Environmental Noise & Vibration Feasibility Assessment

1950 Scott Street

Ottawa, Ontario

REPORT: GWE18-031 – Noise & Vibration

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EXECUTIVE SUMMARY

This document describes an environmental noise & vibration feasibility assessment performed for a proposed mixed-use 20-storey development at 1950 Scott Street in Ottawa, Ontario. Upon completion, the development will rise approximately 70.5 metres above local grade. The major sources of transportation noise are Scott Street and the future LRT line to the north of the development. To the west and southwest are mixed-use buildings which contain sources of stationary noise from mechanical equipment. Figure 1 illustrates a site plan with surrounding context.

The assessment is based on: (i) theoretical noise prediction methods that conform to the Ministry of the Environment and Climate Change (MOECC) and City of Ottawa requirements; (ii) noise level criteria as specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG); (iii) future vehicular traffic volumes based on the City of Ottawa's Official Plan roadway classifications; and (iv) architectural drawings received from Neuf Architects.

The results of the current analysis indicate that noise levels will range between 54 and 68 dBA during the daytime period (07:00-23:00) and between 47 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 68 dBA) occurs along the north façade which is nearest and most exposed to Scott Street and the future Confederation Line LRT. Minimum building construction in all areas is required to satisfy the Ontario Building Code (2012). In addition, upgraded Sound Transmission Class (STC) ratings are required for building components where noise levels exceed 65 dBA.

Results of the calculations also indicate that the development will require central air conditioning, which will allow occupants to keep windows closed and maintain a comfortable living environment. A Warning Clause will also be required be placed on all Lease, Purchase and Sale Agreements. Additional design considerations regarding transportation noise are detailed in Section 5.1.1.

Our assessment of existing stationary noise sources indicates that sound levels produced by Heating Ventilation and Air Conditioning (HVAC) equipment on surrounding buildings are expected to fall below the ENCG noise criteria. As such, the proposed development is expected to be compatible with the surrounding properties.

With regards to stationary noise impacts from the proposed building on surrounding noise-sensitive buildings, once the mechanical plans for the proposed building become available, a stationary noise study will be performed. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels at the surrounding noise-sensitive buildings due to mechanical equipment on the roof of the proposed building are below the City of Ottawa's Noise Guidelines.

Estimated vibration levels at the nearest point of reception, based on an offset distance of 47 metres between the development the Confederation line LRT centerline and the nearest building foundation, are expected to be 0.018 mm/s RMS (56.8 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dBA.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (GWE) was retained by EBC Inc., to undertake an environmental noise & vibration feasibility assessment of a proposed mixed-use 20-storey development at 1950 Scott Street in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to a noise & vibration feasibility assessment. GWE's scope of work involved assessing exterior noise levels generated by local transportation noise sources and existing and future stationary noise sources surrounding the development, as well as vibration levels at the building foundation. The assessment was performed on the basis of theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment and Climate Change (MOECC)[2] guidelines. Noise calculations were based on architectural drawings received from Neuf Architects, with future traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications.

2. TERMS OF REFERENCE

The focus of this PLW study is a proposed residential development located at 1950 Scott Street in Ottawa, Ontario. The study site is located on the northeast corner of a parcel of land bounded by Scott Street to the north, Clifton Road to the east, Richmond Road to the south, and McRae Avenue to the west. The major sources of transportation noise are Scott Street and the future Confederation Line LRT to the north of the development. The site is surrounded on all sides with mixed-use land, specifically commercial and residential. Along the south side of Scott Street future developments are planned at 320 McRae, 1960 Scott Street, and 1946 Scott Street. An existing mixed-use building is located to the southwest which contains sources of stationary noise from mechanical equipment.

The proposed development is a 20-storey building with a three-storey podium. The podium planform is nearly rectangular with a rectangular inset at the southwest corner, and a diagonal north wall oriented along Scott Street. The building comprises indoor amenity and office spaces at grade. The second level and above contain residential units (160 residential units). A ramp at the southeast corner of the site provides access to two-and-a-half levels of underground parking. Common outdoor amenity space is

[1] City of Ottawa – Environmental Noise Control Guidelines, January 2016

[2] Ministry of the Environment and Climate Change (MOECC) – Environmental Noise Guideline, Publication NPC-300, August 2013

located on site, specifically at the 20th floor terrace surrounding the penthouse. Figure 1 illustrates a complete site plan with surrounding context.

3. OBJECTIVES

The main goals of this work are to: (i) calculate the future noise levels on the study building produced by transportation and stationary noise sources, (ii) calculate future vibration levels on the study building produced by transportation sources, and (iii) provide provisional recommendations to ensure that interior noise and vibration levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG) as outlined in Section 4 of this report.

4. METHODOLOGY

4.1 Background

Noise can be defined as any obtrusive sound. It is created at a source, transmitted through a medium, such as air, and intercepted by a receiver. Noise may be characterized in terms of the power of the source or the sound pressure at a specific distance. While the power of a source is characteristic of that particular source, the sound pressure depends on the location of the receiver and the path that the noise takes to reach the receiver. Measurement of noise is based on the decibel unit, dBA, which is a logarithmic ratio referenced to a standard noise level (2×10^{-5} Pascals). The 'A' suffix refers to a weighting scale, which better represents how the noise is perceived by the human ear. With this scale, a doubling of power results in a 3 dBA increase in measured noise levels and is just perceptible to most people. An increase of 10 dBA is often perceived to be twice as loud.

4.2 Roadway and LRT Traffic Noise

4.2.1 Criteria for Roadway and LRT Traffic Noise

For vehicle traffic and rail, the equivalent sound energy level, L_{eq}, provides a measure of the time varying noise levels, which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a period of time. For roadways, the L_{eq} is commonly calculated on the basis of a 16-hour (L_{eq16}) daytime (07:00-23:00) / 8-hour (L_{eq8}) nighttime (23:00-07:00) split to assess its impact on residential buildings. The City of Ottawa's Environmental Noise Control Guidelines (ENCG) specifies that the recommended indoor noise limit range (that is relevant to this study) is 50, 45 and 40 dBA for retail space, residence living rooms and sleeping quarters respectively, as listed in Table 1. To account for deficiencies in building construction, theses levels should be targeted toward 47, 42 and 37 dBA.

TABLE 1: INDOOR SOUND LEVEL CRITERIA (ROAD & RAIL)[3]

Type of Space	Time Period	L_{eq} (dBA)	
		Road	Rail
General offices, reception areas, retail stores, etc.	07:00 – 23:00	50	45
Living/dining/den areas of residences, hospitals, schools, nursing/retirement homes, day-care centres, theatres, places of worship, libraries, individual or semi-private offices, conference rooms, etc.	07:00 – 23:00	45	40
Sleeping quarters of hotels/motels	23:00 – 07:00	45	40
Sleeping quarters of residences, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	40	35

Predicted noise levels at the plane of window (POW) and outdoor living area (OLA) dictate the action required to achieve the recommended sound levels. An open window is considered to provide a 10 dBA reduction in noise while a standard closed window is capable of providing a minimum 20 dBA noise reduction. Therefore, where noise levels exceed 55 dBA daytime and 50 dBA nighttime, the ventilation for the building should consider the need for having windows and doors closed, which normally triggers the need for central air conditioning (or similar systems). Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, building components will require higher levels of sound attenuation[4].

The sound level criterion for outdoor living areas is 55 dBA, which applies during the daytime (07:00 to 23:00). When noise levels exceed 55 dBA, mitigation must be provided to reduce noise levels where technically and administratively feasible to acceptable levels at or below the criterion.

4.2.2 Roadway and LRT Traffic Volumes

The ENCG dictates that noise calculations should consider future sound levels based on a roadway's classification at the mature state of development. Therefore, traffic volumes are based on the roadway

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Ministry of the Environment and Climate Change (MOECC) – Environmental Noise Guideline, Publication NPC-300, August 2013

classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[5] which provides additional details on future roadway expansions. Average Annual Daily Traffic (AADT) volumes are then based on data in Table B1 of the ENCG for each roadway classification. Table 2 (below) summarizes the AADT values used for each roadway included in this assessment. Confederation Line LRT train volumes are based on information received through GWE's involvement with the Confederation Line Western LRT Environmental Assessment (EA).

TABLE 2: ROADWAY AND LRT TRAFFIC DATA

Roadway	Roadway Class	Speed Limit (km/h)	Official Plan AADT
Scott Street	2-UAU	50	**15,000**
Confederation Line LRT	LRT	70	**540/60***

* - Daytime/nighttime volumes

4.2.3 Theoretical Roadway and LRT Traffic Noise Predictions

Noise predictions were performed with the aid of the MOECC computerized noise assessment program, STAMSON 5.04, for road and rail analysis. Appendix A includes the STAMSON 5.04 input and output data, and Figure 3 to 7 include STAMSON 5.04 input data.

Roadway and transit noise calculations were performed by treating each road / LRT segment as separate line sources of noise, and by using existing building locations as noise barriers. In addition to the traffic volumes summarized in Table 4, theoretical noise predictions were based on the following parameters:

- Truck traffic on all roadways was taken to comprise 5% heavy trucks and 7% medium trucks, as per ENCG requirements for noise level predictions
- The day/night split was taken to be 92% / 8% respectively for all streets
- Reflective intermediate ground surface used based on specific source-receiver path ground characteristics (pavement/concrete)
- Study site topography considered in receptor, source and barrier height parameters
- LRT line was treated using 4-Car SRT function in STAMSON

[5] City of Ottawa Transportation Master Plan, November 2013

Transportation noise receptors were strategically placed at five (5) locations around the study area (see Figure 2).

4.3 Stationary Noise

The MOECC has published the D-series guidelines to assist planners and municipalities in the planning process to minimize the impacts industrial facilities and sensitive land uses will have on one another. In the document D-6 "*Compatibility between industrial facilities and sensitive land uses*[6]" general areas of influence and minimum separation distance are recommended to minimize the potential for incompatible land uses creating an adverse effect on sensitive land use. Under the guidelines, industrial facilities are characterized into three categories depending on their size and potential output of noise, odour, dust and / or vibration. Sensitive land use under the guideline can include land uses such as residential, parks, schools, child care facilities, senior citizens residences, hospitals, churches and other places of worship.

The only industrial facility in the area is the Canadian Bank Note (CBN) Company, located at 145 Richmond Road. Under the D-6 guideline, CBN would be defined as a Class II industry for the following reasons:

(i) They are a medium-scale operation
(ii) The facility operates 24-hours a day
(iii) There are frequent truck movements
(iv) There is a low risk of fugitive emissions

For a Class II industry, the recommended minimum separation distance from sensitive land uses is 70 m and the potential influence zone is 300 m. The D-6 guideline allows for development within the influence zone in cases of infill, provided the appropriate studies are conducted to ensure the potential for an adverse effect is minimized. Impacts from the CBN facility have been assessed in GWE's Stationary Noise Feasibility study dated February 24, 2014 for the adjacent 319 McRae Avenue development. Because 319 McRae Avenue is located in closer proximity to the CBN facility and noise impacts were found to fall below ENCG noise criteria, it is expected that impacts at 1950 Scott Street would also be minor.

Several commercial buildings are along McRae Avenue and Scott Street including retail outlets and an automotive shop, and a mixed-use building at 319 McRae Avenue to the southwest. Although they are

[6] Ministry of the Environment and Climate Change – Guideline D-6, July 1995

not industrial facilities under the D-6 guideline, they could be considered a Class I industry, where a recommended minimum separation distance from sensitive land uses is 20 m and the potential influence zone is 70 m. The only existing commercial building within 70 m of the proposed development is 319 McRae Avenue, for which GWE was involved in the assessment of stationary noise impacts from the development's mechanical equipment. The impacts of the 319 McRae commercial and residential buildings, on the proposed development were considered in GWE's assessment as outlined below.

4.3.1 Stationary Noise Assumptions

Mechanical information for the development has been based on GWE experience on the 319 McRae Avenue development. The following assumptions have been included in the analysis:

(i) The location, quantity and size of rooftop units has been assumed based on GWE's work on the 319 McRae Avenue development.

(ii) During the daytime, evening and nighttime period, the rooftop mechanical units (RTU) on the building are in full operation.

(iii) Parking garage exhaust fans are only in operation when concentration levels exceed a given threshold. They are assumed to operate at 10% of the time as a worst-case scenario.

