase 2 New Victoria: office development are presented below:

Table 2-1: Planning conditions relevant to acoustics from the Extant Consent (ref. 111777/FO/2016/C1)

Condition	Details
23	The buildings shall be acoustically insulated and treated to limit the break out of noise in accordance with a noise study of the buildings and a scheme of acoustic treatment that has been submitted to and approved in writing by the City Council as local planning authority. The scheme shall be implemented in full before the use commences. Additionally, where entertainment noise is a factor in the noise climate the sound insulation scheme shall be designed to minimize as far as is reasonably practicable the intrusive internal noise levels in habitable rooms in the 63Hz and 125Hz octave centre frequency bands. The mechanical ventilation scheme shall be designed to provide a level of masking of intrusive noise in the lower frequency bands up until 23:00 and the scheme shall be submitted to and approved in writing by the City Council as local planning authority.
26	Before any use hereby approved commences, within each of the ground floor units below the residential and office blocks, details of the proposed opening hours shall be submitted to and approved in writing by the City Council as local planning authority. The units shall not be operated outside the hours approved in discharge of this condition.

Condition	Details
34 and 39	The Proposed Development shall be carried out in accordance with the recommendations in the Noise Survey section of the Environmental Statement prepared by Arup and Deloitte and stamped as received by the City Council, as local planning authority on 15 April 2016 in relation to NSE1 and subject to the following: • Prior to occupation of each block of the residential element of the scheme, a post completion report to verify that all of the recommended mitigation measures have been installed in the residential accommodation shall be submitted and agreed in writing by the City Council as local planning authority and any non-compliance suitably mitigated in accordance with an agreed scheme prior to occupation. • Prior to the first use of the commercial units, a scheme of acoustic insulation shall be implemented for the commercial units in accordance with the noise recommendations in the Noise Survey section of the Environmental Statement prepared by Deloitte and stamped as received by the City Council, as local planning authority on 15 April 2016. The approved scheme shall be retained and maintained for as long as the development remains in use and any non-compliance suitably mitigated in accordance with an agreed scheme prior to occupation.
36	Prior to occupation of the development a scheme for the acoustic insulation of any externally mounted ancillary equipment associated with: • the residential development; and • any of the commercial uses; to ensure that it achieves a background noise level of 5dB below the existing background (L_{A90}) in each octave band at the nearest noise sensitive location shall be submitted to and approved in writing by the City Council as local planning authority in order to secure a reduction in the level of noise emanating from the equipment. The approved scheme shall be implemented prior to occupancy and shall remain operational thereafter.

In relation to the above planning conditions, the relevant obligations that apply to the Proposed Development are as follows:

- Mitigation measures in the form of suitable façade treatments are required to control break-out noise from the proposed commercial units (retail/café – bar). This should be limited to levels detailed in the MCC Technical Guidance on Noise, summarised below.
- Building services will need to be controlled to achieve a rating level that is at least 5 dB below the existing representative background sound level, dB $L_{A90,T}$.
- The accompanying site suitability section of the Environmental Statement presents the expected sound insulation requirements of the building envelope to the Phase 2 New Victoria: office development with the aim of achieving 35 dB $L_{Aeq,T}$ indoors. The previous assessment is considered to be superseded by the assessment in this report.

It is expected that, subject to consent, the Proposed Development would be subject to the same (or similar) planning conditions relating to acoustics.

2.5.2 MCC Planning & Noise: Technical Guidance

MCC provide technical guidance and requirements for developments at Sites within their jurisdiction in Planning & Noise: Technical Guidance (December 2015). The relevant requirements within this document are presented below.

The overarching vision for sustainable development is supported by the following aims:

- 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.

Specific MCC assessment criteria are then presented to align with these aims.

Entertainment noise (including recorded music, live bands, karaoke) must be evaluated and meet the following:

- Music noise levels in the 63 Hz and 125 Hz octave centre frequency bands (L_{eq}) should be controlled so as not to exceed (in habitable rooms) 47 dB and 41 dB (L_{eq}), respectively.
- Entertainment noise (L_{Aeq}) should be controlled to 10 dB below the background noise level (L_{A90}) without the entertainment noise present, in each octave band at the nearest noise sensitive location.

Industrial / commercial sound sources including sound from fixed installations which such as building services plant and equipment must be evaluated via an assessment in accordance with BS 4142:2014 and meet the following:

- 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.
- Where the development generates high noise levels of a short duration (e.g. loud bangs) on a regular basis, these should aim to be controlled so as not to exceed 60 dB (L_{Amax}) at the façade of nearest noise sensitive premises.

The above requirements have been accounted for in establishing the acoustic criteria for the development.

2.6 Guidance on Suitable Indoor Noise Levels

2.6.1 British Standard 8233:2014

British Standard (BS) 8233:2014⁴ provides guidance for controlling noise in and around buildings. It proposes ambient noise level guidelines for different situations to be applied when designing new or refurbished buildings.

The BS 8233:2014 indoor noise levels guidelines for offices are presented in Table 2-2.

Table 2-2: BS 8233:2014 indoor ambient noise guidelines for office developments

Activity / Objective	Location	Design range for indoor ambient noise levels [dB $L_{Aeq,T}$]
Study and work requiring concentration	Staff/meeting room, training room	35 to 45
	Executive office	35 to 40
Acoustic privacy in shared spaces	Open plan office	45 to 50

BS 8233:2014 states that, 'If partially open windows were relied upon for background ventilation, the insulation would be reduced to approximately 15 dB.' This is usually the starting point for determining a ventilation strategy that is suitable for achieving these indoor ambient noise guidelines. For office developments, the level of sound insulation provided by the building envelope while windows open is expected to be less. However, this is largely irrelevant, given that the building is proposed to be mechanically ventilated.

Section 7 of BS 8233:2014 presents guidance on acoustic design for specific types of buildings. In relation to indoor ambient noise in offices, Section 7.7.6 of BS 8233:2014 refers the reader to the guidance produced by the British Council for Offices and the Association of Interior Specialists (now the Finishes and Interiors Sector).

⁴ British Standard 8233:2014: *Guidance on sound insulation and noise reduction for buildings*, BSI, 2014.

2.6.2 British Council for Offices: Guide to Specification 2019

The British Council for Offices (BCO) provide guidance on the specification and fit-out of office buildings in the UK. The 'Guide to Specification' includes guideline values for indoor ambient noise inside office spaces, with separate criteria for noise ingress (external noise intrusion) and for noise from indoor building services systems.

The BCO external noise intrusion criteria are presented in Table 2-3.

Table 2-3: BCO guideline upper limits on external noise intrusion

Location	BCO external noise intrusion criteria	
	Noise Rating [NR ($L_{eq,T}$)]	One-percentile sound pressure level not normally exceeded [dB $L_{A01,1 \text{ hour}}$]
Open plan office	NR40 (approx. 45 dB L_{Aeq})	55
Speculative offices	NR38 (approx. 43 dB L_{Aeq})	55
Cellular offices / meeting rooms	NR35 (approx. 40 dB L_{Aeq})	50

The above apply to measurements taken in accordance with the Association of Noise Consultants Guidelines: *Measurement of Sound Levels in Buildings* Version 1.0, June 2020 during a normal working day. Speculative office criteria apply upon completion of the Cat A development (i.e. with raised floor, internal building services systems, and, where provided a sound absorbent ceiling).

It is noted that relaxations in the external noise intrusion criteria apply in maximum ventilation mode for naturally ventilated buildings.

2.7 Summary of Assessment Approach

The above policies, guidance and standards, and the MCC typical planning policy requirements have been used to inform the assessment approach for each aspect.

The following approach will be adopted for the assessments within this report:

Noise from Proposed Building Services

- Undertake an environmental noise survey to include positions representing the nearest noise-sensitive receptors.
- Carry out an analysis of the measured background sound levels to determine the most commonly occurring background sound level, dB $L_{A90,15 \text{ min}}$ for relevant time periods.
- Determine limits for noise from building services systems and fixed mechanical plant. These limits shall be set to as a rating level that is 5 dB below the most commonly occurring background sound level and defined at one metre from the window of the nearest noise-sensitive premises. This is in accordance with the MCC requirements.
- Carry out an assessment of outdoor noise from the proposed building services systems accounting for the initial proposals for primary ventilation and heating/cooling systems.
- Identify the expected noise control measures required to achieve the building services sound 'rating level' limits.

Activity Noise arising from Proposed Commercial Uses

- Undertake a noise survey at positions representing the nearest noise-sensitive receptors.
- Carry out an analysis of the measured background sound levels to determine the lowest background sound level, dB L_{A90} , for relevant time periods.

- Determine limits for noise breakout from the proposed commercial units. These limits shall be set to a level that is 10 dB below the representative background sound level at one metre from the window of the nearest noise-sensitive premises.
- Carry out a preliminary assessment of noise breakout from the proposed commercial units accounting for the proposed façade dimensions and an assumed activity noise level.
- Identify the expected façade sound reduction performance required to achieve the noise limits.

Site Suitability: Environmental Noise Ingress Assessment

- Carry out an environmental noise survey to include positions representing the façade of the Proposed Development.
- Use the results of the survey to estimate the external noise levels at each floor and each façade.
- Determine the likely constraints on ventilation strategy and building fabric specification that apply in order to achieve the BCO guidelines for external noise intrusion within the Proposed Development.

Site Suitability: Ground-borne Vibration Assessment

- Carry out a vibration survey to include positions representing the parts of the Proposed Development that would be subject to the highest level of ground-borne vibration (i.e. structural elements closest to the adjacent Metrolink tram lines).
- Carry out estimates of the level of tactile vibration and re-radiated ground-borne noise that would be present within the Proposed Development, using an empirical transfer function.
- Determine the likely constraints due to vibration or ground-borne noise from the Metrolink and consider the potential effects on the future occupants.

3. Environmental Noise Survey

3.1 Overview

An environmental noise survey was undertaken by Sweco UK in March 2022 in order to quantify the prevailing environmental noise levels on and around the Site. This survey consisted of long-term unattended monitoring at four positions, supplemented with short-term attended monitoring at additional positions.

Long-term measurements were carried out between the morning of Thursday 10th March 2022 and the morning of Wednesday 16th March 2022, to cover typical weekdays and the weekend.

This section presents details of the survey procedure along with the summary noise measurements results at each position.

3.2 Procedure

The environmental noise survey was undertaken using suitable noise measurement equipment configured to log sound pressure level in each octave frequency band every 15 minutes. The sound level logging data was then analysed to determine the following parameters, described in Appendix 1, for relevant times of day and night:

- dB L_{Aeq,T}: Equivalent continuous A-weighted sound pressure level.
- dB L_{A01,T}: One-percentile A-weighted sound pressure level.
- dB L_{A90,T}: 90th percentile A-weighted sound pressure level (commonly described as the background sound level).

All noise measurements were undertaken by a consultant experienced in environmental noise monitoring and following the principles of BS 7445⁵.

The sources of noise that contributed to the noise climate at each position were noted upon installation and collection of the long-term unattended monitoring equipment. The prevailing weather conditions also were observed and supplemented with weather data from local weather stations (Weather Underground).

Long-term environmental noise measurements were taken at the positions listed in Table 3-1 and is shown in Figure A2-2 in Appendix 2.

Table 3-1: Long-term noise measurement positions

Position ref.	Position description	Conditions and height
MP1	At a location in vicinity of the southern corner of the Proposed Development. The microphone was attached to the existing site hoarding, 8 metres from the kerb of the adjacent Corporation Street and 7.5 metres from the nearest Metrolink tram track. Measurements undertaken in this position were intended to provide a representative worst-case level at the southern corner of the development as well as to establish the existing background sound level at the nearest noise-sensitive receptors.	Free-field conditions, circa 3 m above local street level

⁵ British Standard 7445: 2003: *Description and measurement of environmental noise*, BSI, 2003

Position ref.	Position description	Conditions and height
MP2	At a location in vicinity of the eastern corner of the Proposed Development. The microphone was attached to the existing site hoarding and at the kerbside of Corporation Street. Measurements undertaken in this position were intended to provide a representative worst-case level for the south-eastern and north-eastern façade of the development as well as to establish the existing background sound level at the nearest noise-sensitive receptors.	Free-field conditions, circa 2.5 m above street level
MP3	At a location in vicinity of the south-western façade of the Proposed Development. The microphone was attached to the existing site hoarding 4.5 metres from the nearest Metrolink tram track. Measurements undertaken in this position were intended to provide a representative worst-case level affecting the south-eastern façade the development as well as to establish the existing background sound level at the nearest noise-sensitive receptors.	Free-field conditions, circa 3 m above local street level
MP4	At the fourth floor balcony of the nearest residential block of Phase 1 of New Victoria (currently under construction). Measurements undertaken in this position were intended to establish a representative background sound level at this residential block, particularly during the evening and night-time. Measurements at this location commenced on Tuesday 15 March 2022 afternoon and ended the following day.	Façade conditions, 1.5 m above fourth floor balcony level (circa 17 m above street level)

3.3 Equipment

Details of the noise monitoring equipment used during the survey is presented within Appendix 3. All equipment used during the survey conformed to Type 1 specification of British Standard 61672.

The microphones were fitted with protective windshields for the measurements.

Each meter had been calibrated by a UKAS accredited laboratory within the previous 24 months. The calibration level was also checked at the start and end of the survey using field calibrators (which had been suitably calibrated by an accredited laboratory). No significant drift in the calibration over the course of the survey (≤ 0.4 dB).

3.4 Observations and Weather Conditions

The sources of noise that contributed to environmental noise climate were noted during attended periods.

The following sound sources were observed to affect the site of the Proposed Development:

- Construction noise (see below);
- Road traffic noise from Corporation Street and, to a lesser extent, from the A665 Ring Road;
- Mechanical/building services noise from Manchester Victoria station and the other surrounding buildings;
- Intermittent noise from Metrolink tram movements to and from the adjacent Manchester Victoria station;
- Public address announcements from Manchester Victoria station; and
- Sounds of pedestrian activity.

At the time of writing and during the environmental noise survey, construction noise from the New Victoria Phase 1 development was also present. These works affected the survey results during construction working hours (between approximately 07:00 – 18:30 on weekdays and 08:00 – 13:00 on Saturdays). Extrapolations from the available noise survey data have therefore been carried out on a precautionary basis. Sweco have recommended that additional environmental noise monitoring is obtained later in the design programme, which would be secured by way of a planning condition. This

would inform the detailed acoustic specifications for the building and ensure that any required noise control measures are robust.

Weather conditions during the monitoring period were dry with average wind speeds remaining below 5 m/s and were therefore suitable for environmental noise monitoring. Weather conditions during the long-term measurements have been investigated using Weather Underground and were also suitable for environmental noise monitoring.

