HMH One Clyde Ltd.

Noise & Vibration Impact Assessment

Oswald Chambers, Glasgow

10204310/NJM/R1/v1 – 29th January 2021

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Document Control Sheet

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Appendices

1. Introduction

1.1 Bureau Veritas was instructed by Ian Gallacher of Iceni on behalf of HMH One Clyde Ltd. to undertake a noise impact assessment for a proposed residential style hotel development situated on the corner of Broomielaw and Oswald Street in central Glasgow.

1.2 A glossary of acoustic terminology is included as Appendix A. The assessment criteria applicable to this site are reproduced in Section 3. Furthermore, a schedule of the monitoring equipment is presented in Appendix B of this report.

1.3 Scaled site plans of the proposed development were supplied by Iceni. A copy of the proposed site plan can be found in Appendix C.

1.4 This assessment looks to establish the current noise impact at the proposed development site with a view to facilitate Glasgow City Council requirements with respect to noise for the daytime and night-time periods. The assessment also looks at the likelihood of adverse impact due to vibration levels arising from the railway.

1.5 Due to the current restrictions in place due to the Covid-19 pandemic, it was not be possible to measure typical road traffic noise levels, as would be normal procedure. To that end, Bureau Veritas have created a road traffic noise model, using typical traffic flows for the Broomielaw and Oswald Street.

2. Description of Site and Noise Sources

2.1 It is understood that Iceni proposed to submit a planning application to Glasgow City Council for a proposed residential hotel on the corner of the Broomielaw and Oswald Street in central Glasgow.

2.2 It is understood the intention is to repurpose the existing Oswald Chambers and also to construct a new 6-storey building on the vacant land adjacent to form a new bespoke hotel. A total of approximately 128 bedrooms will be created. As part of the planning application a noise and vibration impact assessment has been anticipated and will be submitted to the Local Authority.

2.3 The proposed development site is bound by Broomielaw to the south, Oswald Street and the Glasgow Central railway line to the east, the Clydeport Building on Robertson Street to the west and a derelict building (11 Oswald Street) to the north.

2.4 During our site visit it was noted that the proposed development site was dominated by local road traffic noise on Broomielaw and Oswald Street. Railway noise was insignificant as road traffic dominated despite the lower levels of traffic than usual.

3. Criteria for Noise & Vibration Assessment

3.1 Bureau Veritas have been commissioned as part of the planning process to undertake a noise and vibration impact assessment with a view to establishing whether the proposed development site is suitable for residential style hotel.

3.2 Due to the identification of noise sources and previous council requirements, it was considered suitable to proceed in line with the following;

- Calculation of Road Traffic Noise 1988;
- British Standard BS 8233:2014, *"Guidance on sound insulation and noise reduction for buildings;*
- British Standard BS 6472, *"Guide to evaluation of human exposure to vibrations in buildings (1 Hz to 80 Hz)"*
- BS 4142:2014+A1:2019, *"Methods for rating and assessing industrial and commercial sound";*
- World Health Organisation (WHO) *"Guidelines for Community Noise".*

Calculation of Road Traffic Noise (CRTN) 1988

3.3 This memorandum describes the methodology to calculate the road traffic noise at a given distance from the highway, the results of which can then be input into a computer noise model.

3.4 The methodology considers the intervening ground cover, road configuration and road layout. The calculation assumes a typical traffic and noise propagation conditions. Noise levels are presented in terms of the noise descriptor $L_{A10,18h}$ which is the arithmetic average of the noise level exceeded for 10% of the time each hour between 06:00 and 24:00 hours.

3.5 The variables used in the calculation of the traffic noise level are:

- The annual average week day traffic flow (AAWT) for the 18-hour period from 06:00 to 24:00 hours;
- Mean traffic speed;
- Percentage of heavy vehicles;
- Road gradient;
- Type of road surface;
- Distance of the receptor from the road;
- Nature of the ground cover between the road and the receptor;
- Screening and reflections.

Internal Noise Criteria

3.6 BS 8233:2014 provides recommendations for the control of noise in and around buildings. The standard suggests suitable internal noise levels within different types of buildings, including residential dwellings. Although this development is classed as a hotel, it is considered that because suites could be let out for long periods, similar amenity levels to residential dwellings should be achieved.

3.7 BS 8233:2014 suggests that an internal noise level of 30 dB $L_{Aeq,T}$ within bedrooms is required for the night-time (23:00 and 07:00). For the daytime (07:00 and 23:00) the standard stipulates that in order to provide suitable resting conditions within bedrooms the level should not exceed 35 dB dB $L_{Aeq,T}$.