(iv) All mechanical equipment has received appropriate noise control measures as per GWE's stationary noise assessment report for 319 McRae Avenue, dated October 21, 2015.

(v) Screening effects of buildings and parapets have been considered in the modelling.

4.3.2 Criteria for Stationary Noise

The equivalent sound energy level, L_{EQ}, provides a weighted measure of the time varying noise levels (including quasi-impulsive), which is well correlated with the annoyance of sound. It is defined as the continuous sound level, which has the same energy as a time varying noise level over a selected period of time. For stationary sources, the L_{EQ} is commonly calculated on an hourly interval, while for roadways, the L_{EQ} is calculated on the basis of a 16-hour daytime / 8-hour nighttime split.

Noise criteria taken from the ENCG apply to outdoor points of reception (POR) on the property; for daytime operations it is considered 30 m from a dwelling, and for nighttime operations the plane of window (POW). According to this document, the recommended maximum noise levels in an urban environment (Class 1 Area) are the higher of the limits set out in Table 3, or the noise produced by roadway traffic, whichever is greater[7]. The site is considered to be in a Class 1 area as background noise levels are expected to be dominated by traffic. The new ENCG guidelines also allow for a new noise sensitive land adjacent to existing stationary sources to be considered a Class 4 area if the building has central air conditioning and approval is granted by the Municipality for the new land use. However, the use of a Class 4 area is reserved for extraordinary circumstances, where traditional mitigation strategies are unfeasible.

TABLE 3: MOECC EXCLUSIONARY SOUND LEVEL LIMITS

Time of Day	Class 1 Sound Limits (dBA)		Class 4 Sound Limits (dBA)	
	Outdoor Point of Reception	Plane of Window	Outdoor Point of Reception	Plane of Window
07:00 – 19:00	50	50	55	60
19:00 – 23:00	50	50	55	60
23:00 – 07:00	N/A	45	N/A	55

4.3.3 Determination of Noise Source Power Levels

Figure 8 and 9 illustrate the location of each noise source corresponding to the labels in Table 4 below. Sources associated with the development include air handling units (AHU), Make-up Air Units (MUA), fan coil units (FCU), Cooling Towers (CT), Air cooled chiller (CH), dry coolers (DC), and emergency generator (Gen), as listed below.

[7] Ministry of the Environment and Climate Change (MOECC) – Environmental Noise Guideline, Publication NPC-300, August 2013, page 28

TABLE 4: STATIONARY SOURCE SOUND DATA

Source	Sound Power (dBA @ Hz)								
	63	125	250	500	1000	2000	4000	8000	Total (dBA)
AHU1 E/A	55	69	85	86	86	78	76	69	91
AHU1 O/A	53	72	83	92	87	83	78	72	94
AHU2 E/A	55	69	85	86	86	78	76	69	91
AHU2 O/A	53	72	83	92	87	83	78	72	94
CH1	62	81	90	94	92	91	82	78	98
CT1	69	79	86	88	88	85	83	75	94
DC1	--	--	--	--	83	--	--	--	83
DC2	--	--	--	--	83	--	--	--	83
EFPH1	69	77	77	73	66	65	61	55	81
EF-PH1	57	71	75	76	76	76	72	66	83
EF-PH2	55	64	68	72	73	71	67	61	78
FCU-1.1	57	72	70	75	69	69	69	62	79
FCU-1.12	53	57	55	48	45	46	45	38	61
FCU-1.2	57	72	70	75	69	69	69	62	79
FCU-1.3	57	72	70	75	69	69	69	62	79
FCU-1.4	57	72	70	75	69	69	69	62	79
FCU-1.5	57	72	70	75	69	69	69	62	79
FCU-1.6	57	72	70	75	69	69	69	62	79
FCU-1.7	57	72	70	75	69	69	69	62	79
FCU-1.8	57	72	70	75	69	69	69	62	79
FCU-VP2	58	63	53	41	35	36	34	23	64
MAU1	56	63	73	81	75	72	65	51	83
Parking	48	69	73	77	81	82	82	83	89
SFPH1	64	73	67	65	59	59	55	48	75
Gen R Comb Ex	54	60	71	79	83	84	81	73	89
Gen R Rad Ex	65	66	67	67	67	65	64	64	75
Gen R Intake	71	77	77	76	76	75	74	74	84
Gen C Comb Ex	68	77	61	72	81	82	75	63	86
Gen C Rad Ex	35	64	73	75	77	77	80	81	86
Gen C Intake	35	64	78	78	80	82	84	83	89

4.3.4 Stationary Source Noise Predictions

The impact of the stationary noise sources on the nearby residential areas was determined by computer modelling. Stationary noise source modelling is based on the software program Predictor-Lima developed from the International Standards Organization (ISO) standard 9613 Parts 1 and 2. This computer program is capable of representing three-dimensional surfaces and first reflections of sound waves over a suitable spectrum for human hearing. The methodology has been used on numerous assignments, and has been accepted by the Ministry of Environment and Climate Change as part of Environmental Compliance Approvals applications.

A combination of horizontal / vertical grids, along with five (5) discrete worst-case receptor locations were chosen around the site to measure the noise impact around the study building during the daytime / evening period (07:00 – 23:00), as well as the nighttime period (23:00 – 07:00). Point of Reception (POR) locations included outdoor points of reception (OPOR) and the plane of windows (POW) of the subject site. Sensor locations are described in Table 5 and illustrated in Figure 10. All units were represented as point sources in the Predictor model. Table 6 below contains Predictor-Lima calculation settings. These settings are typical and have been based on ISO 9613 standards and guidance from the MOECC.

Ground absorption over the study area was determined based on topographical features (such as water, concrete, grassland, etc.). An absorption value of 0 is representative of hard ground, while a value of 1 represents grass, and similar soft surface conditions. Existing and proposed buildings were added to the model to account for screening and reflection effects from building façades.

TABLE 5: RECEPTOR LOCATIONS

Receptor Number	Location	Height Above Grade/Roof (m)
R1	POW – 19th Floor West Façade	57
R2	POW – 19th Floor South Façade	57
R3	POW – 19th Floor East Façade	57
R4	POW – 3rd Floor West Façade	7.5
R5	POW – 3rd Floor South Façade	7.5
R6	POW – 3rd Floor East Façade	7.5
R7	OPOR – 20th Floor Terrace North	1.5
R8	OPOR – 20th Floor Terrace South	1.5

TABLE 6: CALCULATION SETTINGS

Parameter	Setting
Meteorological correction method	Single value for C0
Value C0	2.0
Default ground attenuation factor	1
Ground attenuation factor for roadways and paved areas	0
Temperature (K)	283.15
Pressure (kPa)	101.33
Air humidity (%)	70

4.4 Ground Vibration & Ground-borne Noise

Transit systems and heavy vehicles on roadways can produce perceptible levels of ground vibrations, especially when they are in close proximity to residential neighbourhoods or vibration sensitive buildings. Similar to sound waves in air, vibrations in solids are generated at a source, propagated through a medium, and intercepted by a receiver. In the case of ground vibrations, the medium can be uniform, or more often, a complex layering of soils and rock strata. Also, similar to sound waves in air, ground vibrations produce perceptible motions and regenerated noise known as 'ground-borne noise' when the vibrations encounter a hollow structure such as a building. Ground-borne noise and vibrations are generated when there is excitation of the ground, from a train for instance. Repetitive motion of the wheels on the track or rubber tires passing over an uneven surface causes vibrations to propagate through the soil. When they encounter a building, vibrations pass along the structure of the building beginning at the foundation and propagating to all floors. Air inside the building excited by the vibrating walls and floors represents regenerated airborne noise. Characteristics of the soil and the building are imparted to the noise, thereby creating a unique noise signature.

Human response to ground vibrations is dependent on the magnitude of the vibrations, which is measured by the root mean square (RMS) of the movement of a particle on a surface. Typical units of ground vibration measures are millimeters per second (mm/s), or inch per second (in/s). Since vibrations can vary over a wide range, it is also convenient to represent them in decibel units, or dBV. In North America, it is common practice to use the reference value of one micro-inch per second (μin/s) to represent vibration levels for this purpose. The threshold level of human perception to vibrations is about 0.10 mm/s RMS or about 72 dBV. Although somewhat variable, the threshold of annoyance for continuous vibrations is (0.5 mm/s RMS or 85 dBV), five times higher than the perception threshold, whereas the threshold for significant structural damage is (10 mm/s RMS or 112 dBV) at least one hundred times higher than the perception threshold level.

4.4.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land use next to Transit corridors. Similar standards have been developed by a partnership between the MOECC and the Toronto Transit Commission[8]. These standards indicate that the appropriate criteria for residential buildings is 0.10 mm/s RMS for vibrations. For main line railways, a document titled Guidelines for New Development in Proximity to Railway Operations[9] indicates that vibration conditions should not exceed 0.14 mm/s RMS averaged over a one second time-period at the first floor and above of the proposed building. As the main vibration source is due to the LRT lines, which will have frequent events, the 0.10 mm/s RMS (72 dBV) vibration criteria and 35 dBA ground borne noise criteria were adopted for this study.

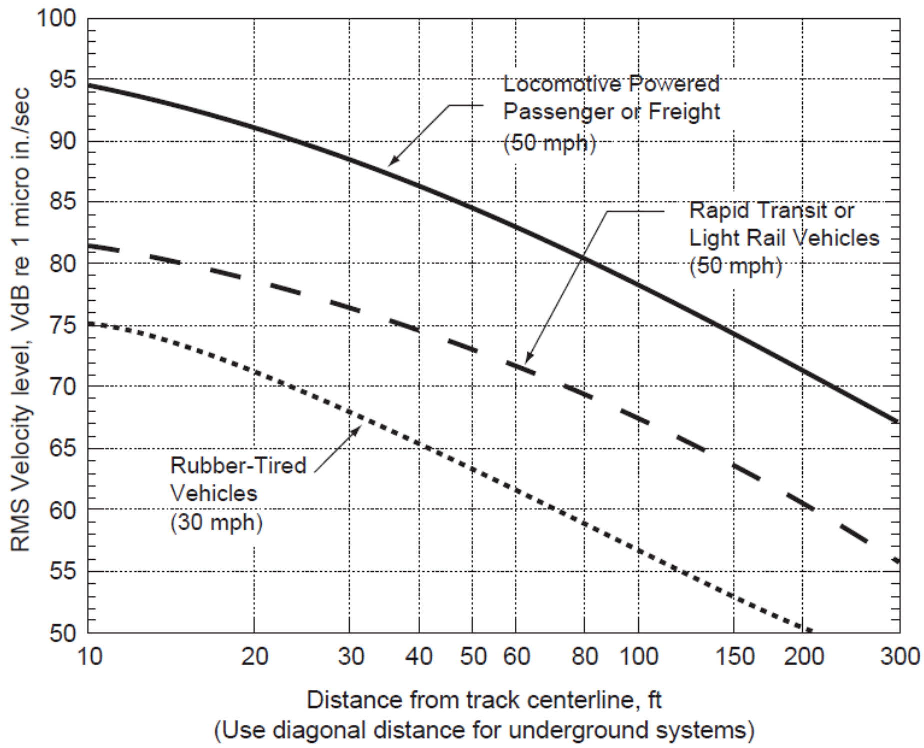
4.4.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the future Confederation LRT rail line, currently under construction, were predicted using the FTA's Transit Noise and Vibration Impact Assessment[10] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These curves, illustrated in the figure below, are based on ground vibration measurements at various transit systems throughout North America. Vibration levels at points of reception are adjusted by various factors to incorporate known characteristics of the system being analyzed, such as operating speed of vehicle, conditions of the track, and construction of the track and geology, as well as the structural type of the impacted building structures. Based on the setback distance of the closest building foundation, initial vibration levels were deduced from a curve for light rail trains at 50 miles per hour (mph) and applying an adjustment factor of -1.2 dBV to account for an operational speed of 43.4 mph (70 km/h). The track was assumed to be jointed with no welds. Details of the vibration calculations are presented in Appendix B.

[8] MOECC/TTC Protocol for Noise and Vibration Assessment for the Proposed Yonge-Spadina Subway Loop, June 16, 1993

[9] Dialog and J.E. Coulter Associates Limited, prepared for The Federation of Canadian Municipalities and The Railway Associated of Canada, May 2013

[10] C. E. Hanson; D. A. Towers; and L. D. Meister, Transit Noise and Vibration Impact Assessment, Federal Transit Administration, May 2006.



