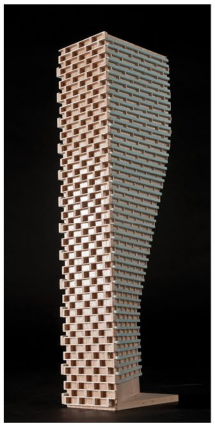
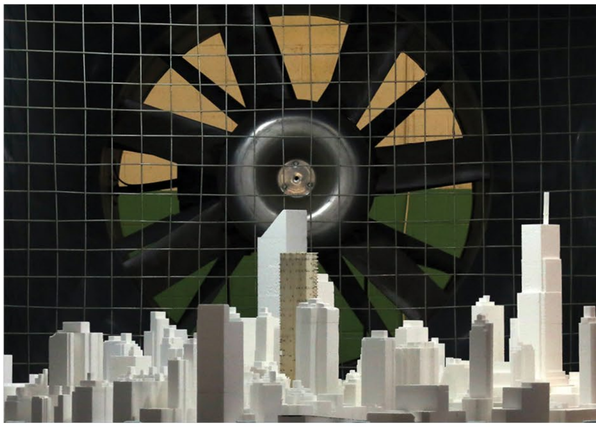
ENVIRONMENTAL NOISE AND VIBRATION ASSESSMENT

100 Steacie Drive
Ottawa, Ontario

Report: 20-123-Noise & Vibration





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EXECUTIVE SUMMARY

This report describes an environmental noise and vibration assessment for proposed low-rise apartment buildings located at 100 Steacie Drive in Ottawa, Ontario. The development comprises two 4-storey buildings; Building A and B, situated on an irregular-shaped parcel of land. Building A and B, on the east and west respectively, are connected and create a C-shaped planform. The major source of transportation noise is the existing rail line to the north of the study site. Figure 1 illustrates the site plan with the surrounding context.

The assessment is based on (i) theoretical noise prediction methods that conform to the Ministry of the Environment, Conservation and Parks (MECP) and City of Ottawa requirements; (ii) noise level criteria as specified by the City of Ottawa's Environmental Noise Control Guidelines (ENCG); (iii) rail train counts based on Gradient Wind's experience and information obtained from reports for other projects in the surrounding area; (iv) a site plan drawings of the subject site received from Brigil in January 2024; (v) satellite imagery; and (vi) Gradient Wind's experience with similar projects.

The results of the current analysis indicate that noise levels will range between 38 and 61 dBA with whistle noise, and 40 to 46 dBA without whistle noise during the daytime period (07:00-23:00). As there are no trains operating during the nighttime, the nighttime noise levels associated with the railway are zero. The highest noise level (i.e. 61 dBA) while considering whistle noise occurs along the northeast façade of the building, which is nearest and most exposed to the rail line and the grade-level crossing at March Road. Without the consideration of whistle noise, the highest noise level (i.e. 46 dBA) occurs along the north façade, which is nearest and most exposed to the rail line. Building components with a higher Sound Transmission Class (STC) rating will be required where exterior noise levels exceed 60 dBA, as indicated in Figure 5. Warning Clauses will also be required in all Lease, Purchase and Sale Agreements for Building A, as summarized in Section 6.

Regarding stationary noise, sources from rooftop HVAC units at 62 Steacie Drive, and sources from wood processing equipment at 40 Station Road were assessed for their impact on the proposed development. The adjacent office building at 62 Steacie Drive is equipped with small and medium rooftop air handling units. The wood processing facility to the west of the site at 40 Station Road is assumed to intermittently operate a chainsaw and wood splitter. Stationary noise sources associated with commercial/industrial operations at 413 March Road and 447 March Road are not expected to have any significant impacts on the study building, due to the setback distances of 200 metres and 400 metres, respectively.

The results of the stationary noise assessment indicate that the noise levels produced by the rooftop HVAC equipment of 62 Steacie Drive fall below the stationary noise criteria of 50 dBA and 45 dBA for daytime and nighttime, at the plane of window of the proposed buildings. The noise produced by wood processing operations at 40 Station Road is expected to exceed these criteria at the north façades of Buildings A and B. The preferred method of noise mitigation specified by the ENCG is source-based mitigation, however, this option is not considered viable. Investigation into the placement of a 4.5 metre-tall noise barrier on the edge of the property line nearest to the wood processing noise sources proved ineffective in reducing noise levels at the plane of window on the upper floors. Therefore, noise mitigation will be achieved through enhanced construction quality such as brick cladding (or acoustical equivalent) and multipane windows along the north façades of Buildings A and B, as indicated in Figure 5. Warning Clauses will also be required in all Lease, Purchase and Sale Agreements for Buildings A and B, as summarized in Section 6.

Estimated vibration levels due to railway activity in the area are expected to fall below the criterion of 0.14 mm/s RMS at the nearest building foundation (northeast corner of Building A) to the rail line. Thus, mitigation for vibrations is not required.

The residential community to the south is the nearest noise-sensitive point of reception to the development. With regard to stationary noise impacts of the development's mechanical equipment, we recommend placing the mechanical equipment (i.e. air handling units, cooling towers, generators) on the rooftop or in a mechanical penthouse to reduce the line of sight exposure and with the intake/exhaust louvres pointed away from the noise-sensitive areas. Given the setback distance between the development and the residential community (approximately 95 metres to the closest residence), in addition to the proposed buildings having a higher elevation than the adjacent office building, the development is expected to be compatible with the surrounding existing land uses, with noise control features considered.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (Gradient Wind) was retained by Brigil to undertake an environmental noise and vibration assessment for proposed low-rise apartment buildings located at 100 Steacie Drive in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations related to an environmental noise and ground vibration assessment.