3.8 Furthermore, the World Health Organisation (WHO) *"Guidelines for Community Noise,"* states that in dwellings, the critical effects of noise are on sleep, annoyance and speech interference. To protect the majority of people being awakened at night, noise events should not exceed 45 dB $L_{A,max}$.

3.9 It is understood that there are no large spaces for the proposed development, therefore the assessment will focus on internal noise levels only.

Railway Vibration

3.10 Due to the close proximity of the railway line, vibration levels must be taken into account. This assessment has been carried out in accordance with the guidance given in BS 6472-1:2008, *"Guide to Evaluation of Human Exposure to Vibration in Buildings".*

3.11 The assessment is in terms of the Vibration Dose Value (VDV) which is a parameter used to estimate the probability of adverse comment which might be expected from humans experiencing vibration in buildings. It considers the magnitude of the vibration events as well as the number and duration of those events, to quantify the total vibration exposure. Consideration is given to the time of day and use of occupied space in buildings, whether residential, office or workshop.

3.12 The assessment is in terms of VDV that would be experienced by an occupier over a sixteen-hour daytime and an eight-hour night-time period. Table 3.1 below (taken from, BS 6472-1:2008, Table 1) details the range of VDV's that would be likely to generate degrees of adverse comment.

Table 3.1: VDV ranges which might result in various probabilities of adverse comment within residential buildings.

Place and Time	Low Probability of Adverse Comment $m/s^{1.75}$	Adverse Comment Possible $m/s^{1.75}$	Adverse Comment Probable $m/s^{1.75}$
Daytime (07:00 to 23:00 hours)	0.2 to 0.4	0.4 to 0.8	0.8 to 1.6
Night-time (23:00 to 07:00 hours)	0.1 to 0.2	0.2 to 0.4	0.4 to 0.8

NOTE: For offices and workshops, multiplying factors of 2 and 4 respectively should be applied to the above vibration dose value ranges for a 16 h day.
1) Below these ranges adverse comment is not expected.
2) Above these ranges adverse comment is very likely.

4. Noise Model

4.1 An acoustic model has been created for the proposed development site using CadnaA noise mapping software. The software calculates the contribution from each noise source, input as a specified source type (e.g. point, line, area, etc.) octave band sound power level at defined locations.

4.2 The model predicts noise levels based on hemispherical propagation, atmospheric absorption, ground effects, in plant reflections, screening and directivity based on the procedure detailed in ISO 9613-2, *"Acoustics -- Attenuation of sound during propagation outdoors -- Part 2: General method of calculation"*.

4.3 The model has been run using a receiver height of 1.5 metres above grade, equivalent to ear level at standing height for the ground floor rooms. Additionally, the model has been run at 5.0m representative of the first floor. Both ground and first are considered to be most impacted in terms of noise levels. The model accounts for equal sound radiation of noise sources in all directions.

4.4 ISO 9613-2 gives the estimated accuracy of the noise model as ±3 dB, for the calculation of broadband A-weighted sound levels, for receiver distances of up 1 km. The standard also states that errors in the calculation of individual octave bands may be somewhat larger than the estimated errors given for broadband A-weighted sound levels.

Acoustic Model Inputs

4.5 The noise model has been prepared using the site plans provided by Iceni.

4.6 Road traffic flows for the Broomielaw adjacent to the proposed development were taken from the Department for Transport website. The most up to date traffic counts for 2019 were used to inform the noise model along with a typical traffic speed of 30mph, 17% HGV flow and an impervious, bituminous 5mmTD road surface. Furthermore, data for Oswald Street using typical traffic speed of 30mph, 27% HGV flow and an impervious, bituminous 5mmTD road surface.

4.7 The results from the road traffic noise model have been used to assess the impact of transportation noise on the proposed development for the daytime (07:00 to 23:00) and night-time periods (23:00 to 07:00).

4.8 Furthermore, a measured L_{Amax} noise levels of 82.0 dB @ 4m, taken on the Broomielaw has been used to predict the impact of potential waking events for this development.

Assumptions and Limitations

4.9 In terms of ground effect, a low ground absorption will be used, i.e. hard terrain.

4.10 Conservative climatic conditions, favourable to noise propagation were selected i.e. downwind conditions. It is envisaged however that due to the short propagation distance with which the receptors lie, atmospheric conditions will have very little impact of projected noise levels.