FTA GENERALIZED CURVES OF VIBRATION LEVELS VERSUS DISTANCE (ADOPTED FROM FIGURE 10-1, FTA TRANSIT NOISE AND VIBRATION IMPACT ASSESSMENT)

5. RESULTS AND DISCUSSION

5.1 Roadway and LRT Traffic Noise Levels

The results of the roadway and LRT traffic noise calculations are summarized in Table 7 below. Appendix A contains the complete set of input and output data from all STAMSON 5.04 calculations. Appendix A includes the STAMSON 5.04 input and output data, and Figure 3 to 7 include STAMSON 5.04 input data.

TABLE 7: EXTERIOR NOISE LEVELS DUE TO ROAD AND LRT TRAFFIC

Receptor Number	Receptor Height (m)	Plane of Window Receptor Location	Noise Level (dBA)	
			Day	Night
1	42.1	14th Floor - North Façade	68	61
2	42.1	14th Floor - East Façade	65	58
3	20.8	7th Floor - West Façade	65	57
4	42.1	14th Floor - West Façade	65	58
5	64.8	20th Floor Terrace North	54	47

The results of the current analysis indicate that noise levels will range between 54 and 68 dBA during the daytime period (07:00-23:00) and between 47 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 68 dBA) occurs along the north façade which is nearest and most exposed to Scott Street and the future Confederation Line LRT.

5.1.1 Roadway and LRT Traffic Noise Control Measures

The noise levels predicted due to roadway traffic on the development's north façade exceed the criteria listed in the ENCG for building components. Therefore, upgraded building components will be required. The building layouts should consider placing non-sensitive uses, such as bathrooms and utility rooms, along these façades, and reducing the area of the windows to reduce STC requirements for glazing elements. Due to the limited information available at the time of the study, which was prepared for rezoning application, detailed STC calculations could not be performed at this time. As per city of Ottawa requirements, detailed STC calculations will be required to be completed prior to building permit application for each unit type.

Results of the calculations also indicate that the development will require central air conditioning which will allow occupants to keep windows closed and maintain a comfortable living environment. Warning Clauses will also be required be placed on all Lease, Purchase and Sale Agreements.

Noise levels at the 20th floor terrace were found to approach 54 dBA during the daytime period, which is below the ENCG criteria; therefore, no mitigation would be required. However, it is recommended outdoor living areas (OLA) should be positioned away from the roadway to reduce noise levels. If the need arises for OLA noise mitigation, this can be addressed during site plan control.

5.2 Stationary Noise Levels

As summarized in Table 8 noise levels from existing stationary sources fall below the Class 1 sound level limits, without any mitigation. Table 9 summarizes the results of emergency standby power equipment, which show compliance with the ENCG sound level limits. Figure 11 and 12 contain daytime and nighttime stationary noise contours for non-emergency equipment.

TABLE 8: NOISE LEVELS FROM STATIONARY HVAC SOURCES

Receiver Number	1-HR L_{eq} (dBA)		ENCG Criteria (dBA) – Class 1		Meets Criteria
	Day / Evening	Night	Day / Evening	Night	
R1	43	43	50	45	YES
R2	43	43	50	45	YES
R3	33	33	50	45	YES
R4	44	44	50	45	YES
R5	44	44	50	45	YES
R6	33	33	50	45	YES
R7	25	25	50	N/A	YES
R8	39	39	50	N/A	YES

TABLE 9: NOISE LEVELS FROM EMERGENCY EQUIPMENT

Receiver Number	1-HR L_{eq} (dBA)		ENCG Criteria (dBA) – Class 1		Meets Criteria
	Day / Evening	Night	Day / Evening	Night	
R1	41	41	55	50	YES
R2	41	41	55	50	YES
R3	31	31	55	50	YES
R4	34	34	55	50	YES
R5	33	33	55	50	YES
R6	33	33	55	50	YES
R7	25	25	55	N/A	YES
R8	39	39	55	N/A	YES

Our stationary noise feasibility assessment indicates that noise levels on-site from existing stationary noise sources are expected to fall below the ENCG noise criteria, at sensitive points of reception on the proposed building. As such, the proposed development is expected to be compatible with the surrounding properties.

With regards to stationary noise impacts from the proposed building on surrounding noise-sensitive buildings, once the mechanical plans for the proposed building become available, a stationary noise study will be performed. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels at the surrounding noise-sensitive buildings due to mechanical equipment on the roof of the proposed building are below the City of Ottawa's Noise Guidelines.

5.3 Ground Vibrations & Ground-borne Noise Levels

Based on an offset distance of 47 metres between the development the Confederation line LRT centerline and the nearest building foundation, the estimated vibration levels at the nearest point of reception are expected to be 0.018 mm/s RMS (56.8 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required.

According to the United States Federal Transit Authority's vibration assessment protocol, ground borne noise can be estimated by subtracting 35 dB from the velocity vibration level in dBV. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 54 and 68 dBA during the daytime period (07:00-23:00) and between 47 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 68 dBA) occurs along the north façade which is nearest and most exposed to Scott Street and the future Confederation Line LRT. Minimum building construction in all areas is required to satisfy the Ontario Building Code (2012). In addition, upgraded Sound Transmission Class (STC) ratings are required for building components where noise levels exceed 65 dBA.

Results of the calculations also indicate that the development will require central air conditioning, which will allow occupants to keep windows closed and maintain a comfortable living environment. A Warning Clause will also be required be placed on all Lease, Purchase and Sale Agreements. Additional design considerations regarding transportation noise are detailed in Section 5.1.1.

Our assessment of existing stationary noise sources indicates that sound levels produced by Heating Ventilation and Air Conditioning (HVAC) equipment on surrounding buildings are expected to fall below the ENCG noise criteria. As such, the proposed development is expected to be compatible with the surrounding properties.

With regards to stationary noise impacts from the proposed building on surrounding noise-sensitive buildings, once the mechanical plans for the proposed building become available, a stationary noise study will be performed. This study will include recommendations for any noise control measures that may be necessary to ensure noise levels at the surrounding noise-sensitive buildings due to mechanical equipment on the roof of the proposed building are below the City of Ottawa's Noise Guidelines.

Estimated vibration levels at the nearest point of reception, based on an offset distance of 47 metres between the development the Confederation line LRT centerline and the nearest building foundation, are expected to be 0.018 mm/s RMS (56.8 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.10 mm/s RMS, no mitigation will be required. Since measured vibration levels were found to be less than 0.10 mm/s peak partial velocity (ppv), ground borne noise levels are also expected to be below the ground borne noise criteria of 35 dB.

This concludes our assessment and report. If you have any questions or wish to discuss our findings please advise us. In the interim, we thank you for the opportunity to be of service.

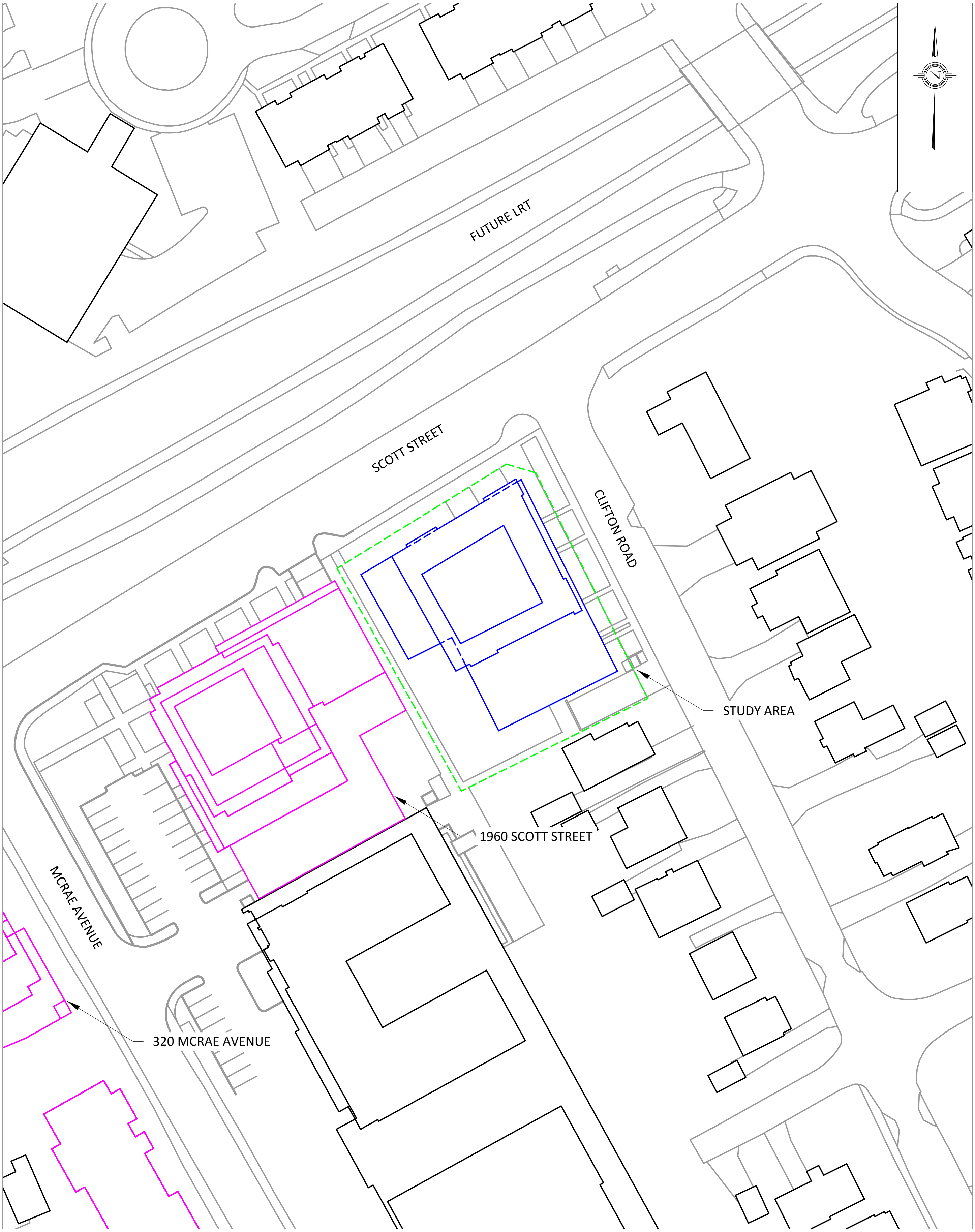
Yours truly,

Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
100155655
PROVINCE OF ONTARIO