3.5 Measurement Results

The measurement data has been analysed to determine the following parameters for each day of the survey:

- The equivalent continuous sound pressure level, dB $L_{Aeq,8 \text{ hour}}$, during weekday office hours.
- The one-percentile sound pressure level, dB $L_{A01,1 \text{ hour}}$, during weekday office hours.
- The most commonly occurring background sound level, dB $L_{A90,10 \text{ min}}$, during weekday office hours and the night-time.

The following section presents a summary of these measured noise levels at each position. Detailed measurement results are presented in Appendix 4.

3.5.1 Summary Results

A summary of the noise measurement results obtained at each long-term unattended monitoring position is presented in Table 3-2.

Table 3-2: Summary of the long-term noise measurement results

Position reference and microphone conditions	Range of equivalent continuous SPL		Range of typical one-percentile SPL	Range of most commonly occurring background sound levels per period		
	[dB $L_{Aeq,8 \text{ hour}}$]	[dB $L_{Aeq,8 \text{ hour}}$]	[dB $L_{AF01,1 \text{ hour}}$]	[dB $L_{A90,10 \text{ min}}$]		
	Office hours [09:00-17:00]	Night-time [23:00-07:00]	Office hours [09:00-17:00]	Office hours [09:00-17:00]	Evening [19:00-23:00]	Night-time [23:00-07:00]
MP1 (free-field)	69 to 71	62 to 66	82 to 86	57 to 65	55 to 60	48 to 54
MP2 (free-field)	67 to 74	63 to 66	78 to 82	56 to 71	54 to 59	46 to 53
MP3 (free-field)	68 to 70	58 to 62	82	54 to 65	53 to 57	46 to 51
MP4 (façade)	-	56	-	-	52	44

The one-percentile sound pressure level reported in Table 3-2 were the second highest dB $L_{AF01,1 \text{ hour}}$ value measured between 09:00-17:00. The stated value represents the one-percentile sound pressure that is not normally exceeded during office hours.

3.5.2 Ambient Noise Levels at the Site

Typical equivalent continuous and one-percentile sound pressure levels during weekday office hours have been determined at each noise measurement position. These outdoor noise levels are presented in Table 3-3.

Table 3-3: Summary of the ambient noise levels measured at each elevation of the Proposed Development

Elevation position	Equivalent continuous SPL [dB L _{Aeq,8 hour}]	Typical one percentile SPL [dB L _{A01,1hour}]
	Weekday office hours [09:00-17:00]	Weekday office hours [09:00-17:00]
South-west façade (MP3)	71	85
North-west façade	66 to 71	80 to 85
North-east façade	66 to 72	80 to 81
South-east façade (MP2)	72	81
<i>Ambient sound levels measured in free-field conditions converted to façade levels through the addition of 3 dB.</i>		

3.5.3 Background Sound Levels at Adjacent Noise-Sensitive Receptors

Measured background sound levels at the nearest noise-sensitive properties to the Site are presented in Table 3-4. These levels will be used to establish limits for noise from building services plant and machinery associated with the Proposed Development, and to assess the potential effects of activity noise from the proposed commercial uses during the evening.

Table 3-4: Summary of background noise levels near the Site

Receptor	Representative measurement position	Most commonly occurring background sound level [dB L _{A90,10 min} in façade conditions]		
		Weekday office hours [09:00-17:00]	Evening hours [19:00-23:00]	Night-time [23:00-07:00]
Dwellings within the New Victoria Phase 1 development	Position MP4 (and comparison with MP1)	55*	52	44
Receptors west/south-west of development	Position MP3 (corrected to façade conditions)	57	56	49
Receptors east/south-east of development	Position MP2 (corrected to façade conditions)	59	57	49
<i>*Background sound levels during office hours at this position were affected by construction noise from the Phase 1 New Victoria development. For this reason, a representative background sound level for office hours was determined on a precautionary basis using noise measurement data at position MP4 obtained between 19:00 and 20:00.</i> <i>Background sound levels measured in free-field conditions converted in façade levels through the addition of 3 dB.</i>				

Background sound levels are presented as the most commonly occurring values at the nearest representative measurement positions referenced in Table 3-4. This is considered to be in accordance with the requirements of MCC.

4. Limits on Building Services Noise

4.1 Overview

There will be sources of sound of an commercial nature associated with the operation of the Proposed Development such as building services systems and fixed mechanical plant.

This section presents limits on building services noise which apply at nearby noise-sensitive receptors. These limits depend upon the measured background sound level, which varies depending on the time of day, as shown in Section 3.5.2. Therefore, different building services sound 'rating level' limits apply at different times of day.

4.2 Limits

According to MCC technical guidance, sound from building services systems will need to be assessed according to BS 4142:2014 and the 'rating level' of sound emitted from any new building services systems will need to be at least 5 dB below the representative background sound level, at one metre from the window of the nearest noise-sensitive premises. A building services noise level of at least 5 dB below the representative background sound level is also a requirements stated in planning condition 36 of the New Victoria planning application (ref. 111777/FO/2016/C1).

The above has informed the building services sound 'rating level' limits which are presented in Table 4-1.

Table 4-1: Limits on building services sound according to MCC requirements

Noise sensitive receptor (and position)	Building services sound 'rating level' limits at the nearest noise sensitive receptors [dB $L_{Aeq,T}$ in façade conditions]	
	Systems operating during weekday office hours only [09:00 to 17:00]	Systems operating at any time of day
New Victoria Phase 1 development	50 $L_{Aeq,T}$	39 $L_{Aeq,T}$
Indigo Hotel	52 $L_{Aeq,T}$	45 $L_{Aeq,T}$

These building services sound 'rating level' limits apply to the cumulative level of sound from all building services systems associated with the Proposed Development that is measured or predicted at a position 1 metre from the nearest window to sensitive uses at each receptor.

5. Outline Building Services Noise Impact Assessment

5.1 Overview

This section presents an outline assessment of noise from the building services systems.

At this stage, initial proposals for the primary plant items have been developed. The key sources of building services noise are envisaged to be the external building services plant for ventilation and cooling. This outline building services noise impact assessment therefore presents the noise control measures that are expected to be required for these primary plant items.

5.2 Methodology

In order to predict the level of building services noise associated with the operation of the Proposed Development, a three-dimensional acoustic model has been constructed using the Datakustik Cadna/A sound propagation modelling software. The software carries out sound propagation predictions in accordance with ISO 9613-2⁶.

The sound propagation model allows for the building services noise level to be predicted at the assessment location taking into account factors such as geometric spreading and ground absorption over distance, the effect of any intervening buildings, walls or ground features, as well as reflections from the hard surfaces that are part of the Proposed Development.

Details of the sound source and modelling assumptions incorporated into this outline assessment are presented below.

5.3 Proposed Sound Sources and Assumptions

The primary building services sound sources proposed as part of the development are as follows:

- 2 no. Air Source Heat Pumps (ASHPs) located at Level 9, providing cooling and heating to the building; and
- Air Handling Units (AHUs) located on each office floor, providing fresh air and discharging exhaust air locally. The duct terminations (exhaust and fresh air intake grilles) are proposed to be located on the north-eastern elevation.

The above systems are expected to operate during office hours only. During the colder months, the ASHPs are expected to operate in heat pump mode to pre-heat the interior space up to the design temperature before the start of the occupancy period of 08:00. During this pre-heat period the ASHP will run but not at their peak design duties.

The specifications of the proposed building services systems are under development at this time. However, preliminary source emission levels for the primary building services systems have been provided by Sweco (Building Services Engineers) in the form of manufacturer datasheets. Details of the primary plant systems are presented in Table 5-1.

⁶ ISO 9613 Part 2: *Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation*, International Organization for Standardization, 1996.

Table 5-1: Source emission levels for the proposed plant

Sound source	Number of items	Source sound emission level		Source of sound level information
		Sound pressure level	Sound power level	
Air source heat pump with local attenuation	2 No.	57 dB L_{pA} at 1m	76 dB L_{WA}	Manufacturers' published datasheets and nominal attenuation package.
On-floor AHUs	1 No. per office floor	-	Fresh Air Intake - 70 dB L_{WA} Exhaust - 78 dB L_{WA}	Manufacturers' published datasheets

The location and dimensions of proposed and existing buildings have been modelled using drawings provided by the Client.

The location of the proposed sound sources have been accounted for with reference to drawings provided by the mechanical engineer. The proposed location of the ASHPs is shown in Figure 5-1 and Figure 5-2. The proposed building includes an impermeable screen around the ASHP area that is 4.8m in height relative to ASHP floor level.

Current design proposals allow for AHU atmospheric ducts (fresh air intake and exhaust) to have suitably sized attenuators fitted, and for a local attenuation package on the ASHPs.

The sound level predictions allow for second order reflections of sound from surrounding buildings which are assumed to be highly reflective to sound (e.g. masonry, steel or glass). The intervening ground between the Proposed Development and the nearest receptors is assumed to be hard ground (reflective to sound).

Predicted specific sound levels are expressed in terms of the equivalent continuous sound pressure level over typical office hours, $L_{Aeq,8 \text{ hour } 09:00-17:00}$. At the time of writing, hours of plant operation are not confirmed. However, it has been assumed that the above primary plant systems for the office floors will not be required to operate outside of normal office hours.

Figure 5-1: Proposed ASHP location on Level 9 plan

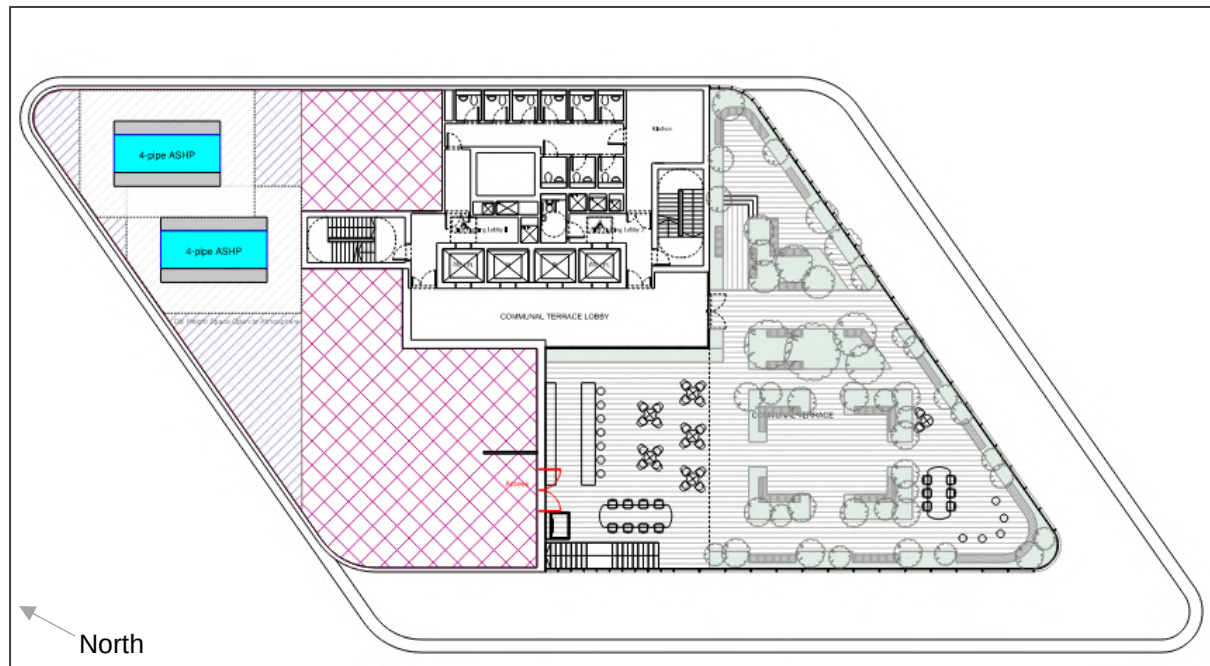
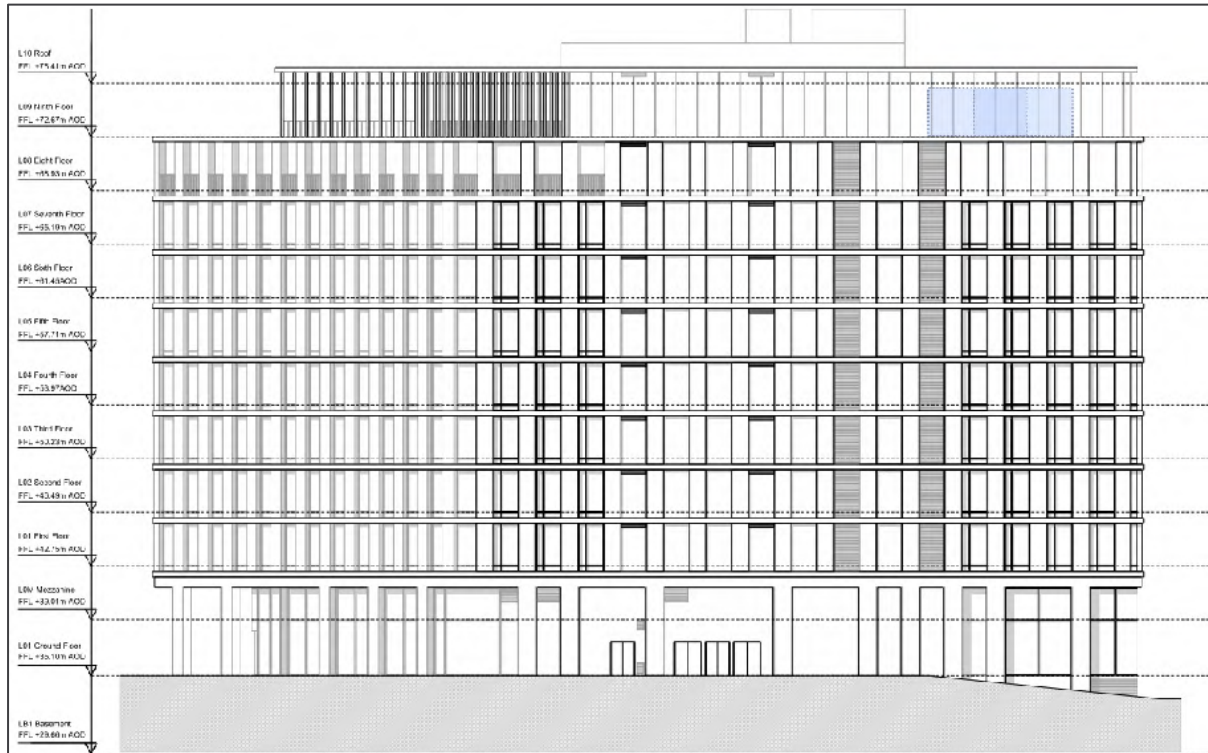
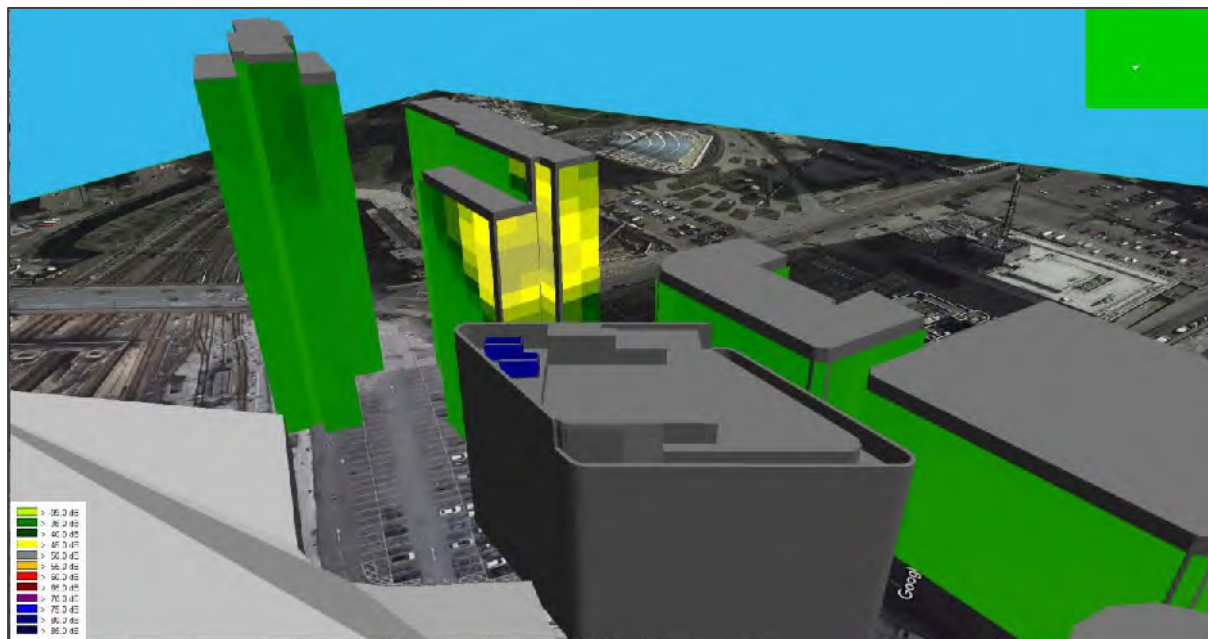