5. Vibration Assessment

5.1 Iceni had initially asked Bureau Veritas to assess the impact of vibration from train pass-bys as these were understood to be perceptible within the existing building, Oswald Chambers. From the site visit made and measurements undertaken it was found that vibration events were caused by passing busses rather than trains, although their magnitudes were very small.

5.2 Vibration measurements were made between 12:00 and 13:20 on the 20th January 2021. The vibration measurements were undertaken in accordance with the methodology given in BS 6472-1:2008, with the geophone located approximately 2m from the closest façade to the railway line. A schedule of the vibration monitoring equipment used is presented in Appendix B.

5.3 BS 6472 states that, *"The primary aim in the selection of the measurement location should be to establish the vibration level at the point of entry to the body. However, it is seldom possible to identify such a position uniquely and therefore it is more normal to measure at a location that would be expected to give rise to the highest levels of vibration to which the occupants would be exposed. Where measurements are made other than at the point of entry of vibration to the body, an allowance should be made for the transfer function between the measurement point and the point of entry to the body. It is essential that this allowance is reported with the measurements."*

5.4 The measurements were made with the geophone placed on the 1st and 2nd floor in rooms closest to the roadside.

5.5 Vibration was measured in terms of PPV and then in accordance with BS 6472, vibration levels were calculated in terms of the vibration dose value (VDV). The VDV prediction was based over the 1 hour and 20 minute monitoring period.

5.6 The highest measured vibration levels for each axis are presented in Table 5.1 below. The highest VDV mm/s$^{1.75}$ value was recorded in the longitudinal axis.

Table 5.1: Highest measured Vibration Dose Value (mm/s$^{1.75}$)

Event	Time	VDV (mm/s$^{1.75}$)		
	Period	Transverse	Vertical	Longitudinal
Buss pass-by	80 mins	10.6	29.9	15.0

5.7 From the representative measurement for busses, the 16 hour (daytime) and 8 hour (night-time) worst case eVDV has been calculated by using the highest measured vibration event, which was measured in the longitudinal axis. The eVDV was calculated by using the number of bus pass-bys during the daytime and night-time. Additionally, during the monitoring period, only 30% of the buses triggered the vibration meter.

5.8 The calculated worst case eVDV values for the day and night-time periods are presented in Table 5.2.

Table 5.2: Calculated worst case eVDV

Assessment Period	eVDV (mm/s$^{1.75}$)	Assessment	VDV Range For Assessment Category
Daytime (07:00-23:00 hours)	0.088	'Low probability of adverse comment'	0.2 to 0.4
Night-time (23:00-07:00 hours)	0.049	'Low probability of adverse comment'	0.1 to 0.2

5.9 The estimated VDV values falls below the category given in BS 6472 for, *"Low probability of adverse comment,"* during both the daytime period and night-time period.

6. Discussion / Mitigation Measures

Criteria

6.1 Internal and external noise levels have been assessed with respect to the criteria provided by Glasgow City Council which taken from BS 8233:2014 *"Guidance on sound insulation and noise reduction for buildings"*. The criteria are summarised below.

Table 6.1: BS 8233:2014 Criteria

Location	Activity	Daytime (07:00 to 23:00)	Night-time (23:00 to 07:00)
Bedroom	Sleeping / Daytime Resting	35 dB $L_{Aeq,16hr}$	30 dB $L_{Aeq,8hr}$

6.2 The now surpassed, BS 8233:1999 stated that a partially open window, which allows ventilation provides approximately 10 – 15 dB(A) attenuation, for the purposes of this assessment we have assumed 13 dB(A) attenuation.

6.3 Furthermore, the World Health Organisation (WHO) recommends that for a good night sleep, maximum indoor noise levels should not exceed L_{AFmax} 45 dB.

Noise Model Results

6.4 The results of the CadnaA noise model have been used to generate colour contour noise maps (see Appendix D) which are able to help assess the suitability of the site for residential development.

6.5 The modelling results show that road traffic noise levels during the daytime typically range from $L_{Aeq,16h}$ 66 - 71 dB across the levels during the day and $L_{Aeq,16h}$ 56 – 60 across the levels during the night. Generally, where noise levels exceed 53 dB during the daytime and 43 during the night-time, acoustic trickle ventilation will be required.

6.6 It was further calculated that the most exposed plots would be subject to an L_{Amax} noise level of 82 dB from road traffic noise.