Michael Lafortune
Environmental Scientist
GWE18-031 – Noise & Vibration

Joshua Foster, P.Eng.
Principal



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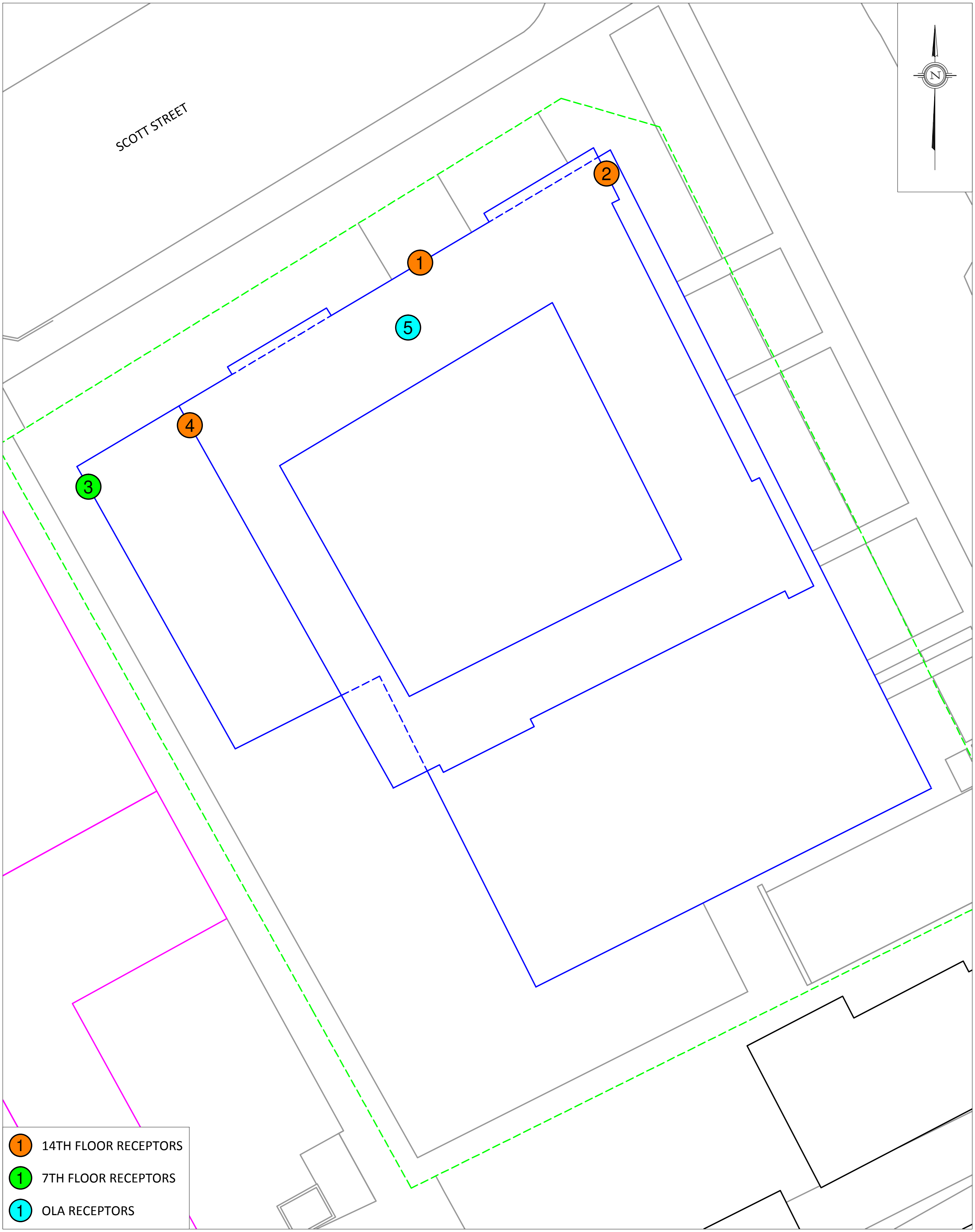
(613) 836 0934

PROJECT: 1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GWE18-031-1	
DATE: APRIL 24, 2018	DRAWN BY: M.L	



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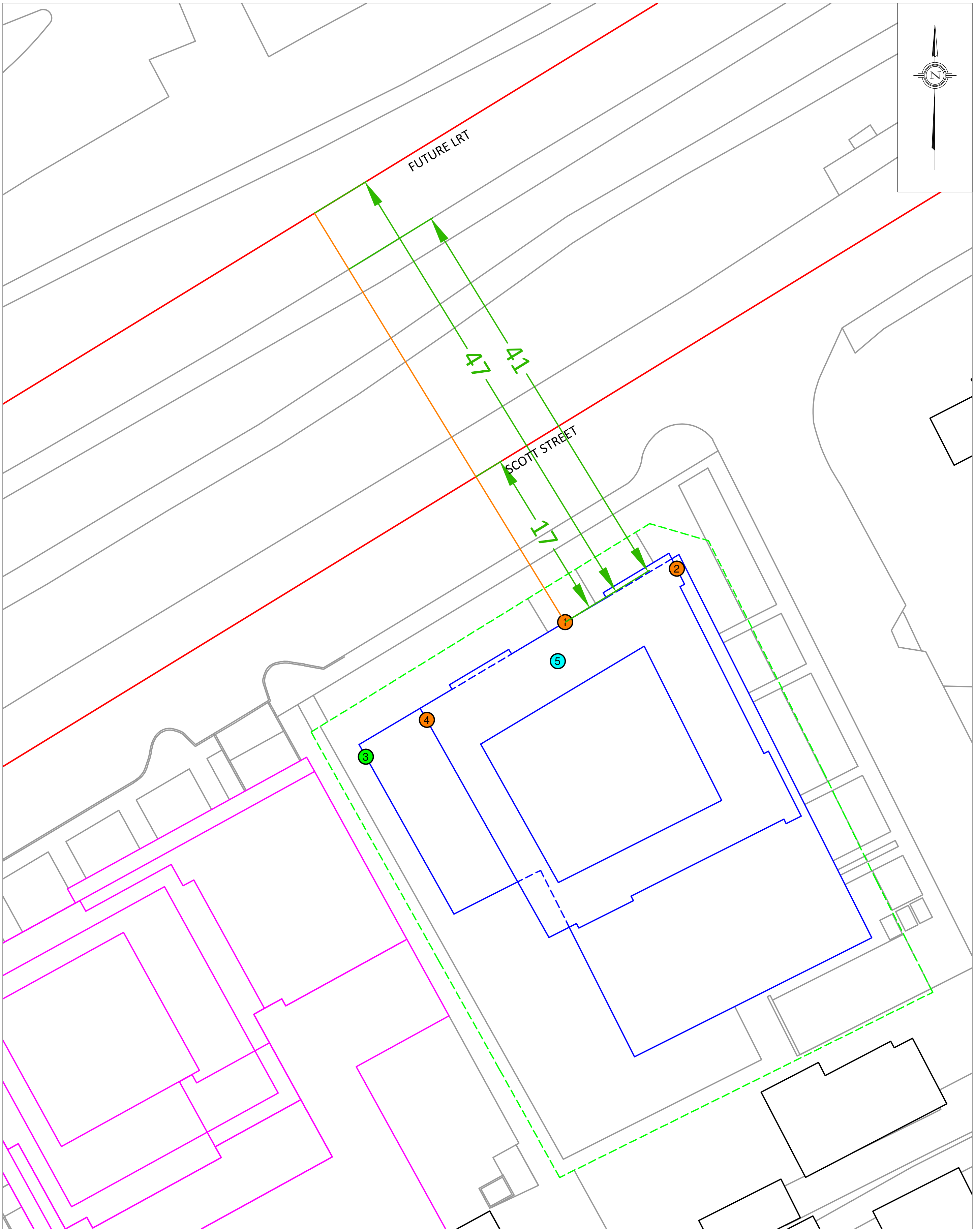
PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT
SCALE	1:300 (APPROX.)
DRAWING NO.	GWE18-031-2
DATE	APRIL 24, 2018
DRAWN BY	M.L
DESCRIPTION	FIGURE 2: TRANSPORTATION NOISE RECEPTOR LOCATIONS



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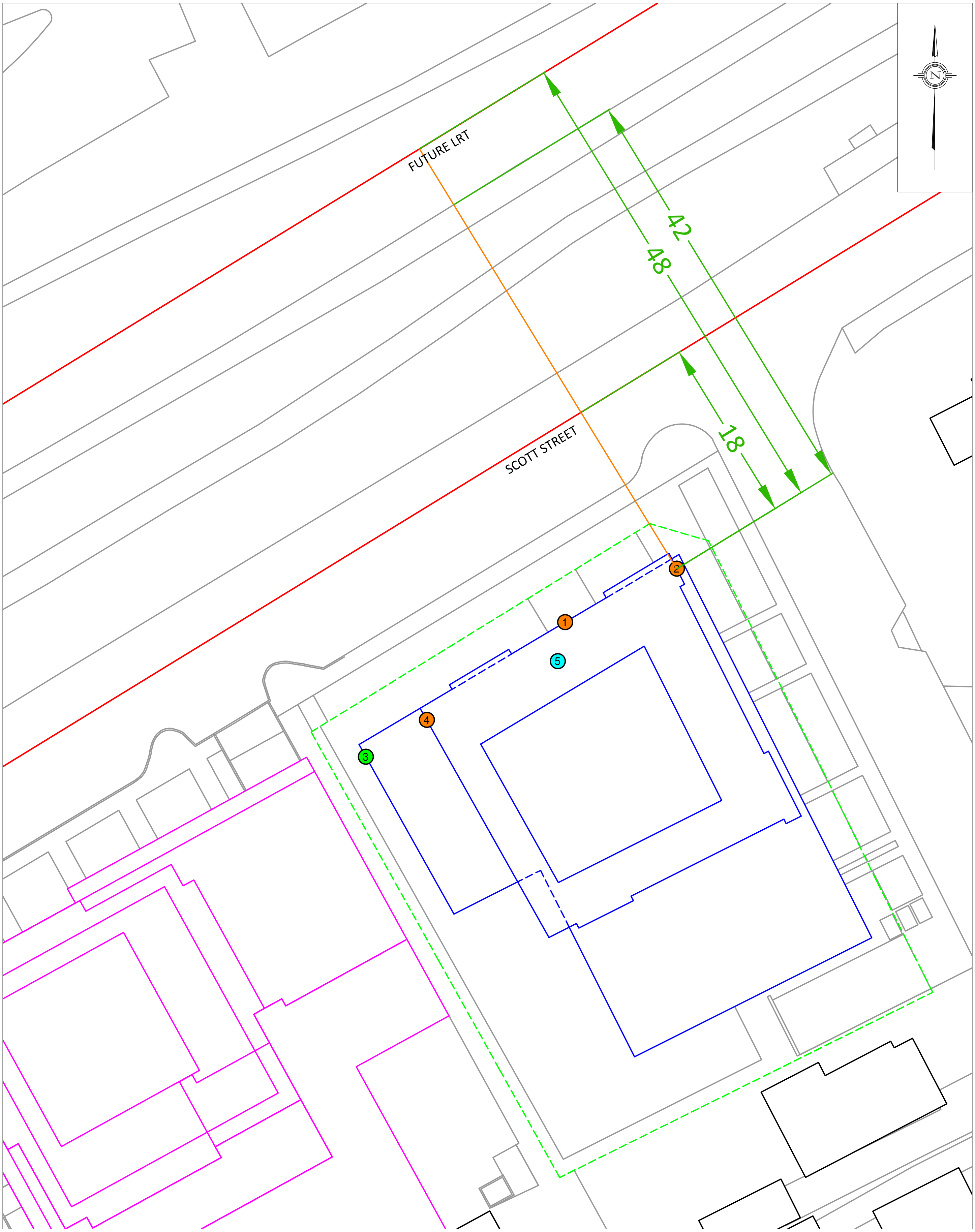
PROJECT 1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		DESCRIPTION FIGURE 3: STAMSON INPUT DATA - RECEPTOR 1
SCALE 1:300 (APPROX.)	DRAWING NO. GWE18-031-3	
DATE APRIL 24, 2018	DRAWN BY M.L	