Figure 5-2: Proposed ASHP location shown on north-east elevation



The sound propagation model with primary building services sound sources is shown in Figure 5-3.

Figure 5-3: Building services noise model (viewed from the south-west). ASHPs shown in blue.



5.4 Outline Building Services Noise Predictions

The level of noise due to the proposed building services systems has been predicted at the nearest noise-sensitive receptors. The predicted building services noise levels at the worst-affected position at each receptor are presented in Table 5-2 and within Figure A5-1 in Appendix 5.

Table 5-2: Predicted building services noise levels at the nearest receptors

Receptor	Time of the day	Predicted building services noise level at worst-affected position on receptor [dB, $L_{Aeq,T}$]
New Victoria Phase 1: Residential dwelling within closest building (worst-affected window)	Weekday office hours	48
New Victoria Phase 1: Residential dwelling within further building (worst-affected window)	Weekday office hours	38
Hotel Indigo (worst-affected window)	Weekday office hours	22

5.5 Sound Character and Acoustic Feature Corrections

The limits on sound of an industrial nature presented in Section 4 are noise rating levels in accordance with BS 4142:2014+A1:2019. The rating level includes corrections, where relevant, to account for acoustic characteristics that could draw more attention to the sound.

The specific sound sources (the primary building services systems) are not yet operating and therefore it is not possible to assess the characteristics directly. Instead, the following corrections have been applied based on the expected sound source characteristics:

- **Tonality:** The expected main source of building services sound are the roof-top ASHP. Sound from these units is expected to be broadband in nature (sound primarily due to movement of air). It is unlikely that sound from the ASHP will be tonal in nature. However, for a precautionary approach, a correction of +2 dB has been applied to allow for the instance where a tonal sounds could be just perceptible at the nearest receptors.
- **Impulsivity:** The nature of the proposed plant and machinery is unlikely to result in any impulsive sounds (crashes and bangs, etc.). No correction has been applied to account for impulsivity.
- **Intermittency:** It is expected that when running, the plant will operate at a constant rate and without fluctuations. No correction applied to account for intermittency.

5.6 Outline Building Services Noise Assessment

Predicted rating levels are shown in Table 5-3 and compared to the rating level limits from Section 4.

Table 5-3: Predicted building services rating levels and assessment

Location	Time of day	BS 4142 assessment			Background sound level	Difference and assessment result
		Predicted specific sound level	Acoustic feature correction	Predicted rating level		
Phase 1: closest building	Weekday office hours	48 dB $L_{Aeq,T}$	+2 dB	50 dB $L_{A,T}$	55 dB $L_{A90,T}$	5 dB below background; Section 4 limit achieved.
Phase 1: further building	Weekday office hours	38 dB $L_{Aeq,T}$	+2 dB	40 dB $L_{A,T}$	55 dB $L_{A90,T}$	15 dB below background; Section 4 limit achieved.
Hotel Indigo	Weekday office hours	22 dB $L_{Aeq,T}$	+2 dB	24 dB $L_{A,T}$	57 dB $L_{A90,T}$	33 dB below background; Section 4 limit achieved.

Predicted building services noise levels at the receptors located further from the Site are lower than those shown within Table 5-3. Therefore, Table 5-3 demonstrates that, subject to the provision of the noise control measures below, the building services sound 'rating level' limits presented in Section 4 will be achieved at all receptors.

Where the building services sound 'rating level' limits are achieved, noise from the building services systems that operate during office hours only will result in a low impact and requirements of MCC are expected to be achieved.

Details of the expected noise control requirements are presented in Section 5.7.

5.7 Expected Noise Control Requirements

The following noise control requirements will need to be introduced into the detailed design of Proposed Development to achieve the building services sound 'rating level' limits in Section 4:

- The ASHP area is to be surrounded by an impermeable screen of height 4.8 m relative to the L9 ASHP area floor level. This is consistent with the proposed architecture;
- AHUs fresh air intake and exhaust ducts are fitted with suitably sized attenuators;
- The ASHPs shall be selected with an individual sound power level that accounts for the number of units and the location of units; and
- The use of the ASHP is to be limited to office hours only (see Section 5.8).

Based on the preliminary building services proposals, assuming two ASHP units within the Level 9 plant area, the sound power level of each ASHP shall not exceed 78 dB L_{WA} . For the current unit size, this is equivalent to a sound pressure level of 57 dB(A) measure at 1m from the unit in free-field conditions above a sound-reflecting floor. This is expected to be straightforward to achieve through provision of a local attenuation package (attenuators on the unit intake and discharge air paths).

Further assessment of buildings services noise will need to be carried out as the detailed design progresses. This will ensure that the building services noise level limits in Section 4 are achieved.

5.8 Out of Office Hours Operation

It is noted that the above assessment applies to the operation of the primary building services systems during office hours. Where building services systems are to be used outside of these hours, additional attenuation will need to be incorporated into the design of the Proposed Development. This would include a lower sound power limit for the ASHP units than that presented above.

Hours of use and the resulting noise control measures will need to be considered carefully during the detailed design stage to ensure that all building services sound 'rating level' limits are achieved.

5.9 Conclusions

All sound 'rating level' limits required by MCC are expected to be achieved subject to the provision of suitable noise control measures as part of the detailed design of the Proposed Development. This will require further consideration of building services noise as the detailed design progresses. The potential for any adverse effects due to noise from the building services systems associated within the Proposed Development will then be minimised.

6. Assessment of Activity Noise from Proposed Commercial Units

6.1 Overview

The Proposed Development includes a commercial unit on the ground floor which could accommodate retail or café-bar uses. This section considers the potential effects of activity noise from these commercial uses on the nearby noise-sensitive receptors.

6.2 Assessment Criteria

Reference has been made to Planning & Noise: Technical Guidance produced by MCC. This document includes guidance on acceptable levels of music “noise” and entertainment noise that apply at the nearest habitable rooms or noise-sensitive receptor. Limits on noise from these sources are defined in octave frequency bands and were presented in Section 2.5.2 of this report.

Activity noise break-out from the proposed commercial unit will need to be sufficiently controlled to achieve the following MCC limit:

“Entertainment noise (L_{Aeq}) should be controlled to 10 dB below the background noise level (L_{A90}) without the entertainment noise present, in each octave band at the nearest noise sensitive location.”

Given the stage of development, there is significant uncertainty in determining music or entertainment noise levels at the nearest receptor in octave frequency bands. For the purposes of this assessment, an A-weighted sound pressure level of entertainment noise (dB L_{Aeq}) that is at least 10 dB below the background sound level (dB L_{A90}) is considered to be an appropriate indication that entertainment noise would be unlikely to result in any adverse effect.

Entertainment noise limits have been defined accounting for the above. For the purposes of this assessment, it is assumed that commercial activity noise during the evening period has the greatest potential result in adverse effects since background sound levels are lower than during office hours. The evening period may also coincide with the busiest period of commercial activity. For these reasons, entertainment noise level limits have been defined based on the existing background sound levels determining during the evening that are presented in Table 3-4 and are as follows:

- New Victoria Phase 1 development: Entertainment noise limit: 42 dB $L_{Aeq,1hour}$.
- Indigo Hotel: Entertainment noise limit: 46 dB $L_{Aeq,1hour}$.

The above values are considered to be LOAEL values, above which entertainment noise would need to be mitigated and minimised.

6.3 Methodology

Sound pressure levels due to noise break-out from the proposed commercial unit to outdoors and the nearby receptors have been predicted using the BS EN ISO 12354-4:2017⁷ methodology.

⁷ BS EN ISO 12354-4:2017, 'Building acoustics - Estimation of acoustic performance of buildings from the performance of elements: Part 4: Transmission of indoor sound to the outside', British Standards Institution, 2017.

In order to predict the level of activity noise associated with the operation of the proposed commercial unit, the three-dimensional acoustic model has been amended include activity noise sources. This software then carries out sound propagation predictions in accordance with ISO 9613-2.

Details of the sound source and modelling assumptions incorporated into this outline assessment are presented below.

6.4 Proposed Sound Sources and Assumptions

The level of activity noise within the proposed commercial unit will depend upon the number of occupants, level of speech, the presence of background music and the room acoustic conditions within the restaurant.

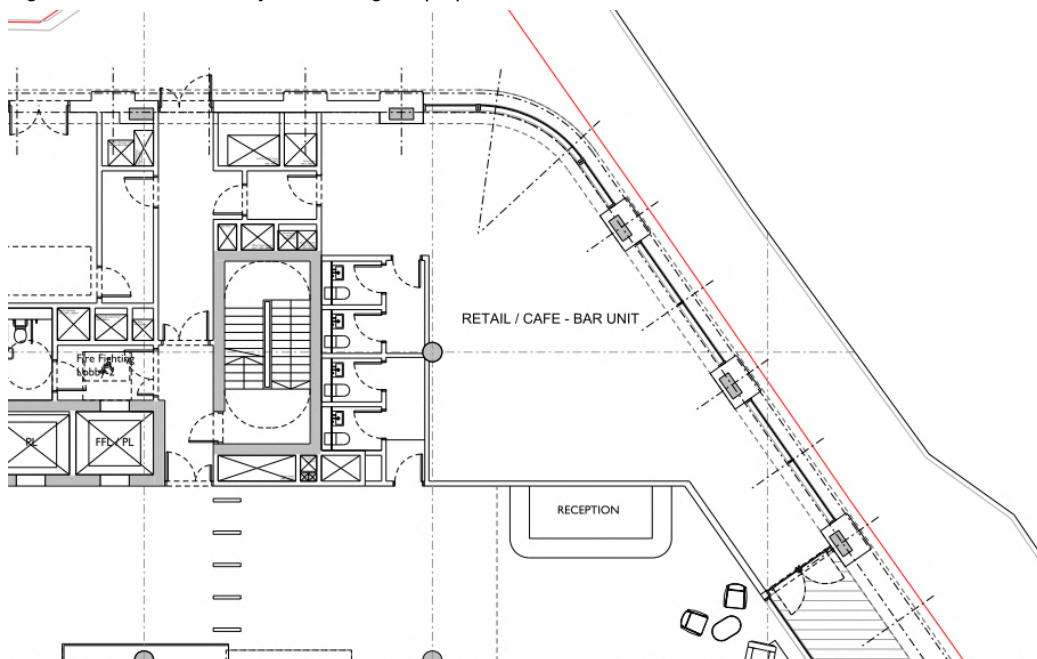
The following assumptions have been made in order to assess noise break-out to outdoors:

- It is assumed that the proposed commercial unit will be relatively reverberant with acoustically hard interior surface finishes. A reverberation time of 1.5 seconds T_{mf} has been assumed.
- It is assumed that the proposed commercial unit would be fully occupied during the evening period.
- It has been assumed that any amplified music would be used for background ambience and that the dominant sound source within the proposed commercial unit would be is activity noise and speech.

Accounting for the above assumptions, a reverberant sound pressure level of 80 dB L_{Aeq} is expected to occur within the proposed commercial unit at full occupancy. This is considered to represent the reasonable worst-case scenario for assessing activity noise break-out.

The location of the proposed sound sources have been accounted for with reference to drawings provided by the architect. The proposed arrangement of the proposed commercial unit is shown in Figure 6-1. The building envelope is proposed to be predominantly glazed with a door within the eastern elevation.

Figure 6-1: Ground floor layout showing the proposed commercial unit



The level of activity noise break-out to outdoors will depend on the sound insulation specifications of the proposed building envelope. These specifications will be determined as the design progresses. For the purposes of this assessment, the following assumptions have been applied:

- The external door is assumed to have a minimum sound insulation rating of 30 dB R_w . This is relatively straight-forward to achieve with a close-fitting doorset with rebated frame and could be achieved with a glazed door. It is assumed that doors will be closed for the majority of the time.
- The external glazing on the eastern and south-eastern elevation is assumed to be a double glazed system with a minimum sound insulation rating of 31 dB R_w (and 27 dB R_w+C_{tr}). This is achievable with a basic double glazed systems (e.g. 6/12/6).
- Negligible noise break-in via ventilation elements.

Predicted activity noise levels are expressed in terms of the equivalent continuous sound pressure level over the busiest hour of operation, $L_{Aeq,1hour}$.