Internal Levels – Façades fronting Broomielaw & Oswald

6.7 The highest façade noise levels fronting Broomlielaw and Oswald Street were found to be the same i.e. $L_{Aeq,16hr}$ 71 dB for the daytime, $L_{Aeq,8hr}$ 60 dB for the night-time and a maximum level of L_{Amax} 82 dB. Therefore, internal noise levels have been calculated based on a partially open window and the results are displayed in Table 6.2 below.

Table 6.2: Internal Noise levels with Partially Opened Windows for homes fronting Broomielaw

Calculation Point:	External dB(A)	With Partially Open Window (-13 dB)	Design Limit (dB)	Criteria Met?
Day – Lounge / Dining Room $L_{Aeq,t}$	71	58	35	×
Night – Bedroom $L_{Aeq,t}$	60	47	30	×
Night – Bedroom L_{Amax}	82	69	45	×

6.8 It can be seen from the results above, that with a partially opened window, internal noise levels are unlikely to be met for rooms fronting Broomlielaw and Oswald Street. Therefore, an alternative form of ventilation may need to be provided to allow for a closed window scenario.

6.9 A detailed break-in assessment of road noise has been made using the methodology outlined within BS 8233 in order to establish suitable glazing and acoustic trickle ventilation.

6.10 We have based our calculations on the most exposed rooms fronting Broomielaw. The building specification used for the purposes of our calculations can be seen below;

- **Flat Type – Smart Guest (Long)**
  Brick / block cavity wall façades
  Room Volume: 68m^3
  Glazing Area: 4.3m^2

6.11 The external noise levels calculated from the noise model have been used to predict the likely internal noise levels within rooms based on room sizes and glazing areas stipulated above. Predicted internal noise levels are displayed in the Table 6.3 below.

Table 6.3: Predicted Average Internal Noise levels (dB) for homes fronting Broomlielaw

Calculation Point	Recommended Glazing	Time Period	Calculated Internal $L_{Aeq,t}$ sound level (dB)	Criteria Met?
Lounge / Dining Room	6/12/10	Day	33.2	✓
Bedroom	6/12/10	Night	22.2	✓
		Max	44.2	✓

6.12 It can be seen from the results above that with the use of a double-glazed unit such as 6/12/10, with an acoustic performance of R_w 35 dB and $R_w + C_{tr}$ 32 dB (or an acoustic performance equivalent) the internal noise level criteria stipulated in BS 8233 and WHO for the daytime and night-time should be met.

6.13 It should be noted that the hotel will be provided with mechanical ventilation system and hence will comprise of a sealed façade. This means that no background acoustic trickle vents will be required.

7. Plant Noise

7.1 The details of the proposed plant associated with the new residential hotel are not yet known at this stage, therefore it is not possible to accurately predict the specific noise levels of the operational site at the noise sensitive receptors. The nearest sensitive receptors have been identified as the Stay Metro Apart Hotel, on Oswald Street.

7.2 Therefore, a maximum daytime and night-time cumulative Rating Level limit at the closest identified dwellings has been calculated. These limits have been calculated based on the typical ambient noise levels established from the noise model (representative ambient noise levels cannot currently be taken due to the impact of the Covid-19 Lockdown).

7.3 Generally it would be recommended that plant noise is inaudible at the nearest receptor. Although inaudibility is not strictly defined, it is considered that if the plant noise is 10 dB below the ambient noise level then it will not be audible

7.4 Due to the normal high level of road traffic noise and existing businesses in the area, we have used the noise model to predict levels at the Stay Metro Apart Hotel. It is considered that if the plant noise is 10 dB below this level, it is likely to be inaudible.

7.5 Due to the normal high level of road traffic noise and existing businesses in the area, we have used the noise model to predict levels at the StayMetro Apart Hotel. It is considered that if the plant noise is 10 dB below this level, it is likely to be inaudible. The proposed cumulative noise limits at the nearest receptor have been provided below.

Table 7.1: Recommended cumulative specific noise limits for operational noise

	Ambient Levels at StayMetro Apart Hotel	Noise Limit at Receptor in order to achieve Inaudibility
Daytime $L_{Aeq,T}$ (dB)	40	**30**
Night-time $L_{Aeq,T}$ (dB)	30	**20**

7.6 It is recommended that once the precise models and location of the plant are known, then the assessment should be re-visited in order to ensure the desired noise limits are achieved. If possible, representative ambient noise levels should be measured as the current levels are based on predicted levels of road traffic noise with levels predicted using data from the Department for Transport website.