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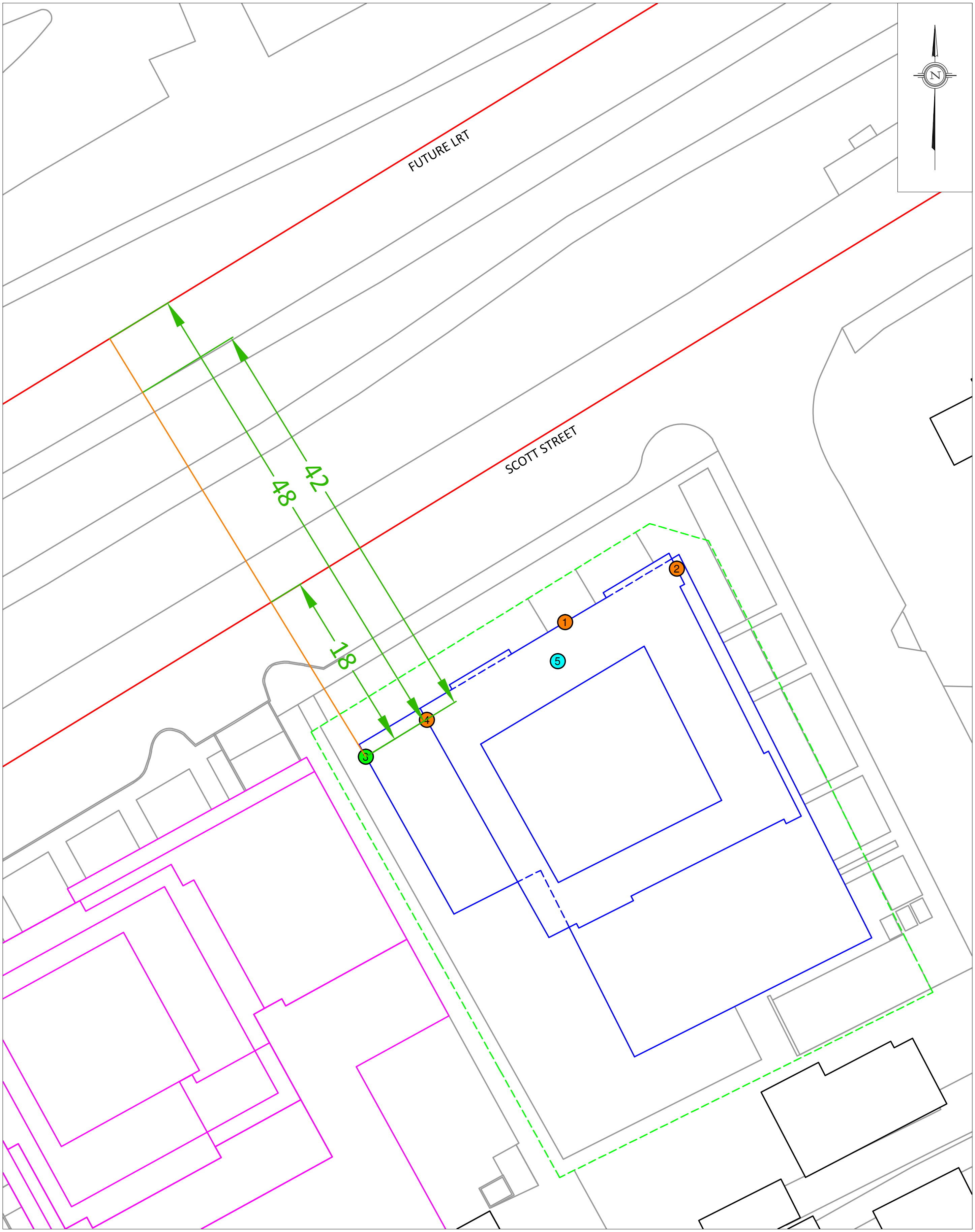
PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		
SCALE	1:300 (APPROX.)	DRAWING NO.	GWE18-031-4
DATE	APRIL 24, 2018	DRAWN BY	M.L

DESCRIPTION

FIGURE 4:
STAMSON INPUT DATA - RECEPTOR 2



PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT	
SCALE 1:300 (APPROX.)	DRAWING NO. GWE18-031-5	
DATE APRIL 24, 2018	DRAWN BY M.L	

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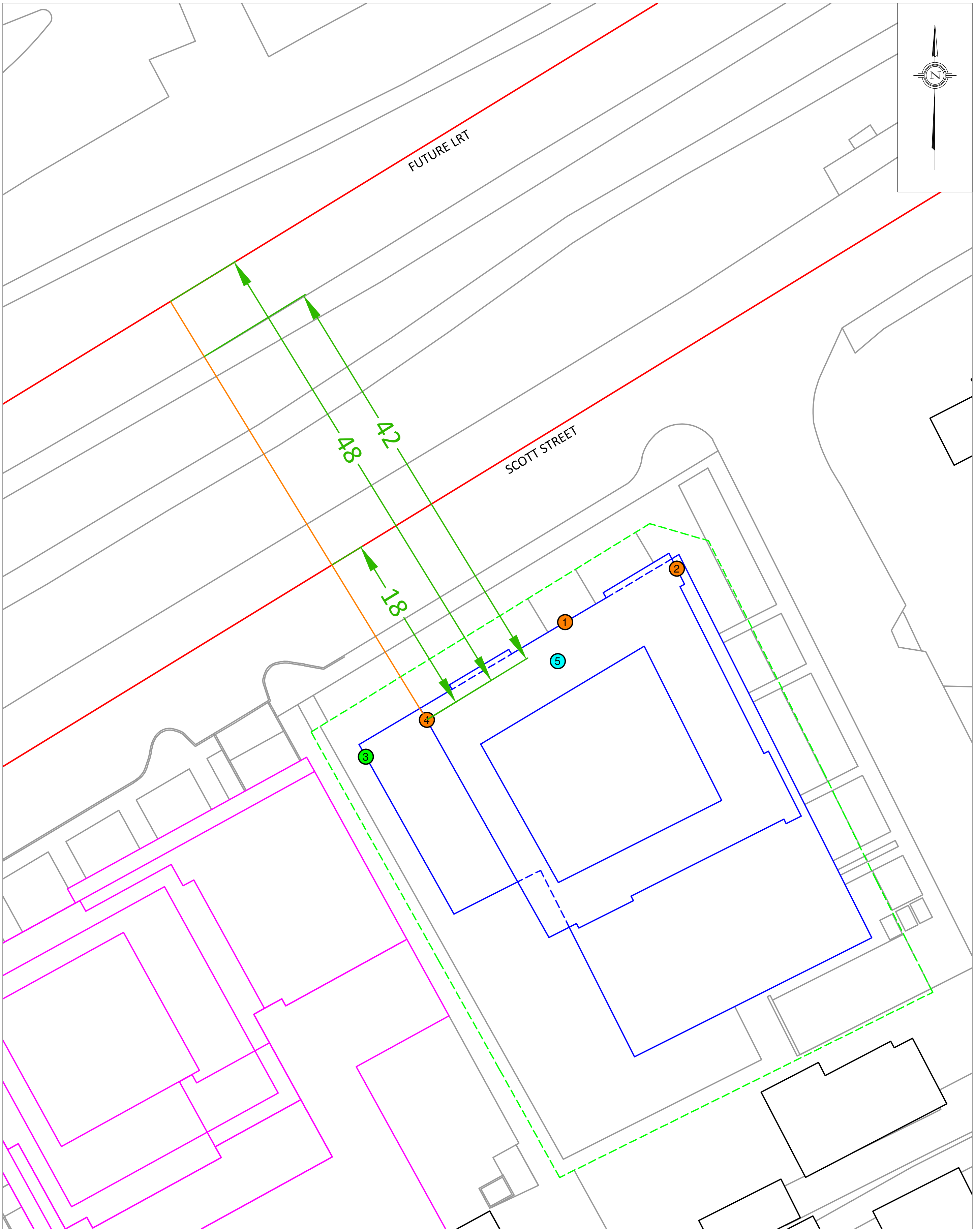
DESCRIPTION

FIGURE 5:
STAMSON INPUT DATA - RECEPTOR 3



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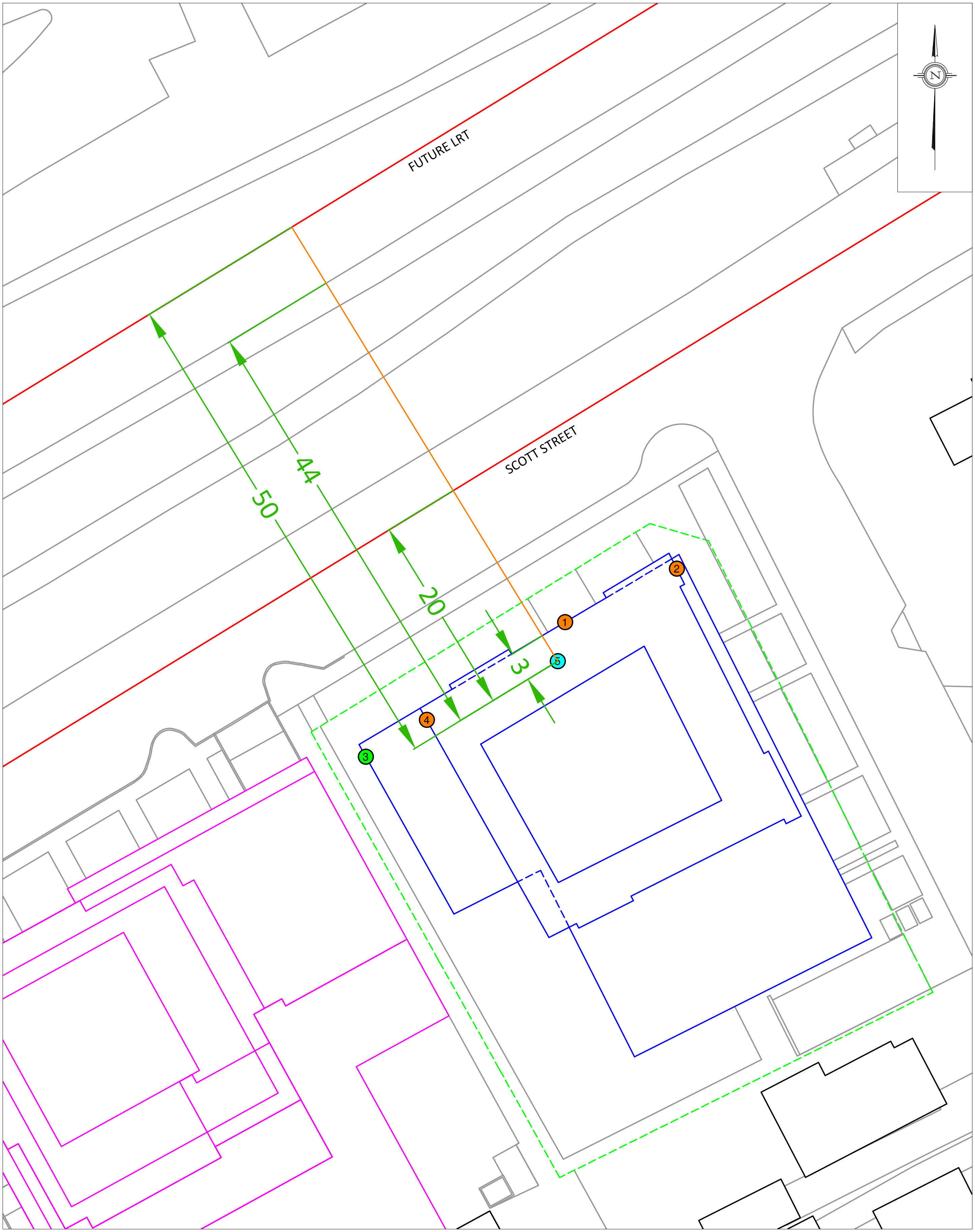
PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT	
SCALE 1:300 (APPROX.)	DRAWING NO. GWE18-031-6	DESCRIPTION FIGURE 6: STAMSON INPUT DATA - RECEPTOR 4
DATE APRIL 24, 2018	DRAWN BY M.L	