The activity noise predictions allow for second order reflections of sound from surrounding buildings which are assumed to be highly reflective to sound (e.g. masonry, steel or glass). The intervening ground between the Proposed Development and the nearest receptors is assumed to be hard ground (reflective to sound).

6.5 Predicted sound levels

Detailed predictions of activity noise break-out are presented in Figure A5-2 in Appendix 5 and summarised in Table 6-1. The activity noise assessment is then presented in Table 6-1.

Table 6-1: Predicted activity noise levels and assessment

Location	Time of day	Activity noise assessment			Difference and assessment result
		Predicted activity noise level	Background sound level (evening)	Proposed activity noise limit	
Phase 1: closest building	Evening	27 dB $L_{Aeq,T}$	52 dB $L_{A90,T}$	42 dB $L_{Aeq,T}$	25 dB below background. Activity noise limit achieved.
Phase 1: further building	Evening	24 dB $L_{Aeq,T}$	52 dB $L_{A90,T}$	42 dB $L_{Aeq,T}$	28 dB below background. Activity noise limit achieved.
Hotel Indigo	Evening	17 dB $L_{Aeq,T}$	56 dB $L_{A90,T}$	46 dB $L_{Aeq,T}$	39 dB below background. Activity noise limit achieved.

Table 6-1 demonstrates that, for the worst-affected residential receptor, activity noise from the proposed commercial unit will be at least 25 dB below background during the evening (while background sound levels are lower than during office hours). This demonstrates that the MCC criteria for activity noise will be achieved at all residential receptors.

6.6 Summary

An assessment of activity noise break-out from the proposed commercial unit to outdoors has been carried out. No significant effects due to noise break-out to outdoors are expected, assuming that the building envelope includes double glazing and doors remains closed for the majority of the time.

7. Site Suitability: Noise Ingress into the Proposed Development

7.1 Overview

Environmental noise from existing sources such as the adjacent transport uses has the potential to affect the future occupants of the Proposed Development. This section considers the potential effects due to environmental noise ingress and the implications for the design of the Proposed Development.

The amount of noise ingress into each space is directly related to the proposed method of ventilation. The ventilation elements (where present) and the glazing are normally the weakest elements in the building envelope in terms of sound insulation, and these elements will control the overall sound insulation performance of the building envelope.

Noise levels inside the Proposed Development have been estimated with openable windows and with alternative ventilation measures. The estimated indoor noise levels can then be compared with indoor noise level guidelines described in Section 2.6 (which originate from BCO guidelines).

An indication of the likely sound insulation requirements for the building envelope and the implications for the ventilation strategy for the proposed building is then presented. Sound insulation requirements for the building envelope depend on factors such as the room use and the window area and therefore may be subject to change as the detailed design of the Proposed Development evolves.

7.2 Noise Ingress with Ventilation via Openable Windows

The simplest form of passive ventilation for the Proposed Development would be by opening windows. When a window is partially open for ventilation the sound insulation of the façade is reduced to approximately 15 dB. Using this approximation, the ambient noise levels inside the Proposed Development can be estimated, as shown in Table 7-1.

Table 7-1: Indoor ambient noise levels during office hours with windows partially open for ventilation

Façade	Indoor noise level, windows open for ventilation			Conclusions
	Equivalent continuous [dB L _{Aeq,8 hour}]	Estimated indoor noise rating [NR(L _{eq})]	Estimated one-percentile SPL [dB L _{A01,1 hour}]	
South-west façade	Circa 56	Circa NR51	Circa 70	BCO guideline values for speculative offices exceeded by up to 15 dB while windows are open. It has been recommended that ventilation for normal conditions is provided via an alternative method to openable windows.
North-west façade	Circa 51 to 56	Circa NR46 to NR51	65 to 70	
North-east façade	Circa 51 to 57	Circa NR46 to NR52	65 to 66	
South-east façade	Circa 57	Circa NR52	Circa 66	

Table 7-1 demonstrates that the BCO noise intrusion guidelines for speculative offices are not achieved with windows partially open for ventilation on all outward facing façades. It has therefore been recommended that ventilation for normal conditions is provided via an alternative method to openable windows. This is consistent with the proposed ventilation strategy for the Proposed Development.

Subject to the above ventilation strategy being employed, noise ingress through the ventilation system is not likely to result in any adverse effects on the future occupants of the Proposed Development,

7.3 Noise Ingress with Windows Closed

BS 8233:2014 advises that *'if relying on closed windows to meet the guide values, there needs to be an appropriate alternative ventilation that does not compromise the façade insulation or the resulting noise level'*. The current ventilation strategy allows for mechanical ventilation during normal conditions. Therefore windows will be the weakest sound insulating element in the building envelope.

Noise ingress calculations have been carried out, using the rigorous calculation method within BS 8233:2014, in order to determine assess the indoor noise levels at the worst affected location and the most sensitive room type with windows closed. The following assumptions were made in the assessment:

- South-west façade cellular office;
- Nominal open plan zone size of 6.0 m x 6.0 m x 3.0 m;
- 70% of the external façade assumed to be glazed (as a worst case); and
- The reverberation time has been assumed to be typical for an office with BCO recommended surface finishes (≤ 0.8 seconds T_{mf}).

Based on the above assumptions, the BCO speculative office indoor noise level guidelines will be achieved with a façade design incorporating the following specifications:

- Glazing with sound insulation rating of minimum 35 dB R_w+C_{tr} (e.g. double glazed unit comprised of 6 mm glass / 20 mm cavity / 10 mm glass); and
- Solid sections of façade with sound insulation rating of minimum 45 dB R_w+C_{tr} . This is a moderate level of sound insulation performance and the building envelope proposals will be reviewed to ensure that this is achieved.

It is noted that other glazing configurations will be suitable and the preferred system will be reviewed as the detailed design progresses. It is also noted that specifications for the building envelope are based on assumptions on room type and finishes. These assumptions and the resulting specifications will need to be reviewed for suitability during the detailed design stage.

7.4 Summary

The above section has demonstrated that environmental noise at the Site has a moderate influence on the Proposed Development. To avoid adverse effects on the future occupants due to transportation noise ingress, it has been recommended that ventilation for normal conditions is not provided via operable windows. This is consistent with the proposed ventilation strategy.

No adverse effects on the office occupants are expected provided that suitable sound insulation specifications for the proposed building are developed during the detailed design stages, accounting for the expected level of environmental noise outside each elevation.

8. Site Suitability: Ground-borne Vibration from Metrolink

8.1 Overview

The movement of trams along the nearby Metrolink has the potential to result in the following within the Proposed Development:

- Perceptible (tactile) vibration within the building due to vibration from tram movements transmitted through the ground, into the building foundations, and then transmitted throughout the building structure.
- Audible 'rumbling' within the building due to the above vibration of the ground and structure. This is called re-radiated ground-borne noise (or structure-borne noise).

Re-radiated ground-borne noise (GBN) occurs when vibration, at levels which are typically imperceptible to the building occupants, gives rise to an audible rumbling sound within the development due to the radiation of sound from the vibrating elements (e.g. the walls, floor, ceiling, etc.). The vibration is due to the passage of trams which has been transmitted through the ground, into the substructure of the proposed building and then onwards to the room within the building.

This section considers the potential effects due to vibration and GBN and the implications for the design of the Proposed Development.

8.2 Guidance on Vibration and GBN

Relevant standards and guidelines on tactile vibration and ground-borne noise from railways or tramlines are described below.

8.2.1 Tactile Vibration: British Standard 6472

Guidance on the human response to vibration is provided within BS 6472:2008⁸. This can be applied to vibration originating from tramlines.

BS 6472:2008 requires that vibration is quantified in terms of the Vibration Dose Value (VDV) and assessed at the point of entry to the body (which for this development would be a mid-span location on each floor in the completed development).

The VDV is a measure of long-term vibration exposure and accounts for the level of vibration due to each event, the duration of each event and the number of events during the day (and night). The standard contains VDV ranges and the expected human response to vibration in different environments, as shown in Table 8-1.

Table 8-1: VDV ranges and the expected human response (BS 6472:2008)

Environment and time	Vibration Dose Value range ($\text{m}\cdot\text{s}^{-1.75}$) and corresponding human response		
	Low probability of adverse comment	Adverse comment possible	Adverse comment probable
Office (16 hour day)	0.4 to 0.8	0.8 to 1.6	1.6 to 3.2

⁸ BS 6472-1:2008 'Guide to evaluation of human exposure to vibration in buildings', BSI, 2008.

The method for assessing vibration dose values comprises the following options:

- Measurement of the 16 hour or 8 hour VDV directly over the full time period.
- Calculation of the 16 hour or 8 hour VDV from the VDV of repeated exposures, assuming that measured VDV of each event is representative of a typical event. This requires knowledge of the number of events with the 16 hour or 8 hour time period.

As noted above, the assessment is to apply at the point at which vibration enters the body. For a future development this requires estimation of the difference between vibration at the point of measurement and vibration at the point of entry to the body (known as a 'transfer function').

8.2.2 Tactile Vibration: The British Council for Offices (BCO) Guidance

The BCO Guide to Specification 2019 does not provide any specific design criteria in relation to perceptible vibration from railways or tramlines, however reference is made to BS 6472:2008.

8.2.3 Guidance on Ground-borne Noise

There are no local requirements for GBN within office or commercial developments within the MCC Technical Guidance for Noise. There are also no UK standards for the assessment of re-radiated ground-borne noise (GBN) within buildings. However, recommended upper limits on GBN for different types of buildings are available in guidance documents as described below.

Section 11.4.2 of the BCO Guide to Specification 2019 states guideline values for GBN within offices, as follows:

- Cellular offices and meeting rooms: 40 dB $L_{A\text{Smax}}$; and
- Open plan offices: 45 dB $L_{A\text{Smax}}$.

GBN criteria are presented in the Crossrail 2 'Information for Developers' document. The relevant operational GBN design aims (above which mitigation would be incorporated into the Crossrail design) are defined as follows:

- Lecture theatres: 35 dB $L_{A\text{Smax}}$; and
- Offices: 40 dB $L_{A\text{Smax}}$.

GBN levels at which various adverse effects may be expected are stated within the Transportation Noise Reference Book are as follows:

- Residential, Office, Theatre: 30 to 40 dB $L_{A\text{Smax}}$;
- Art Gallery or Movie Theatre: 35 to 45 dB $L_{A\text{Smax}}$;
- Cafeteria (e.g. food retail): 45 to 55 dB $L_{A\text{Smax}}$; and
- Department store: 40 to 55 dB $L_{A\text{Smax}}$.

It is noted that the effects of re-radiated GBN will depend upon the level of noise from other sources within each building. Where a design range is presented, the more stringent criteria apply only if the tram-related noise exceeds or equals noise from all other sources.

8.3 Acoustic Design Criteria

Based on the above guidance, it has been recommended that the acoustic design criteria within Table 8-2 are targeted within the Proposed Development.

Table 8-2: Groundborne noise and vibration design criteria

Location	Groundborne noise and vibration design criteria		
	Type of criterion	Design target	Parameter
Any meeting rooms or focus rooms	Tactile vibration	$\leq 0.4 \text{ m}\cdot\text{s}^{-1.75}$	VDV (16 hour) 07:00-23:00
	Groundborne noise	$\leq 40 \text{ dB } L_{A\text{Smax}}$	Typical maximum sound pressure level
Speculative Office or open plan areas	Tactile vibration	$\leq 0.8 \text{ m}\cdot\text{s}^{-1.75}$	VDV (16 hour) 07:00-23:00
	Groundborne noise	$\leq 45 \text{ dB } L_{A\text{Smax}}$	Typical maximum sound pressure level
Retail/café/bar	Tactile vibration	$\leq 0.4 \text{ m}\cdot\text{s}^{-1.75}$	VDV (16 hour) 07:00-23:00
	Groundborne noise	$\leq 45 \text{ dB } L_{A\text{Smax}}$	Typical maximum sound pressure level

8.4 Assessment Approach

8.4.1 General

Vibration monitoring was carried by Sweco in parallel with the noise survey. The results of the vibration monitoring have been incorporated into empirical calculations of tactile vibration and ground-borne noise, accounting for the type of building. The predicted values incorporate a relatively large uncertainty; however, they indicate the potential risk of the tactile vibration and GBN criteria defined above being exceeded within the Proposed Development.

8.4.2 Vibration Survey

Vibration measurements were taken at two positions representing the point of entry into the closest structural element of the Proposed Development. The purpose of the vibration survey was to quantify the existing level of vibration induced by tram movements on the adjacent Metrolink line.

The two vibration measurement positions are presented in Figure A2-3 in Appendix 2. The accelerometer was fixed to a mounting plate which was positioned on hard ground, supported on three ground spikes. The plate was observed to be level and the accelerometer orientated so that the one axis was parallel to the tram line.

Measurements of the unweighted short-term RMS acceleration (time interval of 100 ms) were carried out using a tri-axial piezo-electric accelerometer. Summary measurements of peak, RMS and peak-to-peak acceleration were also taken over contiguous hourly intervals. Third octave measurements were taken over a range that included the 1.25 Hz and 80 Hz bands.

Details of the vibration monitoring equipment used during the survey is shown in Appendix 3. Each meter had been calibrated by a UKAS accredited laboratory within the previous 24 months. The sensitivity of each accelerometer was also manually entered into each vibration meter at the start of the survey using laboratory calibration records.

8.4.3 Vibration and Ground-borne Noise Predictions

The results of the vibration monitoring have been incorporated into empirical calculations of tactile vibration and ground-borne noise (GBN), accounting for the type of building. The level of vibration and GBN within the future development is influenced by many variables including:

- Differences in the level of vibration entering the ground at different positions along the railway (influenced by train speed and local rail condition);
- Differences in ground response between the measurement point and the proposed structural elements;

- The effect of the proposed building on the response of the ground;
- The transfer function of vibration propagation from the ground to the proposed foundations;
- The transfer function of vibration propagation from the building foundations to the receiving floor of the building; and
- The receiving position within the building and geometry of the supporting structure (e.g. distance between supporting columns).

The resulting GBN level is influenced by room surface finishes, room geometry and proximity to structural element.

The influence of the above variables has been accounted using a precautionary approach. Measurements have been taken at positions expected to experience the greatest amplitudes of vibration for any of the proposed structural elements, and at the closest position of any structural element to the railway. Vibration transfer functions have then been applied accounting for the expected building type and allowing for amplification due to the resonance of floor slabs supported on columns. These transfer functions have been applied in third octave frequency bands and originate from measurements and research summarised in the Transportation Noise Reference Book⁹.