8. Conclusions

8.1 Bureau Veritas have undertaken a noise impact assessment for a proposed residential development at Oswald Chambers. The assessment was based on the latest masterplan provided by Icini.

8.2 Due to the current restrictions caused by the Covid-19 pandemic, it was not be possible to attend site and measure typical road traffic noise levels, as would be normal procedure. To that end, Bureau Veritas carried out the assessment based on a road traffic noise model generated using typical traffic flows for the Brommielaw and Oswald Street.

8.3 A noise model was prepared using the CadnaA noise mapping software. Traffic flows were obtained from the Department for Transport website and using the latest site masterplan and topography data, colour contour noise plots were prepared and the noise levels established at the location of all the proposed property.

8.4 Calculations have shown that for façades fronting the Broomielaw and Oswald Street, internal noise limits are unlikely to be met with windows partially opened for ventilation purposes, however, it is understood the hotel will be mechanically ventilated with a sealed façade therefore, no background trickle vents will need to be specified and suitable glazing only will be required to achieve the internal noise limits.

8.5 Detailed noise break-in calculations indicate that with the use of standard double glazing such as **6/12/10** with an acoustic performance of R_w 35 dB and $R_w + C_{tr}$ 32 dB (or an acoustic performance equivalent) internal average noise levels for daytime and night-time periods will meet the criteria stipulated in BS 8233 and WHO.

8.6 The results of the vibration assessment when considered against BS 6472 indicate that the probability of adverse comment due to vibration from the railway line is low and from our site visit it was found than only vibration events from busses were able to be detected. Nevertheless, a vibration assessment for passing buses was undertaken and the results howed that the levels would be below the level for, *"Low probability of adverse comment,"* during both the daytime period and night-time period. However, it can never be said that there is no probability of adverse comment as this is dependent upon the relative sensitivity of the person experiencing the vibration.

8.7 Furthermore, a maximum daytime and night-time cumulative plant noise level at the closest identified receptor (i.e. the Stay Metro Apart Hotel) has been calculated based on predicted typical ambient noise levels established from the noise model. It was calculated that the plant noise should not exceed 20 dB at the nearest receptor at night in order to achieve inaudibility and 30 dB for the daytime. It is recommended that once the precise models and locations of the plant are known, then the assessment be re-visited in order to ensure the desired noise limits are achieved.

Appendix A

Glossary of Acoustic Terminology

"A" Weighting (dB(A))	The human ear does not respond uniformly to different frequencies. "A" weighting is commonly used to simulate the frequency response of the ear. It is used in the assessment of the risk of damage to hearing due to noise.
Decibel (dB)	The range of audible sound pressures is approximately 2 x 10^{-5} Pa to 200 Pa. Using decibel notation presents this range in a more manageable form, 0 dB to 140 dB. Mathematically: Sound Pressure Level (dB) = 20 log {p(t) / P_o} where P_o = 2 x 10^{-5} Pa
Frequency (Hz)	The number of cycles per second, for sound this is subjectively perceived as pitch.
Frequency Spectrum	Analysis of the relative contributions of different frequencies that make up a noise.
$L_{eq}(T)$	The equivalent continuous sound level. It is that steady sound level which would produce the same energy over a given time period T as a specified time varying sound.
$L_{Amax}(T)$	The maximum RMS A-weighted sound pressure level occurring within a specified time period.
L_{AE} or SEL	A measure of A-weighted sound energy used to describe noise events such as the passing of a train or aircraft; it is the A-weighted sound pressure level which, if occurring over a period of one second, would contain the same amount of A-weighted sound energy as the event. The relationship between $L_{Aeq,(T)}$ and SEL is as follows: $L_{Aeq,(T)} = 10 \log [\underline{antilog\ SEL_1/10 + antilog\ SEL_2/10 + ...}$ Total time period in seconds where SEL_n is the measured single event level for a given event
$L_{A10,T}$	Road traffic noise level. The A-weighted sound pressure level of the residual noise in decibels exceeded for 10% of a given time interval.
$L_{A90,T}$	Background noise level. The A-weighted sound pressure level of the residual noise in decibels exceeded for 90% of a given time interval.
Noise	Unwanted sound.
Octave Band	A range of frequencies defined by an upper limit which is twice the lower limit. Octave bands are identified by their centre frequency.
R_{TRA} (dB)	The Traffic Noise Reduction Sound Insulation is derived by taking into account a typical spectrum of road traffic in town and city centres