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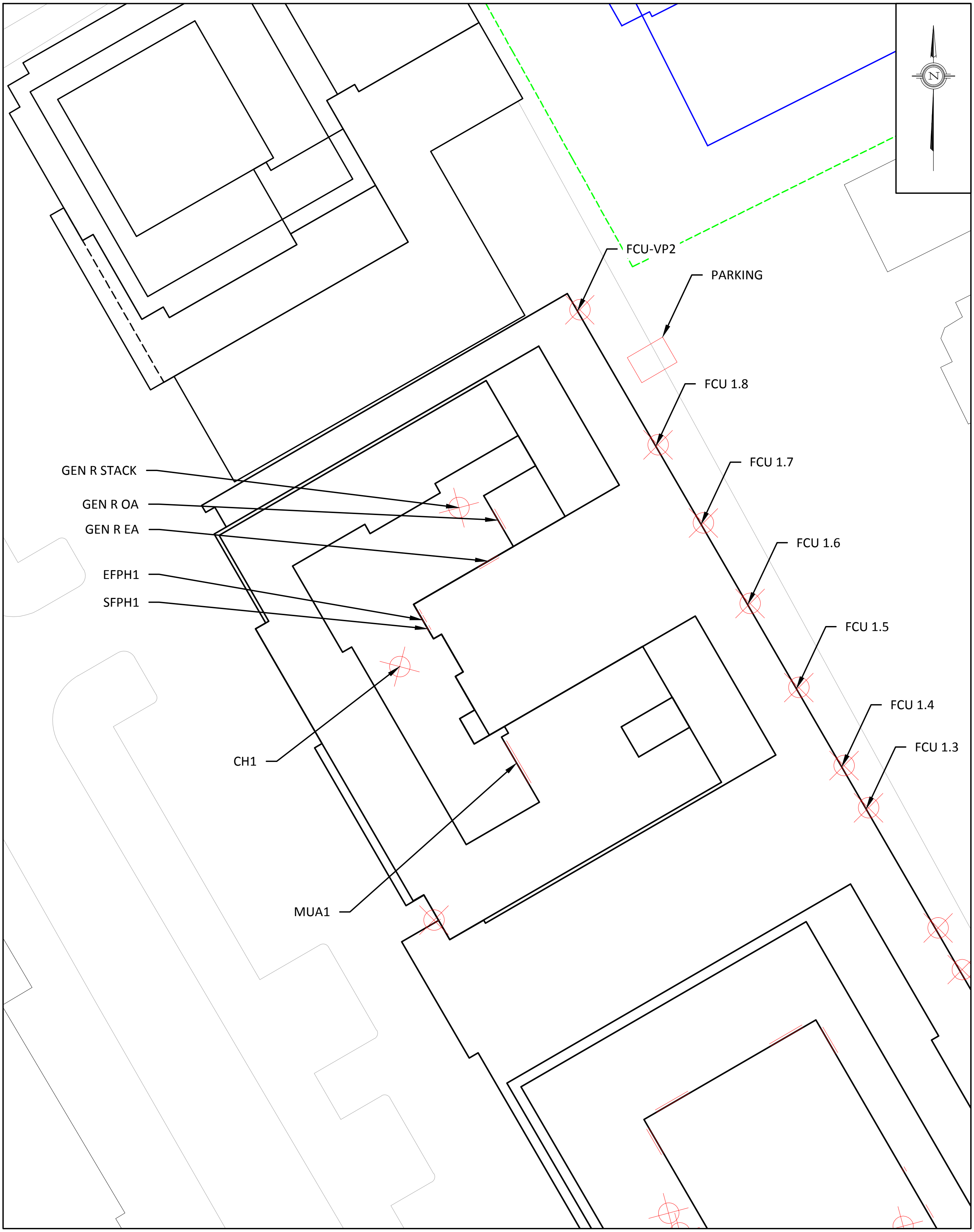
PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		
SCALE	1:300 (APPROX.)	DRAWING NO.	GWE18-031-7
DATE	APRIL 24, 2018	DRAWN BY	M.L

DESCRIPTION

FIGURE 7:
STAMSON INPUT DATA - RECEPTOR 5



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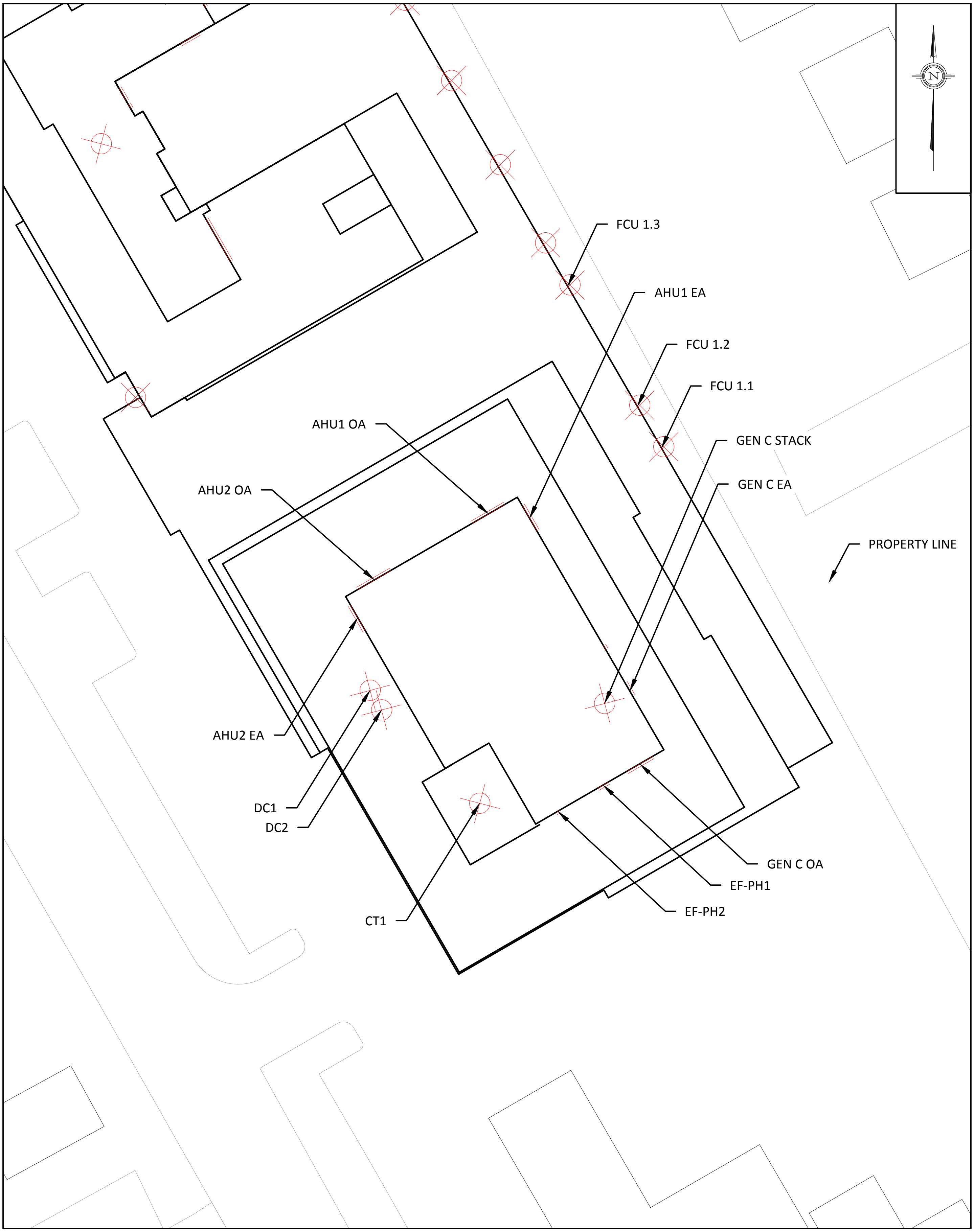
PROJECT		DESCRIPTION
1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		FIGURE 8: STATIONARY SOURCE LOCATIONS
SCALE: 1:500 (APPROX.)	DRAWING NO.: GWE18-031-8	
DATE: APRIL 25, 2018	DRAWN BY: M.L.	



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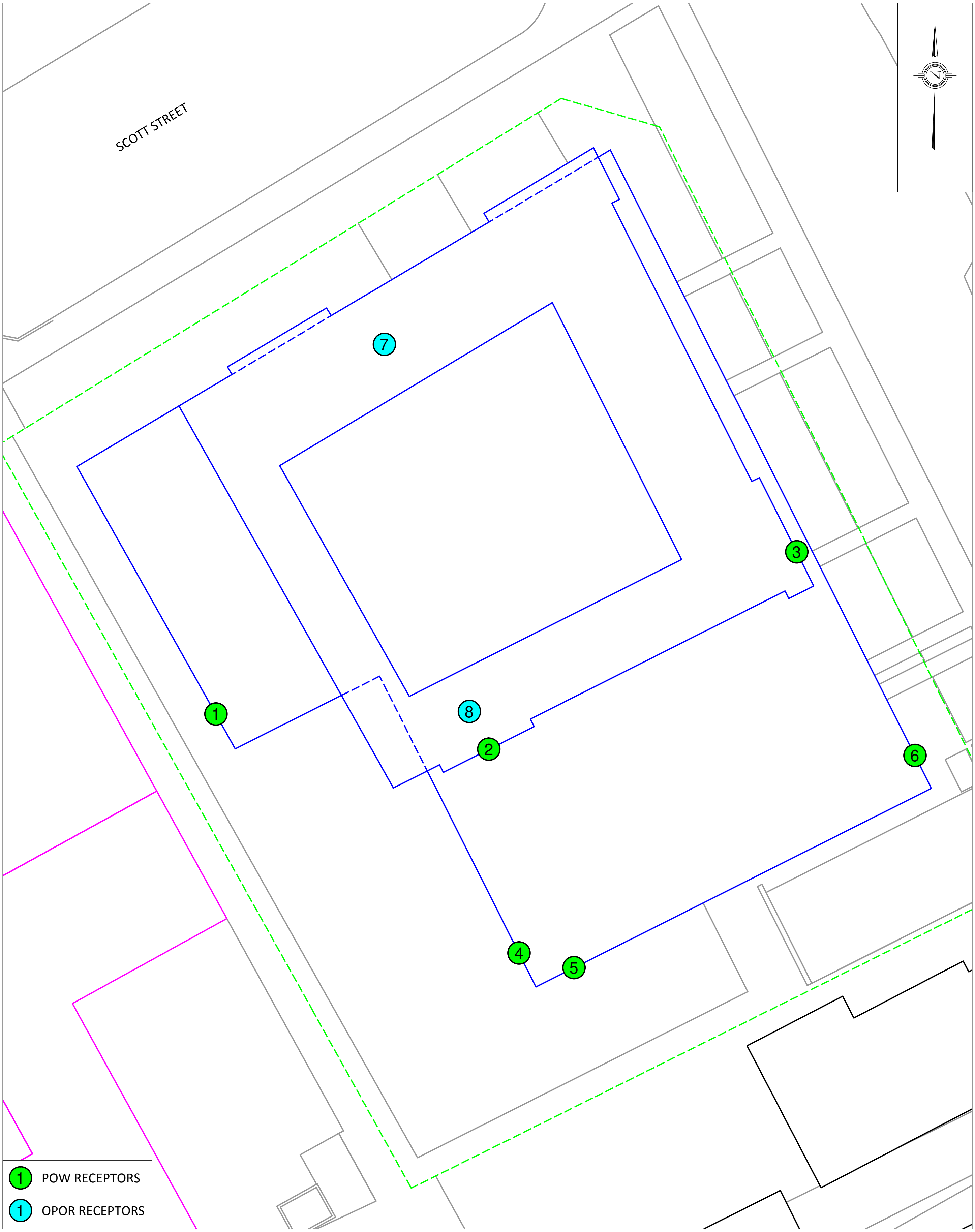
PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		
SCALE	1:500 (APPROX.)	DRAWING NO.	GWE18-031-9
DATE	APRIL 25, 2018	DRAWN BY	M.L.

DESCRIPTION

FIGURE 9:
STATIONARY SOURCE LOCATIONS



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PROJECT	1950 SCOTT STREET ENVIRONMENTAL NOISE & VIBRATION FEASIBILITY ASSESSMENT		
SCALE	1:300 (APPROX.)	DRAWING NO.	GWE18-031-10
DATE	APRIL 24, 2018	DRAWN BY	M.L