The predicted values incorporate a relatively large uncertainty; however, they indicate the potential risk of the tactile vibration and GBN criteria defined in Table 8-2 being exceeded within the Proposed Development.

8.5 Vibration Survey Results

Vibration measurement results have been analysed to determine the frequency characteristics and acceleration amplitudes of the ten worst tram movements. Vibration monitoring results for these tram movements are presented in Figure A4-5 and Figure A4-6 in Appendix 4. It is noted that tram speeds varied between the two monitoring positions and between individual tram movements.

The measured levels of acceleration have been used to estimate the level of tactile vibration and re-radiated GBN within the building (and at the point of entry to the body of the occupants).

8.6 Vibration and GBN within the Proposed Development

Predicted levels of vibration and ground-borne noise within the future development are presented in Table 8-3. Positions where the design targets are expected to be achieved are highlighted in green.

Table 8-3: Estimated levels of tactile vibration and ground-borne noise within the Proposed Development

Position	Floor	Tactile Vibration within Proposed Development		Re-radiated GBN within Proposed Development
		Daytime eVDV _{b,day}	Night-time eVDV _{b,night}	Typical dB L _{ASmax,event}
Position near centre of building (VP2)	Ground Floor (L00)	0.10	0.07	Circa 47 dB L _{ASmax,event}
	Level 01	<0.10	<0.07	Circa 45 dB L _{ASmax,event}
	Level 02	<0.10	<0.07	Circa 43 dB L _{ASmax,event}
	Level 03	<0.10	<0.07	Circa 41 dB L _{ASmax,event}
	Level 04	<0.10	<0.07	Circa 39 dB L _{ASmax,event}
	Level 05	<0.10	<0.07	Circa 38 dB L _{ASmax,event}

⁹ P.M. Nelson,, 'Transportation Noise Reference Book', Butterworth-Heinemann Ltd, 1987.

Position	Floor	Tactile Vibration within Proposed Development		Re-radiated GBN within Proposed Development
		Daytime eVDV _{b,day}	Night-time eVDV _{b,night}	Typical dB L _{ASmax,event}
Southern corner near Corporation Street (VP1)	Ground Floor (L00)	0.14	0.09	Circa 47 dB L _{ASmax,event}
	Level 01	<0.14	<0.09	Circa 45 dB L _{ASmax,event}
	Level 02	<0.14	<0.09	Circa 43 dB L _{ASmax,event}
	Level 03	<0.14	<0.09	Circa 41 dB L _{ASmax,event}
	Level 04	<0.14	<0.09	Circa 39 dB L _{ASmax,event}
	Level 05	<0.14	<0.09	Circa 38 dB L _{ASmax,event}
<i>Estimated levels of tactile vibration and re-radiated ground-borne noise are lower on Level 06 and therefore the design targets would also be achieved.</i>				

8.7 Conclusions

Based on the vibration monitoring and assessment above, the following conclusions can be drawn:

- Tactile vibration within the Proposed Development is expected to be significantly below the vibration dose values stated in Table 8-2. Tactile vibration exposure due to tram events is unlikely to result in any adverse effects on the future occupants of the Proposed Development.
- Expected levels of re-radiated GBN (audible rumble of the building due to tram vibration) within the lower floors of the Proposed Development are relatively high.
- Expected levels of re-radiated GBN exceed the BCO guide value for open-plan areas on the ground floor, and is equal to the BCO guide value on Level 01.
- Expected levels of re-radiated GBN exceed the BCO guide value for meeting rooms and cellular offices (rooms for tasks requiring focus and concentration) from ground floor to Level 03.

The above has demonstrated that ground-borne noise from the Metrolink has a moderate influence on the Proposed Development. The potential effects that could occur in some parts of the development due to ground-borne noise from the Metrolink include distraction from activities requiring focus and concentration and potential annoyance.

To reduce the risk of these potential adverse effects occurring for the future occupants of the Proposed Development, it has been recommended that measures to reduce ground-borne noise within the Proposed Development are incorporated into the design. These measures are under consideration by the Client and design team at the time of writing, and are expected to take the form of resilient isolation materials (e.g. elastomeric bearings) positioned between the substructure and superstructure. Specifications for these mitigation measures will be developed further as the design progresses. The risk of any adverse effects on the future occupants of the Proposed Development would be minimised where the ground-borne noise targets in Table 8-2 are achieved. Measures to control vibration during operation may need to be provided by way of condition prior to the development becoming operational.

It is noted that the above ground-borne noise constraint is a design quality constraint and the potential effects are limited to the future building occupants. The Proposed Development is unlikely to result in any change to the level of vibration or ground-borne noise from the Metrolink that currently occurs at nearby sensitive receptors due to tram movements. Therefore, the Proposed Development is not expected to result in adverse effects due to vibration or ground-borne noise from trams at any nearby sensitive receptor.

9. Summary

Sweco UK Limited has been commissioned by Toriview Ltd to provide acoustic consultancy services in relation to the Phase 2 New Victoria: office development. This report presents assessments of environmental noise and vibration for the Proposed Development.

As part of this work, environmental noise monitoring was carried out at the Site and in the vicinity of adjacent noise-sensitive properties. A survey of vibration resulting from the adjacent Metrolink was also carried out. This report presents the survey methodologies, a description of the observed noise and vibration sources and weather conditions, and the results of the surveys.

The observed sources of noise during the daytime were road traffic movements on the adjacent road network, tram movements and pedestrian activity. During the survey, construction noise from the New Victoria Phase 1: residential development was also present and it has been necessary to make extrapolations from the available noise survey data on a precautionary basis. Given this limitation, it has been recommended that further noise monitoring is carried out later in the programme to ensure that the acoustic specifications for the building and any associated noise control measures are robust.

Limits on noise from building services systems associated with the Proposed Development have been presented. These limits are defined from the results of the noise surveys and account for the requirements of MCC. An outline assessment of building services noise has then been carried out for the primary building services systems (ASHPs and AHUs). The limits on noise from building services are expected to be achieved subject to the noise control measures identified within this report being employed. Based on the current proposals for the primary building services systems, these measures include screening around the ASHP area and appropriate local attenuation measures fitted to each ASHP. With appropriate noise control, no adverse effects would occur due to building services noise.

An assessment of noise break-out from the proposed commercial unit to outdoors has been carried out. No adverse effects due to activity noise are expected at the nearest noise-sensitive receptors.

The noise survey results have informed an assessment of noise ingress into the Proposed Development. This assessment has concluded that ventilation during normal conditions will need to be provided via an alternative method to openable windows. The proposed normal ventilation strategy of mechanical ventilation ensures that BCO guidelines will be achieved subject to appropriate specification of the building envelope. The Site is considered suitable for the Proposed Development from the perspective of existing levels of environmental noise.

The vibration survey results have been used to estimate the level of tactile vibration and ground-borne noise within the Proposed Development. No adverse effects are expected to occur due to tactile vibration within the Proposed Development. However, without mitigation, adverse effects due to ground-borne noise could occur for the future occupants of the Proposed Development, particularly within the lower floors. There are no statutory or mandatory requirements to reduce ground-borne noise, however, the perceived design quality of the Proposed Development could be adversely affected without mitigation. For this reason, it has been recommended that measures to reduce ground-borne noise within the Proposed Development are incorporated into the design. It is noted that the risk of adverse effects applies only to the future building occupants. The Proposed Development is not expected to result in adverse effects due to vibration or ground-borne noise from trams at any nearby sensitive receptor.

The assessments presented in this report demonstrate that, subject to the identified mitigation measures being implemented, the development is not expected to result in any adverse effects due to noise or vibration. Therefore, there is no reason that the development proposals should be refused on the grounds of noise or vibration.

Appendix 1 Glossary

Sound is the **vibration** of particles in a medium, such as air, which may be detected by the human ear. This sound is defined as noise when it is audible and unwanted or undesirable to a listener.

The vibration, or oscillation, of particles about an equilibrium position results in local pressure fluctuations from the normal pressure. These local pressure fluctuations are described as **sound pressure**, and the number of oscillations per second is described as the **frequency**.

The human ear responds to an incredibly large range of sound pressure, from 0.00002 Pa to 200 Pa, and the **perceived loudness** is proportional to the logarithm of the sound pressure squared. For this reason, sound is measured in terms of a logarithmic parameter, the **sound pressure level**, to approximate the response of the ear. Sound pressure levels are quantified in **decibels (dB)** relative to the threshold of hearing.

The human ear responds to a wide range of sound frequencies, from the lowest perceptible bass note, around 20 Hz, to the highest perceptible treble note, around 20,000 Hz. The ear does not respond equally to each frequency and is most sensitive to sound within the mid-frequency range of around 600 to 8000 Hz.

The response of the ear to each frequency also varies with the sound pressure level. For very loud sounds the difference in perceived loudness between each frequency is less pronounced than for low level sound.

Acousticians measure **sound pressure levels** using sound level meters, which incorporate a **microphone**.

A sound level meter approximates the response of the human ear to sound by using frequency filters. For typical environment sounds, the **A-weighting filter** is used to approximate the response of the ear at typical sound pressure levels. The sound pressure level, adjusted to approximate the response of the ear, is quantified in **A-weighted decibels, dB(A) or dB L_{PA}**.

In a typical environment, the A-weighted sound pressure level will vary with time. For this reason, acousticians use statistical measurement parameters to describe the sound environment. The most common measurement parameters are as follows:

- **dB L_{Aeq,T}: Equivalent continuous A-weighted sound pressure level.** This is the energy-average sound pressure level during a measurement period, T.
- **dB L_{AFmax,T}: Maximum A-weighted sound pressure level.**
- This is the maximum sound pressure level during a measurement period, T, and measured in a way that approximates the time-response of the ear.
- **dB L_{A90,T}: 90th percentile A-weighted sound pressure level.**
- This is the sound pressure level exceeded for 90% of the measurement period, T, commonly referred to as the **background sound level**.

The sound pressure level in typical environments are presented in Table A1-1. Further definitions of acoustic parameters are presented in Table A1-2.

Table A1-1: Sound pressure levels within typical environments

Sound Pressure Level, dB	Typical Environment or Description
0	Threshold of hearing
15 to 25	A recording studio
25 to 35	A hotel bedroom at night
35 to 45	An unoccupied office
45 to 55	Quiet residential street
55 to 65	Normal conversation, 1 m away TV programme, listener position
65 to 75	Raised voices, 1 m away Urban high street traffic
75 to 85	Busy motorway traffic, on hard shoulder Typical small plant room
85 to 95	High-speed hand-dryer, operator position Inside London underground (average)
95 to 105	Pneumatic hammer, operator position Concert orchestra
105 to 115	Typical nightclub Untreated generator plantroom
115 to 140	Aircraft take-off, close proximity Threshold of pain

Table A1-2: Definitions of Acoustic Terminology and Parameters

Terminology or Parameter	Definition
Ambient sound level	The total sound pressure level in a given position from all surrounding sources of noise, both near and far. Normally expressed as an equivalent continuous A-weighted sound pressure level, dB $L_{Aeq,T}$.
A-weighting	The process of weighting the observed sound pressure level at each frequency band, to approximate the sensitivity of the human ear to sounds of different frequencies. A-weighted sound pressure levels are expressed as dB(A) or dB L_{Ap} .
Decibel	A logarithmic value quantifying the sound pressure at a specified position or sound power, relative to a reference sound pressure or sound power (20 μ Pa for sound pressure, 10^{-12} W for sound power).
Façade	A sound monitoring position is a "façade" position when it includes a strong reflection from an adjacent building or structure. This corresponds with a position that is between 1 and 2 metres away from a reflecting building or structure.
Free-field	A sound monitoring position is a "free-field" position when it is not affected by sound reflections from surrounding buildings and structures. This corresponds with a position at least 3.5 metres away from reflecting buildings or structures.
Frequency	The number of oscillations per second of a vibrating particle in a medium, measured in Hertz (Hz) or cycles per second.
Groundborne noise (or structure-borne noise)	Audible sound that is caused by vibration of a structure due to vibration transferred through the ground, usually by the movement of trains on nearby rail lines. Groundborne noise is measured indoors within a receiving room and includes noise generated by the vibration of interior

Terminology or Parameter	Definition
	elements (walls, ceiling or furnishings) due to the transfer of vibration through the ground and structure. In the UK, the convention is to assess groundborne noise in terms of the A-weighted maximum sound pressure level measured with a “slow” time-weighting, dB L_{ASmax} , and this applies to the level caused by typical train movements.
$L_{A01,T}$	The A-weighted sound pressure level exceeded during 1% of the time interval, T. Typically used to quantify the sound level of regularly occurring loud events during time interval, T.
$L_{A10,18hr}$	The A-weighted sound pressure level exceeded during 10% of the 18-hour time interval between 06:00 and 24:00. This is the UK Road Traffic Noise Index, as defined in the Calculation of Road Traffic Noise (CRTN, HMSO, 1988).
$L_{A90,T}$	The A-weighted sound pressure level exceeded during 90% of the time interval, T. Typically used to quantify the background sound level at a specified position.
$L_{Aeq,T}$	The equivalent continuous A-weighted sound pressure level over a time interval, T. This is an energy-average sound pressure level over the specified time period.
$L_{AFmax,T}$	The maximum A-weight sound pressure level during a specified time interval, T. Measured with “fast” time-weighting (which approximates the time-response of the human ear).
Noise	Unwanted or undesirable sounds observed by a listener.
Octave band	A frequency band used in acoustical measurements. An octave is a frequency interval between two sounds where the frequency of the lower sound is half the frequency of the upper sound. The human hearing range is divided into ten logarithmically equal frequency divisions called octave bands, with centre-band frequencies as follows: (16 Hz, 32 Hz,) 63 Hz, 125 Hz, 250 Hz, 500 Hz, 1000 Hz, 2000 Hz, 4000 Hz, 16000 Hz.
Residual sound level	The equivalent continuous A-weighted sound pressure level of the ambient sound remaining at a specified position when the specific sound source (the sound source being assessed) does not contribute to the ambient sound.
Sound	The vibration, or oscillation, of particles in a medium, such as air, which may be detected by the human ear.
Sound power level	A logarithmic measurement that quantifies the total sound power of a source emitted in all directions relative to a reference sound power ($W_{ref} = 1 \text{ pW}$ or 10^{-12} W). Equal to $10 \log_{10} (W / W_{ref})$ and expressed in decibels.
Sound pressure level (SPL)	A logarithmic measurement that quantifies the sound pressure at a specified position relative to a reference sound pressure ($p_{ref} = 20 \text{ } \mu\text{Pa}$). Equal to $20 \log_{10} (p / p_{ref})$ and expressed in decibels.
Specific sound level	The equivalent continuous A-weighted sound pressure level at a specified position due to the specific sound source (the sound source being assessed).
Third-octave band	A higher-resolution frequency band used in acoustical measurements. A third-octave band is equal to one of three logarithmically equal parts of the corresponding octave frequency band. The upper band edge frequency is equal to the lower band-edge frequency multiplied by $2^{1/3}$.
Vibration	The oscillation of particles, such as within a structure, about an equilibrium position. Expressed in terms of frequency (Hz), and amplitude (root-mean-squared acceleration over a defined time period).
Vibration dose value (VDV)	VDV is a measure of cumulative vibration exposure over a defined time period. This parameter that has been correlated with human perception effects (e.g. adverse comment). The VDV is defined as the fourth root of the time integral of the fourth power of the frequency weighted acceleration, where the weighting applied takes into account the frequency response of the human body to vibration. The VDV is determined at the point of entry to the body. If the vibration level is 'steady' or where regular events occur with similar vibration levels and characteristics, then VDV can be estimated from shorter measurements of acceleration.