R_W (dB)	The weighted sound reduction incorporates a correction for the ear's response and has been derived in accordance with BS 5821:1984.
Specific Noise	The equivalent continuous A-weighted sound pressure level at the assessment position produced by the specific noise source over a given reference time interval.
Rating Level, $L_{Ar,T}$	The specific noise level plus any adjustment for the character of the noise.
Ambient Noise	Totally encompassing sound in a given situation at any given time composed of noise from many sources, near and far.
Residual Noise	The ambient noise remaining at a given position in a given situation when the specific noise source is suppressed to a degree such that it does not contribute to the ambient noise.

Appendix B

Schedule of Monitoring Equipment

Noise Equipment

Brüel and Kjær Sound Analyser Type 2260	Serial Number 2443404
Brüel and Kjær Microphone Type 4189	Serial Number 2795597
Brüel and Kjær Sound Level Calibrator Type 4231	Serial Number 2122928

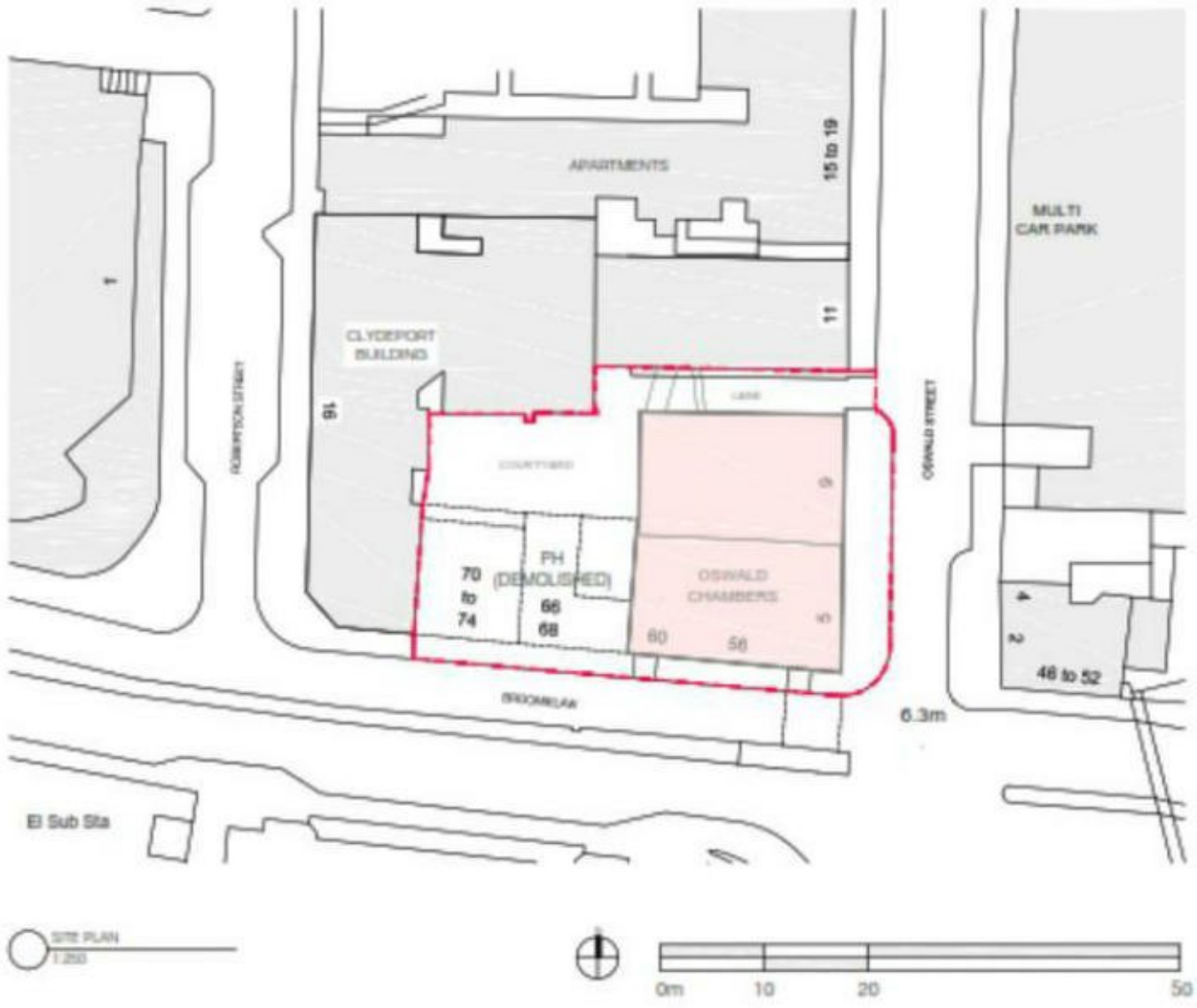
Brüel and Kjær Sound Analysis Software BZ 7202 (version 2)