DESCRIPTION

FIGURE 10:
STATIONARY NOISE RECEPTOR LOCATIONS

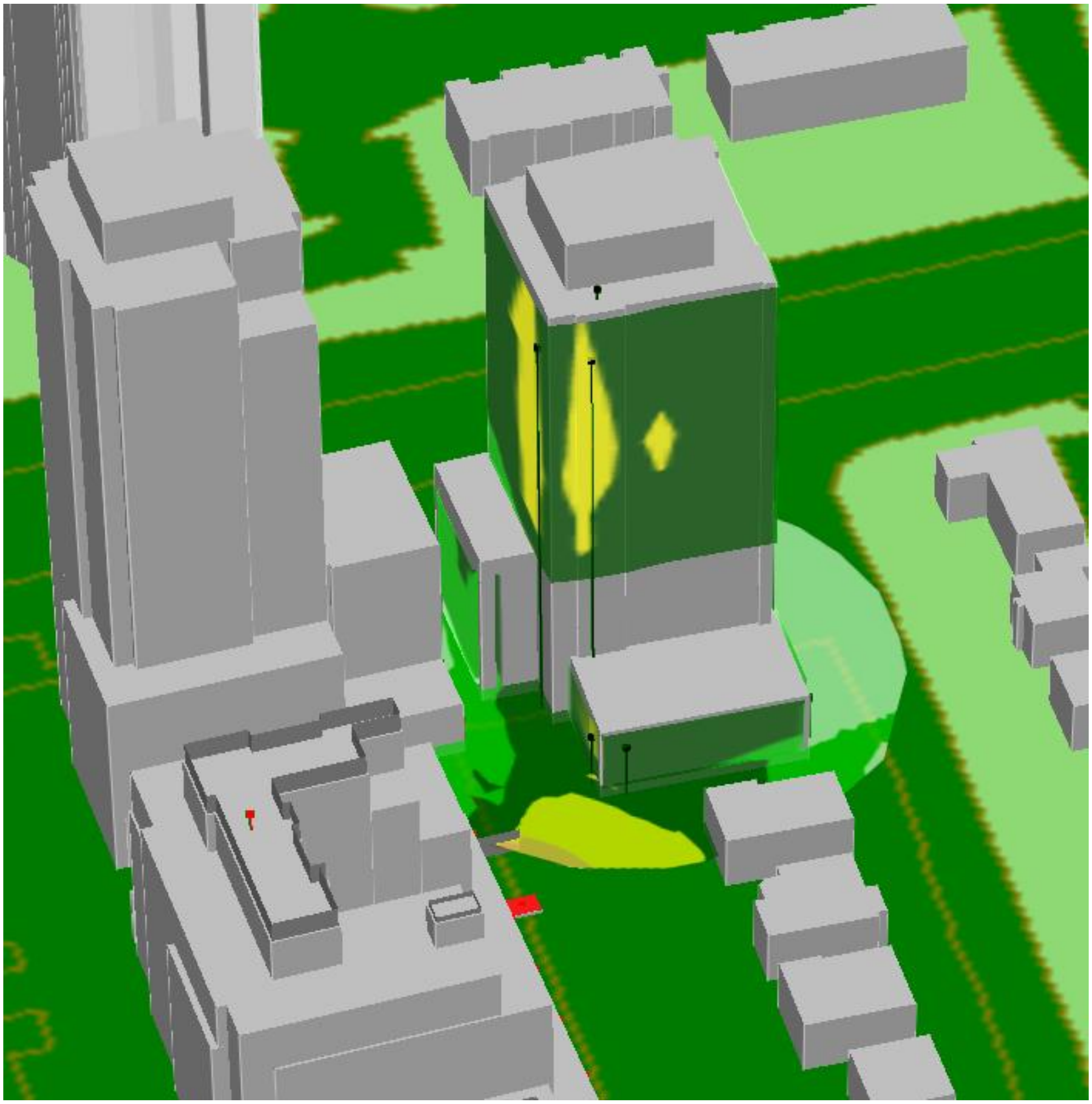


FIGURE 11: DAYTIME NOISE CONTOURS

	80 – 85 dB
	75 – 80 dB
	70 – 75 dB
	65 – 70 dB
	60 – 65 dB
	55 – 60 dB
	50 – 55 dB
	45 – 50 dB
	40 – 45 dB
	35 – 40 dB
	0 – 35 dB

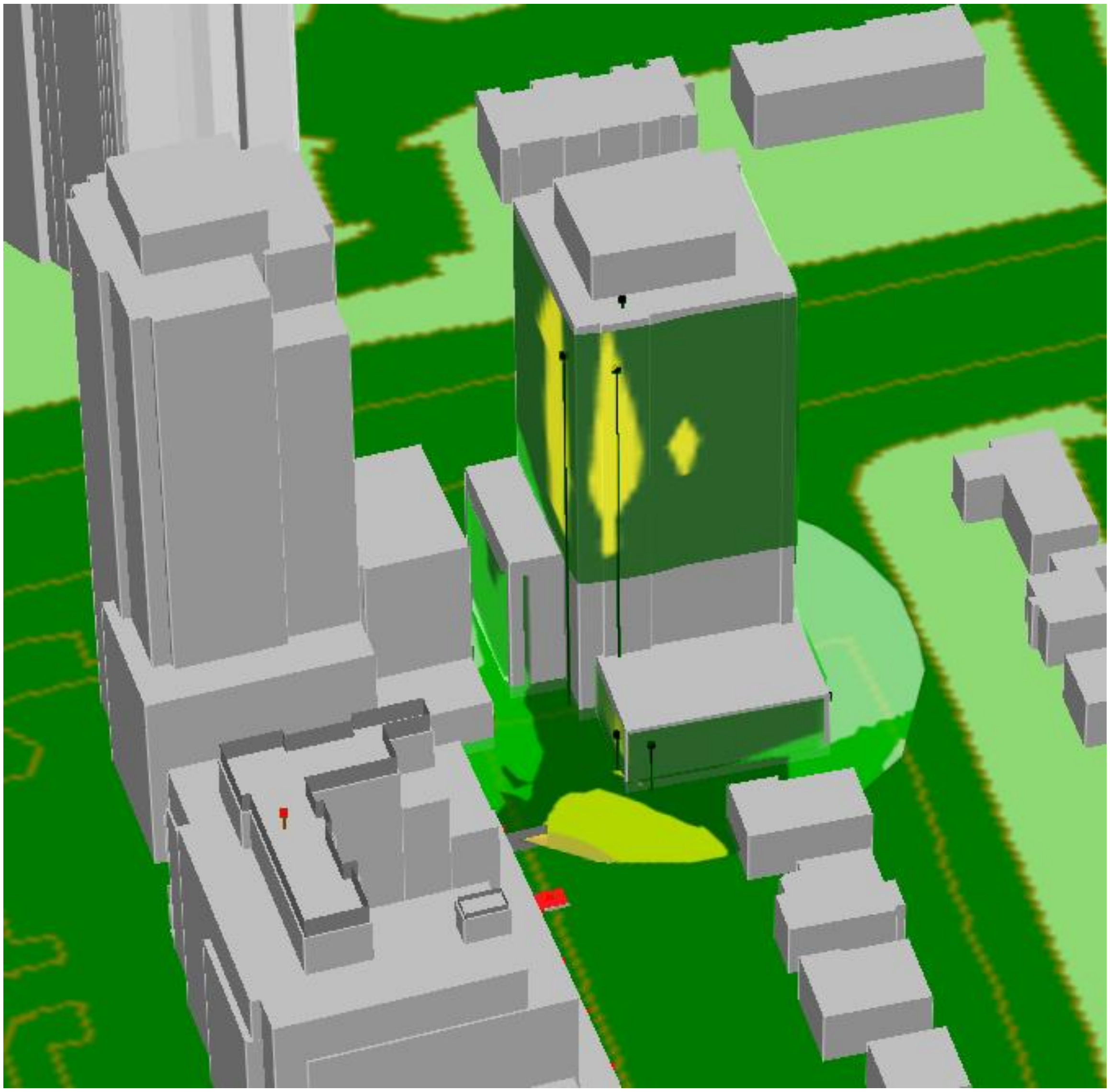
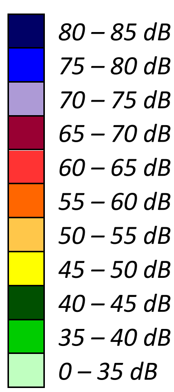