Appendix 2 Additional Figures

Figure A2-1: Noise sensitive locations near the Site

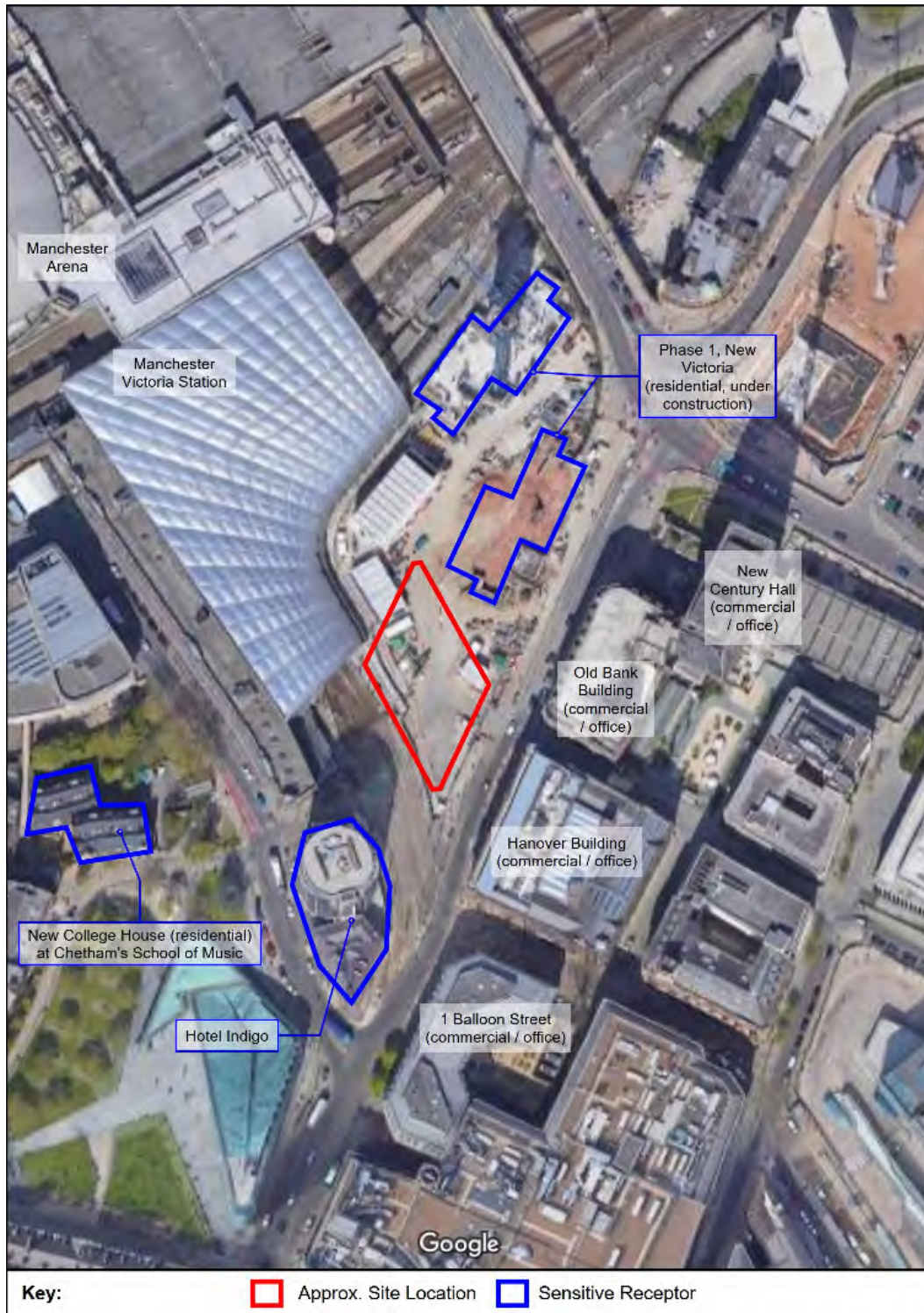


Figure A2-2: Noise measurement positions

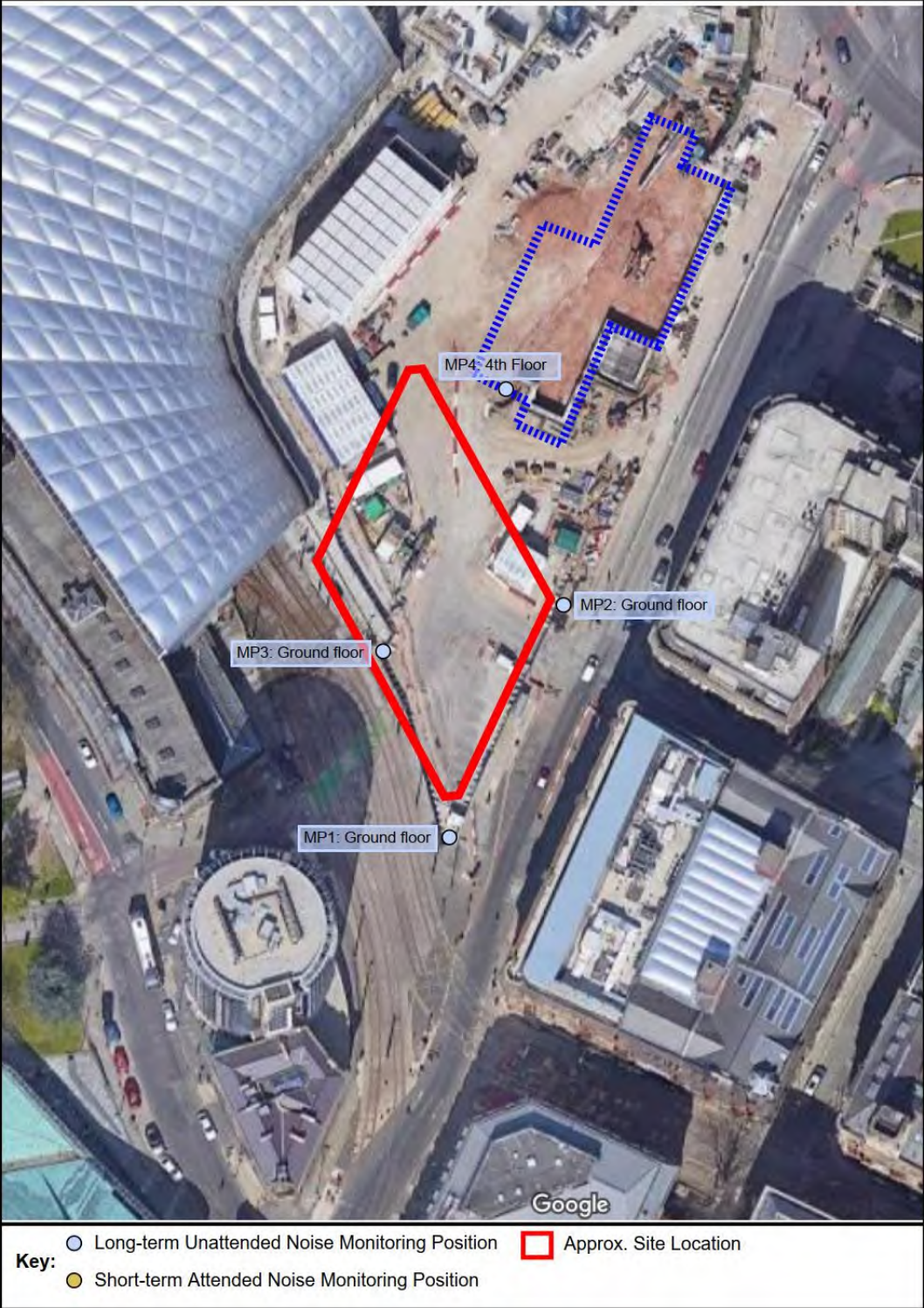
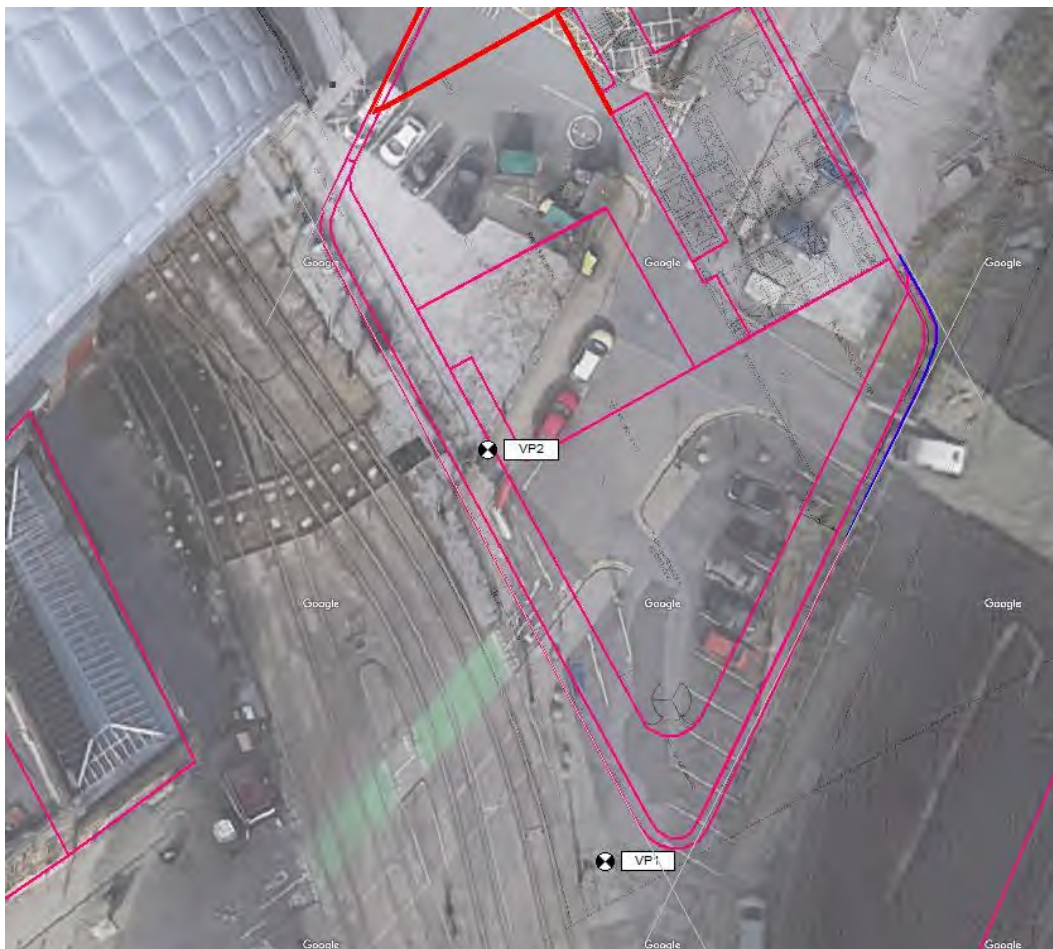


Figure A2-3: Vibration measurement positions



Appendix 3 Measurement Instrumentation

Table A3-1: Noise measurement instrumentation

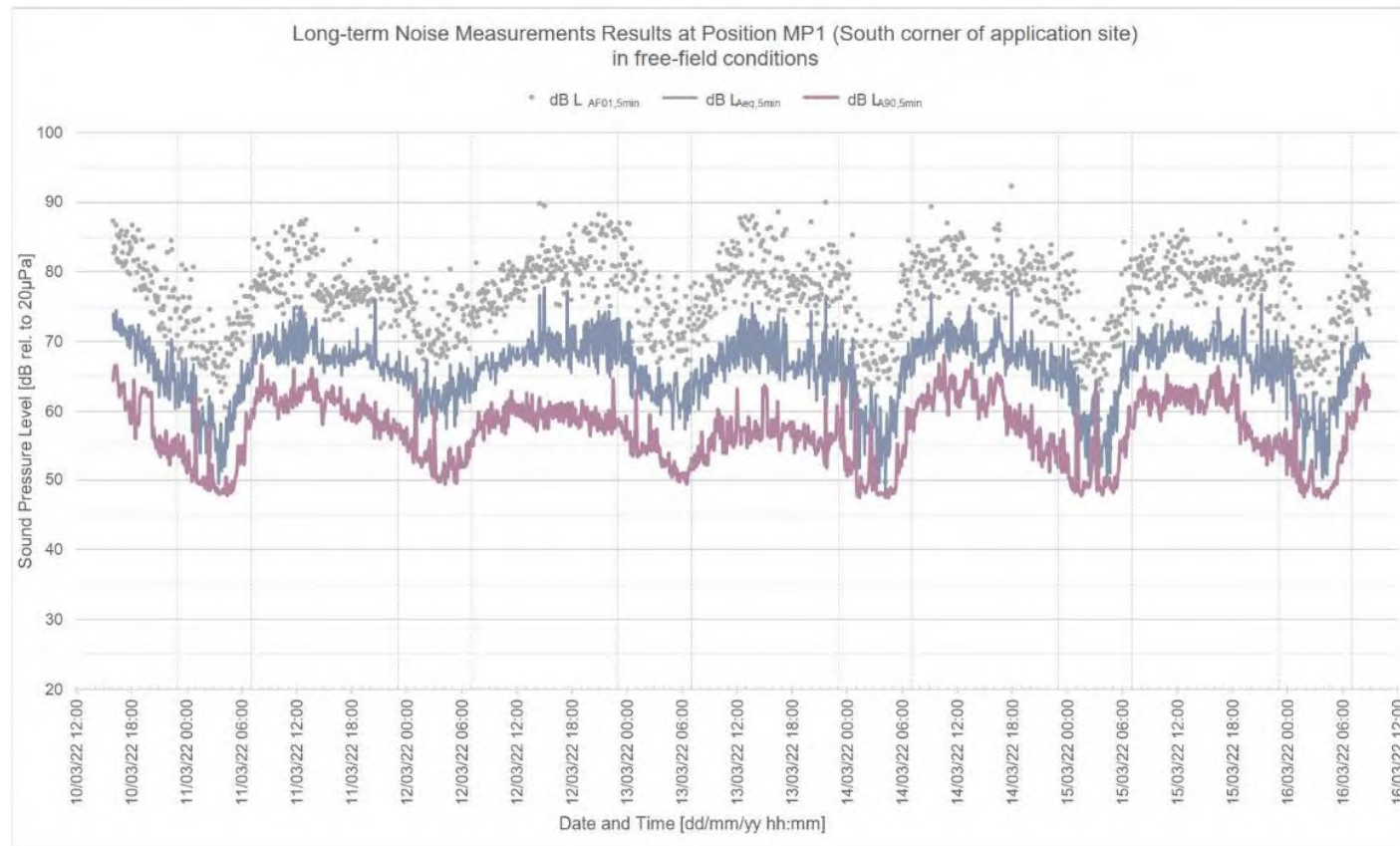
Equipment	Manufacturer-Model Type	Serial Number
1 - Sound Level Meter	Rion NL-52	00620901
1 - Preamplifier	Rion NH-25	76417
1 - Microphone	Rion UC-59	13342
2 - Sound Level Meter	01dB Fusion	11052
2 - Preamplifier	01dB PRE-22N°	1507083
2 - Microphone	GRAS 40CE	226358
3 - Sound Level Meter	01dB Fusion	11052
3 - Preamplifier	01dB PRE-22N°	1507083
3 - Microphone	GRAS 40CE	226358
4 - Sound and Vibration Monitoring Station	Svantek SV958A	59195
4 - Preamplifier	Svantek MK255	12811
4 - Microphone	Svantek SV12L	58565
Calibrator	Rion NC-74	34662223
<i>Calibration details are available on request.</i>		