Vibration Equipment

Instantel Minimate Plus	Serial Number BE11812
Geophone	

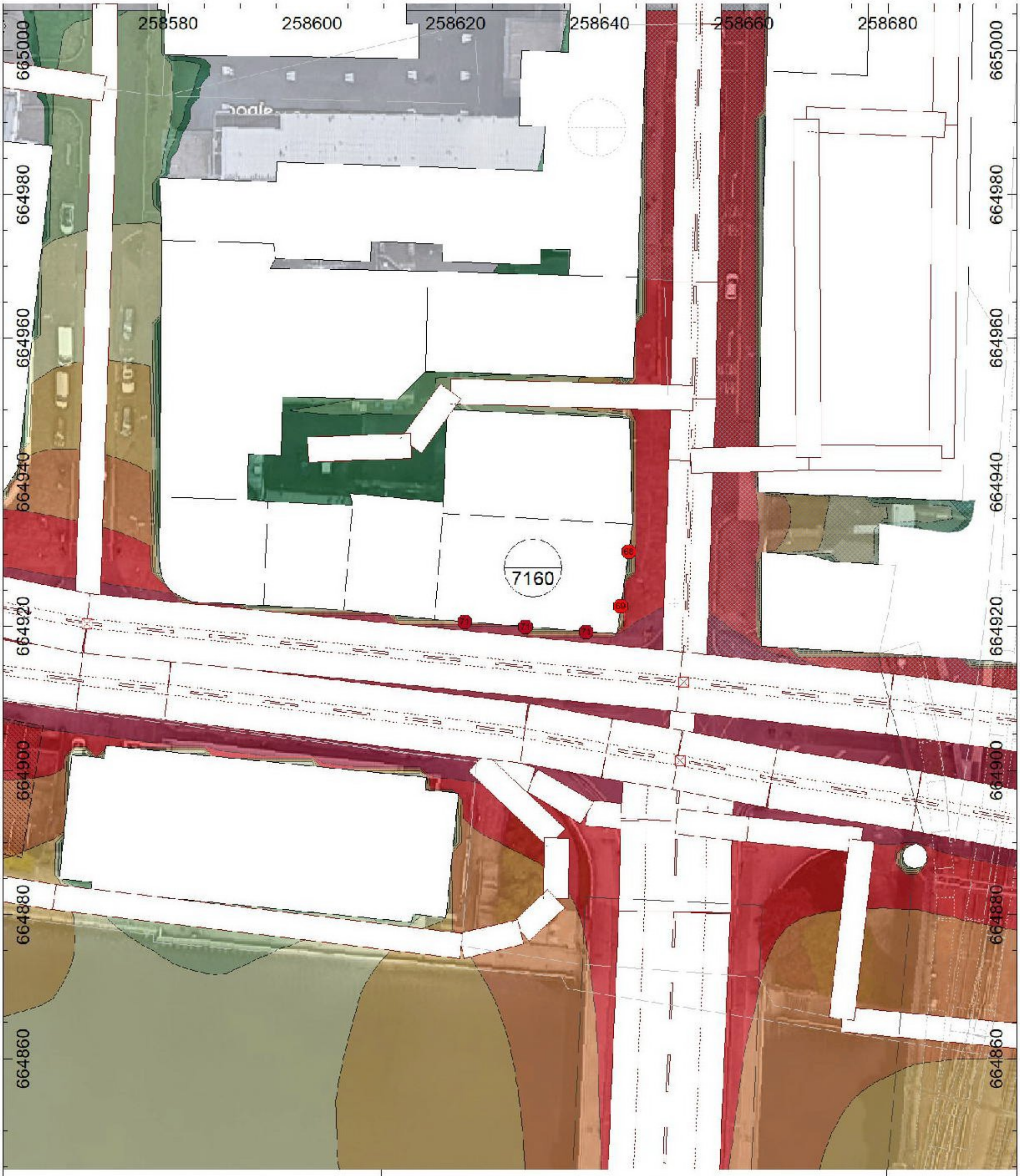
Appendix C

Site Plan (not to scale)