FIGURE 12: NIGHTTIME NOISE CONTOURS



APPENDIX A

STAMSON 5.04 - INPUT AND OUTPUT DATA

```
STAMSON 5.0        NORMAL REPORT        Date: 23-04-2018 37:21:34
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r1.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott (day/night)
-----------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  17.00 / 17.00  m
Receiver height           :  42.10 / 42.10  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Scott (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 67.94 + 0.00) = 67.94 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -90     90   0.00  68.48   0.00  -0.54   0.00   0.00   0.00   0.00
67.94
---------------------------------------------------------------------------
--

Segment Leq : 67.94 dBA

Total Leq All Segments: 67.94 dBA


Results segment # 1: Scott (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 60.34 + 0.00) = 60.34 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
---------------------------------------------------------------------------
--
   -90     90   0.00  60.88   0.00  -0.54   0.00   0.00   0.00   0.00
60.34
---------------------------------------------------------------------------
--

Segment Leq : 60.34 dBA

Total Leq All Segments: 60.34 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  47.00 / 47.00  m
Receiver height           :  42.10 / 42.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :   6.00 m
Barrier receiver distance :  41.00 / 41.00  m
Source elevation          :  -6.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :  -6.00 m
Reference angle           :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.58 !         0.58

RT/Custom (0.00 + 58.48 + 0.00) = 58.48 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -4.96   0.00   0.00   0.00  -4.59  53.89*
   -90     90   0.00  63.44  -4.96   0.00   0.00   0.00   0.00  58.48
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 58.48 dBA

Total Leq All Segments: 58.48 dBA
```

```
Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.58 !         0.58

RT/Custom (0.00 + 51.95 + 0.00) = 51.95 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -4.96   0.00   0.00   0.00  -4.59  47.35*
   -90     90   0.00  56.91  -4.96   0.00   0.00   0.00   0.00  51.95
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 51.95 dBA

Total Leq All Segments: 51.95 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 68.41
                         (NIGHT): 60.93
```

```
STAMSON 5.0        NORMAL REPORT         Date: 23-04-2018 37:21:39
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r2.te                 Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott (day/night)
-----------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  18.00 / 18.00  m
Receiver height           :  42.10 / 42.10  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Scott (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 64.68 + 0.00) = 64.68 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
     0     90   0.00  68.48   0.00  -0.79  -3.01   0.00   0.00   0.00
64.68
--------------------------------------------------------------------------
--

Segment Leq : 64.68 dBA

Total Leq All Segments: 64.68 dBA


Results segment # 1: Scott (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 57.08 + 0.00) = 57.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
     0     90   0.00  60.88   0.00  -0.79  -3.01   0.00   0.00   0.00
57.08
--------------------------------------------------------------------------
--

Segment Leq : 57.08 dBA

Total Leq All Segments: 57.08 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2            :   0.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      2       (Reflective ground surface)
Receiver source distance  :  48.00 / 48.00  m
Receiver height            :  42.10 / 42.10  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             :   0.00 deg   Angle2 : 90.00 deg
Barrier height             :   6.00 m
Barrier receiver distance :  42.00 / 42.00  m
Source elevation           :  -6.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :  -6.00 m
Reference angle            :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.45 !         0.45

RT/Custom (0.00 + 55.38 + 0.00) = 55.38 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
-----------------------------------------------------------------------
     0     90   0.00  63.44  -5.05  -3.01   0.00   0.00  -4.75  50.62*
     0     90   0.00  63.44  -5.05  -3.01   0.00   0.00   0.00  55.38
-----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 55.38 dBA

Total Leq All Segments: 55.38 dBA
```

```
Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.45 !         0.45

RT/Custom (0.00 + 48.84 + 0.00) = 48.84 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.00  56.91  -5.05  -3.01   0.00   0.00  -4.75  44.09*
     0     90   0.00  56.91  -5.05  -3.01   0.00   0.00   0.00  48.84
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 48.84 dBA

Total Leq All Segments: 48.84 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 65.16
                         (NIGHT): 57.69
```

```
STAMSON 5.0        NORMAL REPORT        Date: 23-04-2018 37:21:53
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r3.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott (day/night)
-----------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  18.00 / 18.00  m
Receiver height           :  20.80 / 20.80  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Scott (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 64.68 + 0.00) = 64.68 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90      0   0.00  68.48   0.00  -0.79  -3.01   0.00   0.00   0.00
64.68
--------------------------------------------------------------------------
--

Segment Leq : 64.68 dBA

Total Leq All Segments: 64.68 dBA


Results segment # 1: Scott (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 57.08 + 0.00) = 57.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90      0   0.00  60.88   0.00  -0.79  -3.01   0.00   0.00   0.00
57.08
--------------------------------------------------------------------------
--

Segment Leq : 57.08 dBA

Total Leq All Segments: 57.08 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2            : -90.00 deg   0.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      2       (Reflective ground surface)
Receiver source distance   :  48.00 / 48.00  m
Receiver height            :  20.80 / 20.80  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -90.00 deg   Angle2 : 0.00 deg
Barrier height             :   6.00 m
Barrier receiver distance :  42.00 / 42.00  m
Source elevation           :  -6.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :  -6.00 m
Reference angle            :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top   (m)
-------------+--------------+--------------+---------------
        0.50 !        20.80 !         3.79 !         -2.21

RT/Custom (0.00 + 45.69 + 0.00) = 45.69 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      0   0.00  63.44  -5.05  -3.01   0.00   0.00  -9.69  45.69
----------------------------------------------------------------------

Segment Leq : 45.69 dBA

Total Leq All Segments: 45.69 dBA
```

```
Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       20.80 !        3.79 !        -2.21

RT/Custom (0.00 + 39.16 + 0.00) = 39.16 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      0   0.00  56.91  -5.05  -3.01   0.00   0.00  -9.69  39.16
----------------------------------------------------------------------

Segment Leq : 39.16 dBA

Total Leq All Segments: 39.16 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 64.73
                         (NIGHT): 57.15
```

```
STAMSON 5.0        NORMAL REPORT        Date: 23-04-2018 37:21:57
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r4.te                Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott (day/night)
-----------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   0.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  18.00 / 18.00  m
Receiver height           :  42.10 / 42.10  m
Topography                :      1       (Flat/gentle slope; no barrier)
Reference angle           :   0.00
```

```
Results segment # 1: Scott (day)
--------------------------------

Source height = 1.50 m

ROAD (0.00 + 64.68 + 0.00) = 64.68 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90      0   0.00  68.48   0.00  -0.79  -3.01   0.00   0.00   0.00
64.68
--------------------------------------------------------------------------
--

Segment Leq : 64.68 dBA

Total Leq All Segments: 64.68 dBA


Results segment # 1: Scott (night)
----------------------------------

Source height = 1.50 m

ROAD (0.00 + 57.08 + 0.00) = 57.08 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90      0   0.00  60.88   0.00  -0.79  -3.01   0.00   0.00   0.00
57.08
--------------------------------------------------------------------------
--

Segment Leq : 57.08 dBA

Total Leq All Segments: 57.08 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70  km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2            : -90.00 deg   0.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      2       (Reflective ground surface)
Receiver source distance   :  48.00 / 48.00  m
Receiver height            :  42.10 / 42.10  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -90.00 deg   Angle2 : 0.00 deg
Barrier height             :   6.00 m
Barrier receiver distance :  42.00 / 42.00  m
Source elevation           :  -6.00 m
Receiver elevation         :   0.00 m
Barrier elevation          :  -6.00 m
Reference angle            :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.45 !         0.45

RT/Custom (0.00 + 55.38 + 0.00) = 55.38 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      0   0.00  63.44  -5.05  -3.01   0.00   0.00  -4.75  50.62*
   -90      0   0.00  63.44  -5.05  -3.01   0.00   0.00   0.00  55.38
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 55.38 dBA

Total Leq All Segments: 55.38 dBA
```

```
Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       42.10 !        6.45 !         0.45

RT/Custom (0.00 + 48.84 + 0.00) = 48.84 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      0   0.00  56.91  -5.05  -3.01   0.00   0.00  -4.75  44.09*
   -90      0   0.00  56.91  -5.05  -3.01   0.00   0.00   0.00  48.84
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 48.84 dBA

Total Leq All Segments: 48.84 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 65.16
                         (NIGHT): 57.69
```

```
STAMSON 5.0        NORMAL REPORT        Date: 23-04-2018 37:22:03
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5.te                 Time Period: Day/Night 16/8 hours
Description:


Road data, segment # 1: Scott (day/night)
-----------------------------------------
Car traffic volume  : 12144/1056  veh/TimePeriod  *
Medium truck volume :   966/84    veh/TimePeriod  *
Heavy truck volume  :   690/60    veh/TimePeriod  *
Posted speed limit  :    50 km/h
Road gradient       :     0 %
Road pavement       :     1 (Typical asphalt or concrete)

* Refers to calculated road volumes based on the following input:

    24 hr Traffic Volume (AADT or SADT):  15000
    Percentage of Annual Growth        :   0.00
    Number of Years of Growth          :   0.00
    Medium Truck % of Total Volume     :   7.00
    Heavy Truck  % of Total Volume     :   5.00
    Day (16 hrs) % of Total Volume     :  92.00

Data for Segment # 1: Scott (day/night)
---------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  20.00 / 20.00  m
Receiver height           :  64.80 / 64.80  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  63.30 m
Barrier receiver distance :   3.00 / 3.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00
```

```
Results segment # 1: Scott (day)
--------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top   (m)
-------------+--------------+--------------+---------------
       1.50 !       64.80 !       55.30 !         55.30

ROAD (0.00 + 53.43 + 0.00) = 53.43 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  68.48   0.00  -1.25   0.00   0.00   0.00 -13.80
53.43
--------------------------------------------------------------------------
--

Segment Leq : 53.43 dBA

Total Leq All Segments: 53.43 dBA


Results segment # 1: Scott (night)
----------------------------------

Source height = 1.50 m

Barrier height for grazing incidence
------------------------------------
Source       ! Receiver     ! Barrier      ! Elevation of
Height   (m) ! Height   (m) ! Height   (m) ! Barrier Top   (m)
-------------+--------------+--------------+---------------
       1.50 !       64.80 !       55.30 !         55.30

ROAD (0.00 + 45.83 + 0.00) = 45.83 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj
SubLeq
--------------------------------------------------------------------------
--
   -90     90   0.00  60.88   0.00  -1.25   0.00   0.00   0.00 -13.80
45.83
--------------------------------------------------------------------------
--

Segment Leq : 45.83 dBA

Total Leq All Segments: 45.83 dBA
```

```
RT/Custom data, segment # 1: LRT (day/night)
--------------------------------------------
1 - 4-car SRT:
Traffic volume    :   540/60    veh/TimePeriod
Speed             :    70 km/h

Data for Segment # 1: LRT (day/night)
-------------------------------------
Angle1   Angle2             : -90.00 deg   90.00 deg
Wood depth                  :      0       (No woods.)
No of house rows            :      0 / 0
Surface                     :      2       (Reflective ground surface)
Receiver source distance    :  50.00 / 50.00  m
Receiver height             :  64.80 / 64.80  m
Topography                  :      2       (Flat/gentle slope; with barrier)
Barrier angle1              : -90.00 deg   Angle2 : 90.00 deg
Barrier height              :  63.30 m
Barrier receiver distance   :   3.00 / 3.00   m
Source elevation            :  -6.00 m
Receiver elevation          :   0.00 m
Barrier elevation           :   0.00 m
Reference angle             :   0.00
```

```
Results segment # 1: LRT (day)
------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       64.80 !       60.58 !        60.58

RT/Custom (0.00 + 47.42 + 0.00) = 47.42 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -5.23   0.00   0.00   0.00 -10.78  47.42
----------------------------------------------------------------------

Segment Leq : 47.42 dBA

Total Leq All Segments: 47.42 dBA

Results segment # 1: LRT (night)
--------------------------------

Source height = 0.50 m

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       0.50 !       64.80 !       60.58 !        60.58

RT/Custom (0.00 + 40.89 + 0.00) = 40.89 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -5.23   0.00   0.00   0.00 -10.78  40.89
----------------------------------------------------------------------

Segment Leq : 40.89 dBA

Total Leq All Segments: 40.89 dBA




TOTAL Leq FROM ALL SOURCES (DAY): 54.40
                         (NIGHT): 47.04
```

APPENDIX B

FTA VIBRATION CALCULATIONS

Possible Vibration Impacts on 1950 Scott Street
Perdicted using FTA General Assesment

Train Speed 70 km/h 43.4 mph

	Distance from C/L	
	(m)	(ft)
Confederation	47.0	154.2

	Vibration	
From FTA Manual Fig 10-1		
Vibration Levels at distance from track	64	dBV re 1 micro in/sec
Adjustment Factors FTA Table 10-1		
Speed reference 50 mph	-1	Speed Limit of 70 km/h (43.4 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Weels run true
Track Condition	0	None
Track Treatments	0	None
Type of Transit Structure	0	None
Efficient vibration Propagation	0	Propagation through rock
Vibration Levels at Fdn	63	0.035
Coupling to Building Foundation	-10	Large Massonry on Piles
Floor to Floor Attenuation	-2.0	Ground Floor Ocupied
Amplification of Floor and Walls	6	
Total Vibration Level	56.8	dBV or 0.018 mm/s
Noise Level in dBA	21.8	dBA

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise

Factors Affecting Vibration Source				
Source Factor	**Adjustment to Propagation Curve**			**Comment**
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	Vibration level is approximately proportional to $20*\log(speed/speed_{ref})$. Sometimes the variation with speed has been observed to be as low as 10 to 15 $\log(speed/speed_{ref})$.
	60 mph	+1.6 dB	+6.0 dB	
	50 mph	0.0 dB	+4.4 dB	
	40 mph	-1.9 dB	+2.5 dB	
	30 mph	-4.4 dB	0.0 dB	
	20 mph	-8.0 dB	-3.5 dB	
Vehicle Parameters (not additive, apply greatest value only)				
Vehicle with stiff primary suspension	+8 dB			Transit vehicles with stiff primary suspensions have been shown to create high vibration levels. Include this adjustment when the primary suspension has a vertical resonance frequency greater than 15 Hz.
Resilient Wheels	0 dB			Resilient wheels do not generally affect ground-borne vibration except at frequencies greater than about 80 Hz.
Worn Wheels or Wheels with Flats	+10 dB			Wheel flats or wheels that are unevenly worn can cause high vibration levels. This can be prevented with wheel truing and slip-slide detectors to prevent the wheels from sliding on the track.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			If both the wheels and the track are worn, only one adjustment should be used. Corrugated track is a common problem. Mill scale on new rail can cause higher vibration levels until the rail has been in use for some time.
Special Trackwork	+10 dB			Wheel impacts at special trackwork will significantly increase vibration levels. The increase will be less at greater distances from the track.
Jointed Track or Uneven Road Surfaces	+5 dB			Jointed track can cause higher vibration levels than welded track. Rough roads or expansion joints are sources of increased vibration for rubber-tire transit.
Track Treatments (not additive, apply greatest value only)				
Floating Slab Trackbed	-15 dB			The reduction achieved with a floating slab trackbed is strongly dependent on the frequency characteristics of the vibration.
Ballast Mats	-10 dB			Actual reduction is strongly dependent on frequency of vibration.
High-Resilience Fasteners	-5 dB			Slab track with track fasteners that are very compliant in the vertical direction can reduce vibration at frequencies greater than 40 Hz.

Table 10-1. Adjustment Factors for Generalized Predictions of Ground-Borne Vibration and Noise (Continued)

Factors Affecting Vibration Path		
Path Factor	**Adjustment to Propagation Curve**	**Comment**
Resiliently Supported Ties	-10 dB	Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Configuration (not additive, apply greatest value only)		
Type of Transit Structure	Relative to at-grade tie & ballast: Elevated structure -10 dB Open cut 0 dB	The general rule is the heavier the structure, the lower the vibration levels. Putting the track in cut may reduce the vibration levels slightly. Rock-based subways generate higher-frequency vibration.
	Relative to bored subway tunnel in soil: Station -5 dB Cut and cover -3 dB Rock-based - 15 dB	
Ground-borne Propagation Effects		
Geologic conditions that promote efficient vibration propagation	Efficient propagation in soil +10 dB	Refer to the text for guidance on identifying areas where efficient propagation is possible.
	Propagation in rock layer — **Dist.** / **Adjust.**: 50 ft +2 dB 100 ft +4 dB 150 ft +6 dB 200 ft +9 dB	The positive adjustment accounts for the lower attenuation of vibration in rock compared to soil. It is generally more difficult to excite vibrations in rock than in soil at the source.
Coupling to building foundation	Wood Frame Houses -5 dB 1-2 Story Masonry -7 dB 3-4 Story Masonry -10 dB Large Masonry on Piles -10 dB Large Masonry on Spread Footings -13 dB Foundation in Rock 0 dB	The general rule is the heavier the building construction, the greater the coupling loss.
Factors Affecting Vibration Receiver		
Receiver Factor	**Adjustment to Propagation Curve**	**Comment**
Floor-to-floor attenuation	1 to 5 floors above grade: -2 dB/floor 5 to 10 floors above grade: -1 dB/floor	This factor accounts for dispersion and attenuation of the vibration energy as it propagates through a building.
Amplification due to resonances of floors, walls, and ceilings	+6 dB	The actual amplification will vary greatly depending on the type of construction. The amplification is lower near the wall/floor and wall/ceiling intersections.
Conversion to Ground-borne Noise		
Noise Level in dBA	Peak frequency of ground vibration: Low frequency (<30 Hz): -50 dB Typical (peak 30 to 60 Hz): -35 dB High frequency (>60 Hz): -20 dB	Use these adjustments to estimate the A-weighted sound level given the average vibration velocity level of the room surfaces. See text for guidelines for selecting low, typical or high frequency characteristics. Use the high-frequency adjustment for subway tunnels in rock or if the dominant frequencies of the vibration spectrum are known to be 60 Hz or greater.