Table A3-2: Vibration measurement instrumentation

Equipment	Manufacturer-Model Type	Serial Number
1 - Vibration Monitoring Station	Svantek SV958A	59195
1 - Accelerometer	Svantek SV84	E4993
2 - Vibration Monitoring Station	Svantek SV958A	59196
2 - Accelerometer	Svantek SV84	E5003
<i>Calibration details are available on request.</i>		

Appendix 4 Detailed Survey Results

Figure A4-1: Long-term noise measurement results at position MP1



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Figure A4-2: Long-term noise measurement results at position MP2

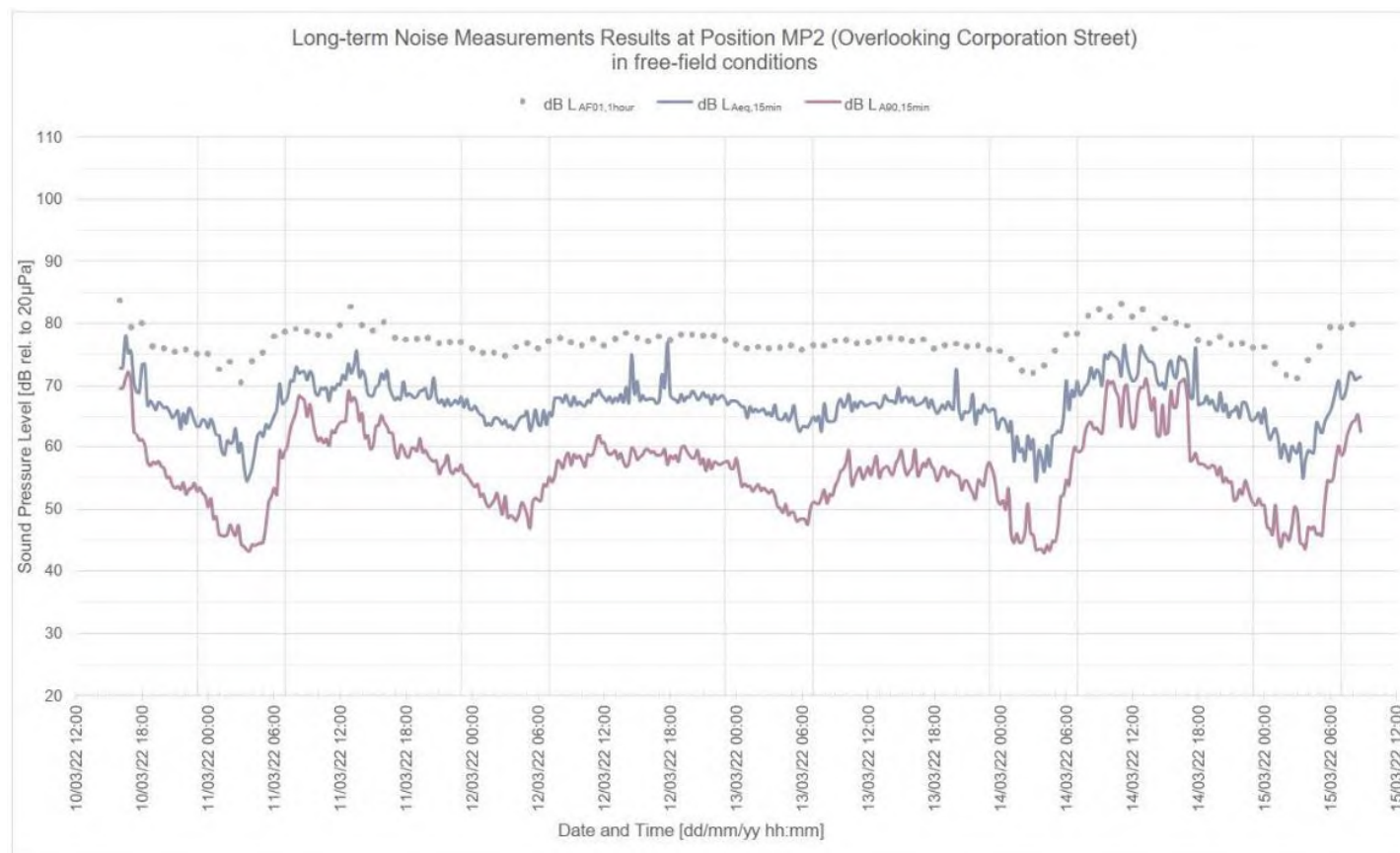


Figure A4-3: Long-term noise measurement results at position MP3

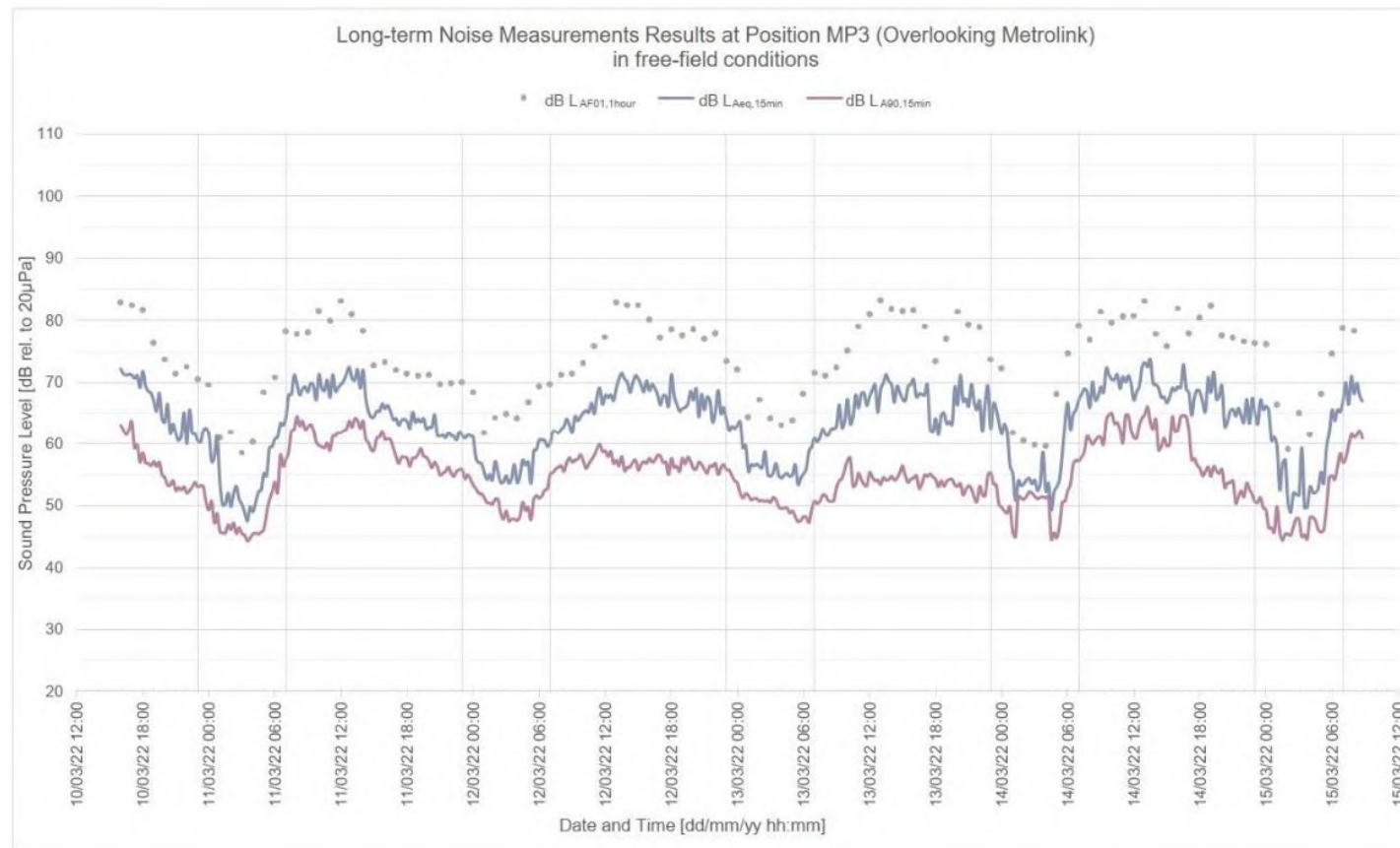


Figure A4-4: Long-term noise measurement results at position MP4

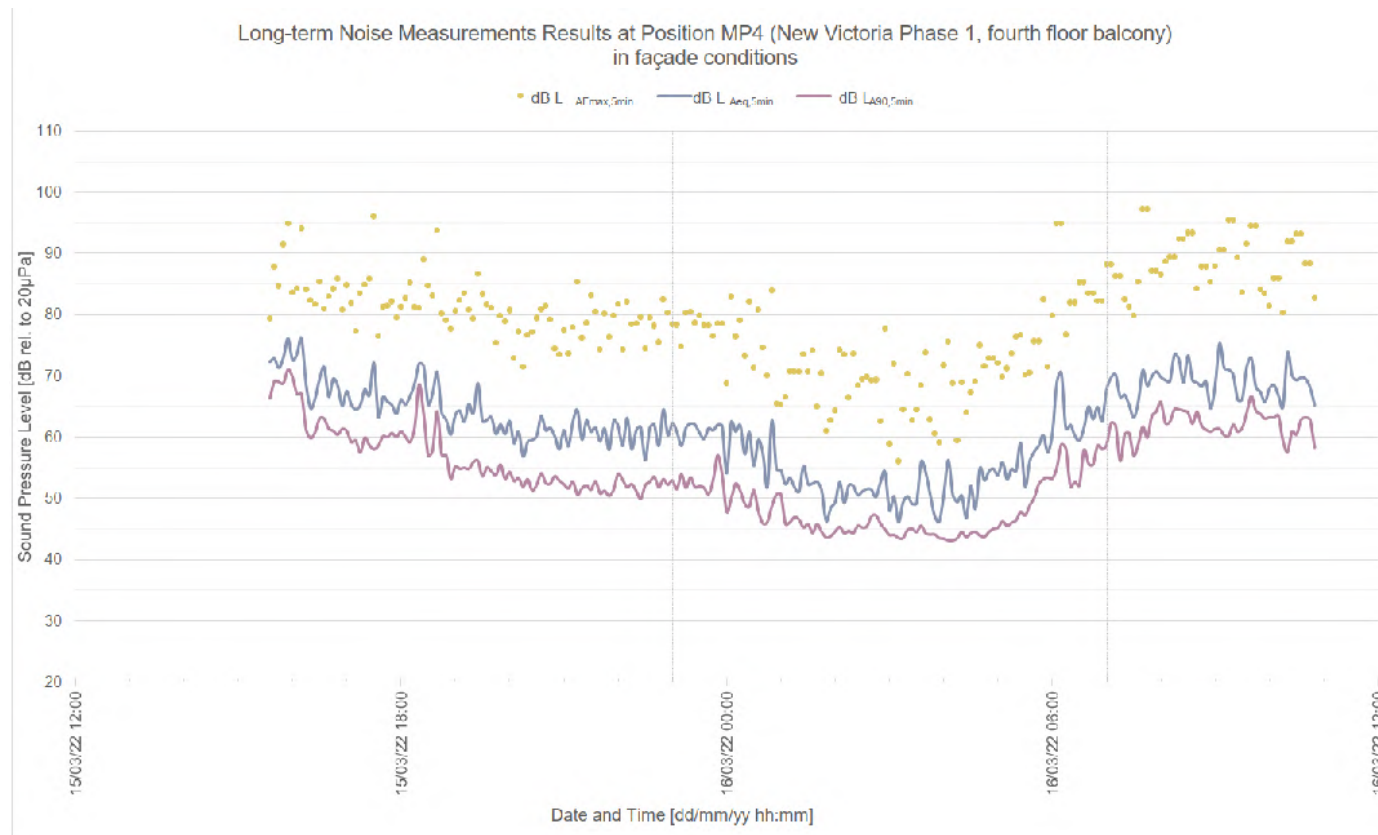


Table A4-1: Summary of noise measurement results at position MP1 (in free-field conditions)

Date	Long-term equivalent continuous SPL		Typical one-percentile SPL*	Most commonly occurring background sound level		
	[dB L _{Aeq,8 hour}]	[dB L _{Aeq,8 hour}]		[dB L _{A90,15 min}]		
	Office hours [09:00-17:00]	Night-time [23:00-07:00]	Office hours [09:00-17:00]	Office hours [09:00-17:00]	Evening [19:00-23:00]	Night-time [23:00-07:00]
Thursday 10/03/2022	-	62	-	-	56	49
Friday 11/03/2022	70	64	85	62	60	53
Saturday 12/03/2022	69	66	82	59	58	54
Sunday 13/03/2022	69	64	86	57	56	48
Monday 14/03/2022	71	63	85	65	55	49
Tuesday 15/03/2022	70	64	84	62	56	48
Representative Value	69	64	82	57	55	48
* The one-percentile sound pressure level were the second highest dB L _{AF01, 1 hour} value measured between 09:00-17:00 on each weekday						