Appendix D

Noise Model Results



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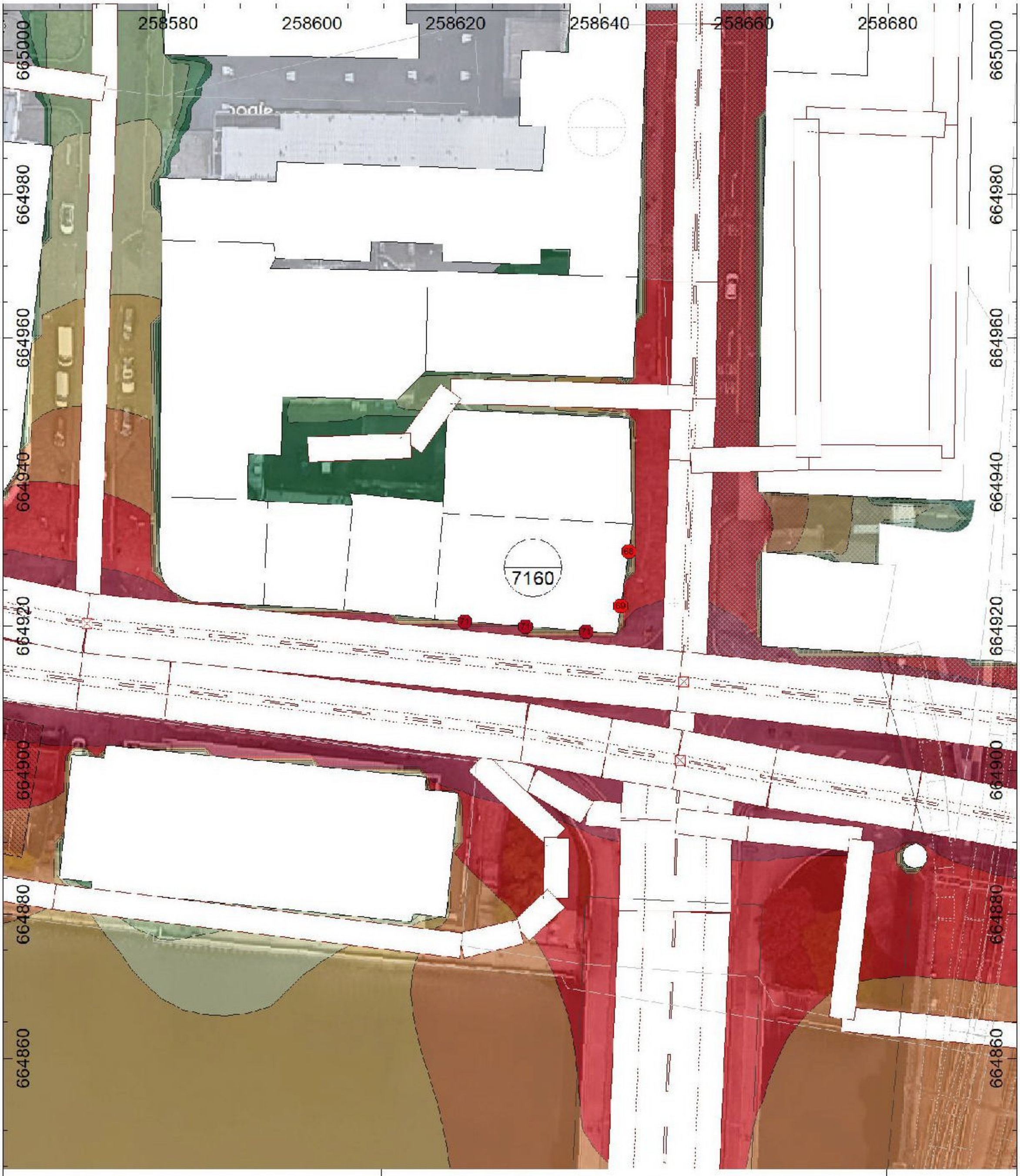
Project:	10204310 - N&VIA Oswald Chambers, Glasgow
Description:	Day
Level:	Ground Floor
Modelled:	N MacDonald
Reviewed:	R Giudice
Date:	29.01.21



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Project:	10204310 - N&VIA Oswald Chambers, Glasgow
Description:	Day
Level:	First Floor
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