Table A4-2: Summary of noise measurement results at position MP2 (in free-field conditions)

Date	Long-term equivalent continuous SPL		Typical one-percentile SPL*	Most commonly occurring background sound level		
	[dB L _{Aeq,8 hour}]	[dB L _{Aeq,8 hour}]		[dB L _{A90,15 min}]		
	Office hours [09:00-17:00]	Night-time [23:00-07:00]	Office hours [09:00-17:00]	Office hours [09:00-17:00]	Evening [19:00-23:00]	Night-time [23:00-07:00]
Thursday 10/03/2022	-	63	-	-	54	46
Friday 11/03/2022	71	65	80	64	59	51
Saturday 12/03/2022	69	66	78	59	58	53
Sunday 13/03/2022	67	64	78	56	56	46
Monday 14/03/2022	74	64	82	71	57	46
Representative Value	69	64	78	56	54	46
* The one-percentile sound pressure level were the second highest dB L _{AF01, 1 hour} value measured between 09:00-17:00 on each weekday						

Table A4-3: Summary of noise measurement results at position MP3 (in free-field conditions)

Date	Long-term equivalent continuous SPL		Typical one-percentile SPL*	Most commonly occurring background sound level		
	[dB L _{Aeq,8 hour}]	[dB L _{Aeq,8 hour}]	[dB L _{AF01,1 hour}]	[dB L _{A90,15 min}]		
	Office hours [09:00-17:00]	Night-time [23:00-07:00]	Office hours [09:00-17:00]	Office hours [09:00-17:00]	Evening [19:00-23:00]	Night-time [23:00-07:00]
Thursday 10/03/2022	-	58	-	-	53	46
Friday 11/03/2022	69	58	82	61	56	51
Saturday 12/03/2022	68	59	82	57	57	51
Sunday 13/03/2022	68	61	82	54	53	51
Monday 14/03/2022	70	62	82	65	54	46
Representative Value	68	61	82	54	53	46
* The one-percentile sound pressure level were the second highest dB L _{AF01, 1 hour} value measured between 09:00-17:00 on each weekday						

Table A4-4: Summary of noise measurement results at position MP4 (in free-field conditions)

Date	Long-term equivalent continuous SPL		Typical one-percentile SPL*	Most commonly occurring background sound level		
	[dB L _{Aeq,8 hour}]	[dB L _{Aeq,8 hour}]	[dB L _{AF01,1 hour}]	[dB L _{A90,15 min}]		
	Office hours [09:00-17:00]	Night-time [23:00-07:00]	Office hours [09:00-17:00]	Office hours [09:00-17:00]	Evening [19:00-23:00]	Night-time [23:00-07:00]
Tuesday 15/03/2022	-	56	-	-	52	44
Representative Value	-	56	-	-	52	44

Figure A4-5: Sample of detailed vibration monitoring results at position V1

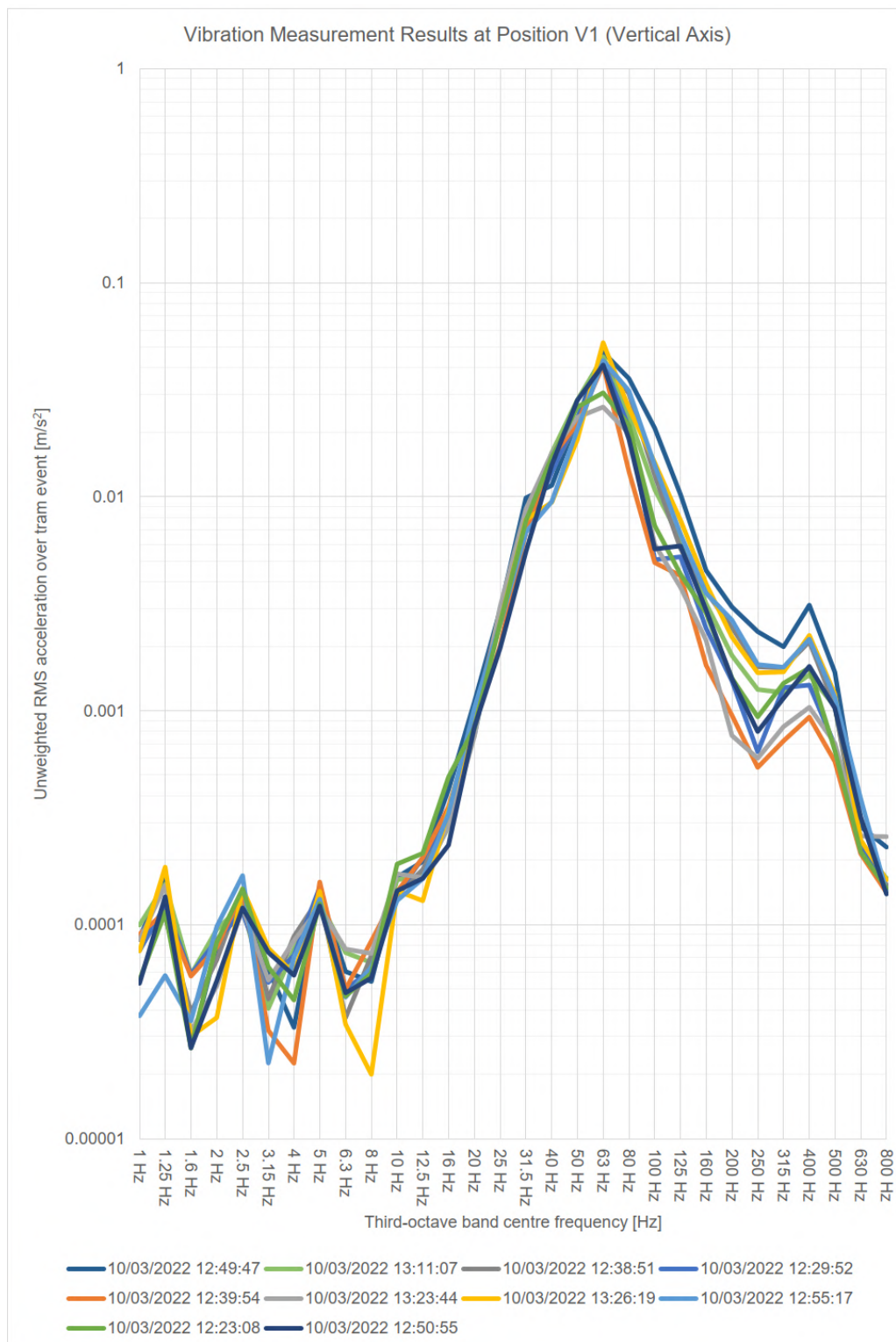
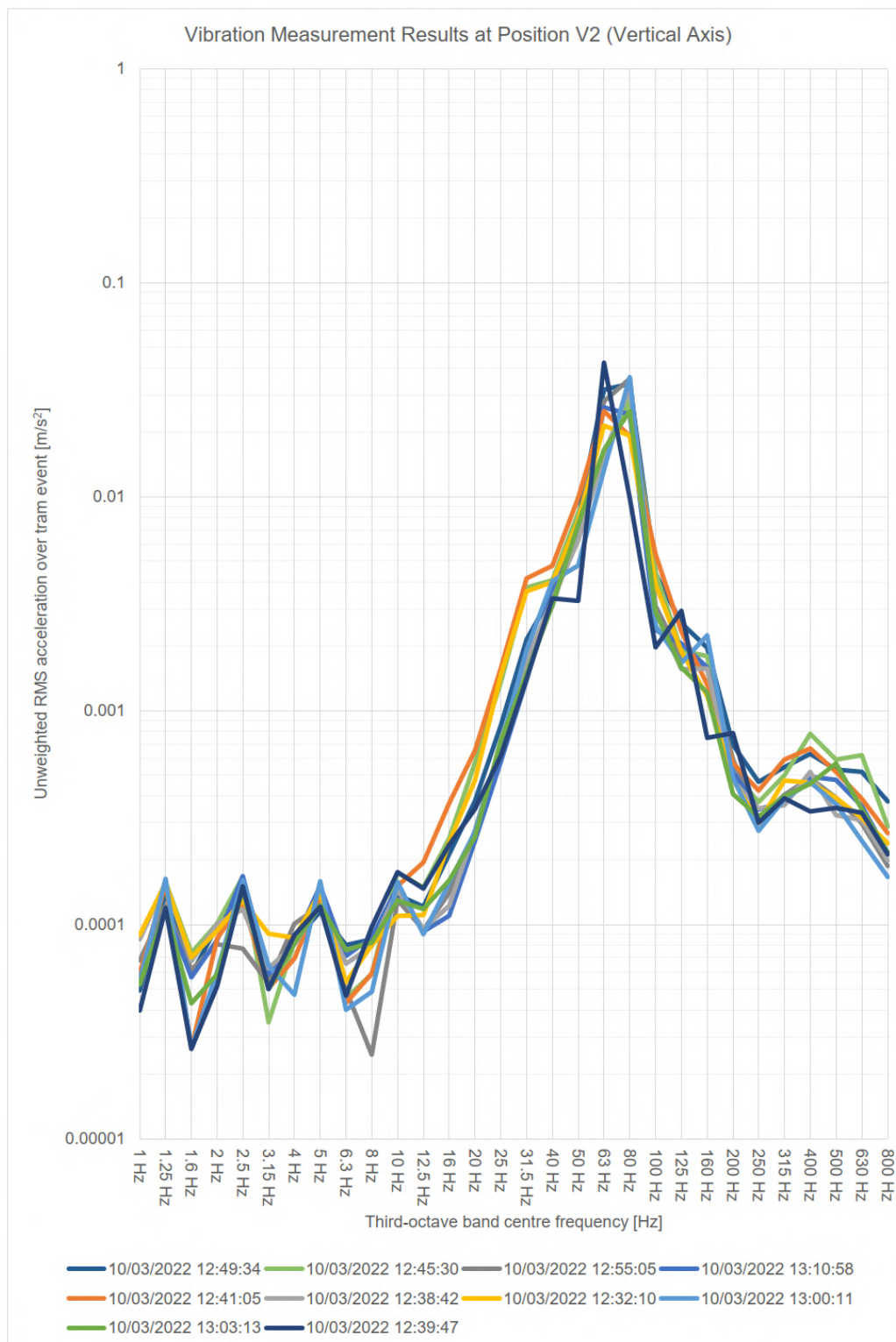


Figure A4-6: Sample of detailed vibration monitoring results at position V2



Appendix 5 Detailed Noise Modelling Results

Figure A5-1: Screenshot of noise model and worst-case building services noise level predictions

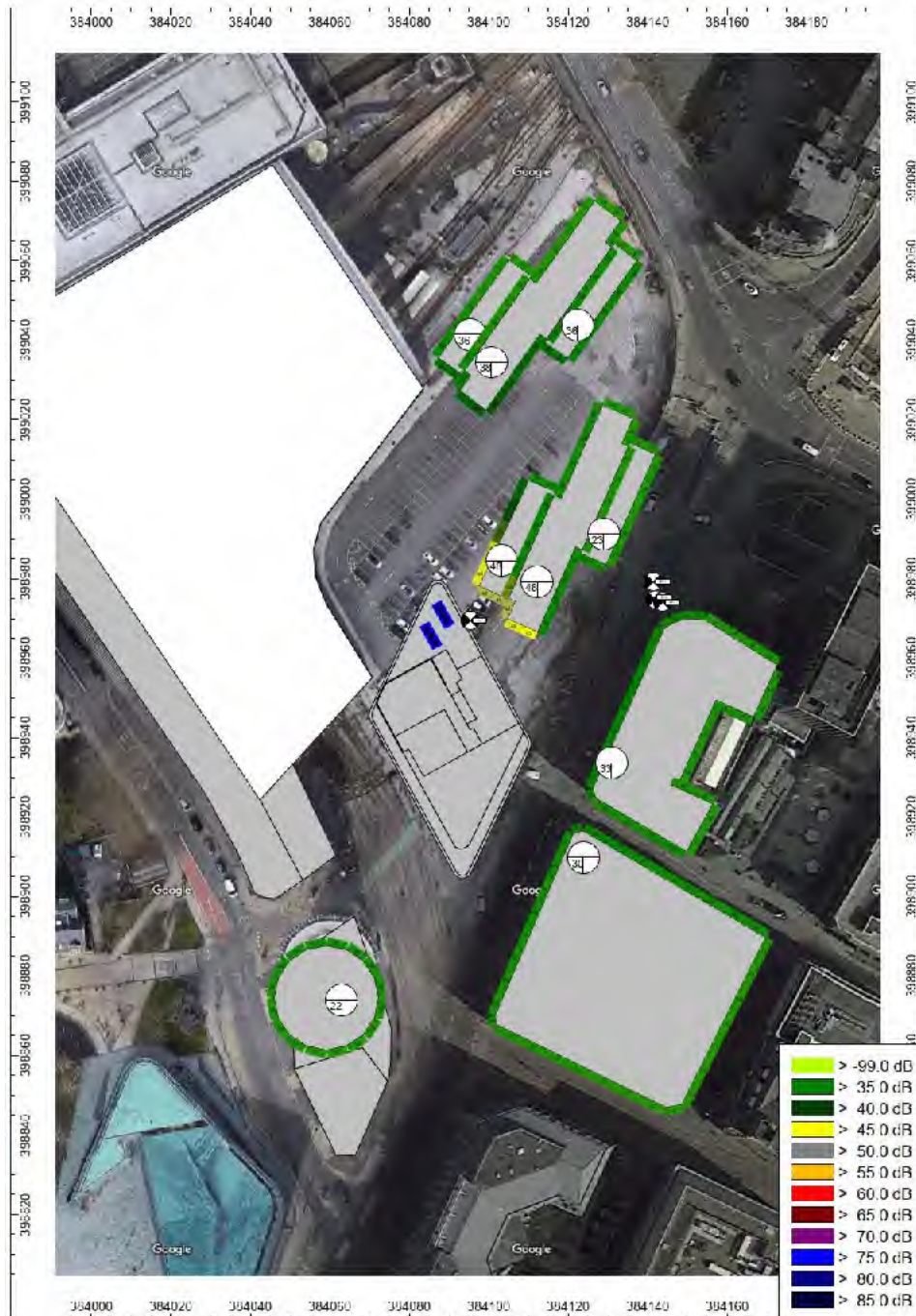


Figure A5-2: Predicted commercial activity noise levels at the nearest noise-sensitive receptors