The present scope of work involves assessing exterior and interior noise levels generated by local railway and existing stationary sources, as well as vibration levels generated by local railway activity. The assessment was performed on the basis of theoretical noise calculation methods conforming to the City of Ottawa[1] and Ministry of the Environment, Conservation and Parks (MECP)[2] guidelines. Noise calculations were based on a site plan drawing received from Brigil, with train counts based on Gradient Wind's experience and information obtained from reports for other projects in the surrounding area. The stationary noise assessment was based on Gradient Wind's experience and satellite imagery of the surrounding properties.

2. TERMS OF REFERENCE

The focus of this environmental noise and vibration assessment is the two proposed low-rise apartment buildings located on an irregular-shaped parcel of land at 100 Steacie Drive in Ottawa, Ontario. The subject site is bounded by an existing rail line from the north, an existing office building to the east, and Steacie Drive, green space and playing fields to the south.

The subject site is comprised of a 4-storey apartment complex with a C-shaped planform. The complex comprises the connected buildings A and B, on the east and west respectively. The existing roundabout has been extended to create a drop-off area at the center of the building, leading to the apartment lobby. There is outdoor amenity space at the back of the building facing north. Underground parking is also present.

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[1] City of Ottawa Environmental Noise Control Guidelines, January 2016
[2] Ontario Ministry of the Environment, Conservation and Parks – Environmental Noise Guidelines, Publication NPC-300, Queens Printer for Ontario, Toronto, 2013

The major source of transportation noise is the Arnprior-Nepean rail line to the north, which is owned by the City of Ottawa and leased to Nylene Canada Inc. Regarding stationary noise, sources from rooftop HVAC units at 62 Steacie Drive, and sources from wood processing equipment at 40 Station Road were assessed for their impact on the proposed development. The facility at 40 Station Road also comprises a plumber and contractor's workshop, for which there are no significant sources of stationary noise expected. Stationary noise sources associated with commercial/industrial operations at 413 March Road and 447 March Road are not expected to have any significant impacts on the study building, due to the setback distances of 200 metres and 400 metres, respectively.

The site surroundings comprise forested areas to the west, low-rise office buildings to the east located along the north side of Steacie Drive, green space and playing fields to the southeast and south along the south side of Steacie Drive followed by low-rise residential homes. To the north beyond the rail line, the site surroundings feature a hydro facility to the northwest and office and commercial buildings to the north and northeast. Figure 1 illustrates a complete site plan with the surrounding context.

3. OBJECTIVES

The main goals of this work are to (i) calculate the future noise levels on the study buildings produced by local railway traffic and stationary sources, (ii) calculate the future vibration levels on the study building produced by local railway traffic, and (iii) ensure that interior noise levels and vibration levels do not exceed the allowable limits specified by the City of Ottawa's Environmental Noise Control Guidelines 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 ($2x10^{-5}$ 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 Railway Traffic Noise

4.2.1 Criteria for Railway Noise

For railway traffic, 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 that has the same energy as a time-varying noise level over a period of time. For railways, 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 40 and 35 dBA for living rooms and sleeping quarters, respectively, as listed in Table 1. However, to account for deficiencies in building construction and control peak noise, these levels should be targeted toward 37 and 32 dBA.

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

Type of Space	Time Period	L_{eq} (dBA)
		Rail
General offices, reception areas, retail stores, etc.	07:00 – 23:00	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	40
Sleeping quarters of hotels/motels	23:00 – 07:00	40
Sleeping quarters of **residences**, hospitals, nursing/retirement homes, etc.	23:00 – 07:00	35

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c

Predicted noise levels at the plane of window (POW) 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[4]. A closed window due to a ventilation requirement will bring noise levels down to achieve an acceptable indoor environment[5]. 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 triggers the need for forced air heating with provision for central air conditioning. Where noise levels exceed 65 dBA daytime and 60 dBA nighttime, air conditioning will be required. Building components will require higher levels of sound attenuation[6] where noise levels exceed 60 dBA daytime and 55 dBA nighttime. Whistle noise is not included in the determination of noise levels at the plane of window; however, it is considered when determining the requirement for upgraded building components.

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. Whistle noise is not included in the determination of noise levels at outdoor living areas.

4.2.2 Railway Traffic Volumes

The NPC-300 dictates that noise calculations should consider railway volumes projected 15 years into the future. Existing daily rail traffic data is based on Gradient Wind's experience, as well as noise reports prepared by others for projects in the area surrounding the rail line of interest[7]. The Arnprior-Nepean rail line to the north is operated by Nylene Canada Inc. Rail traffic is limited to one train a week. This assessment considers one inbound and one outbound train with the worst-case scenario being the round trip is completed in a single day. Therefore, the rail traffic is assumed to remain constant over the next 15 years. Table 2 (below) summarizes the rail traffic counts included in this assessment.

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[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[5] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.8
[6] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[7] Noise Impact Assessment – 437 Donald B. Munro Drive, NOVATECH, May 31, 2019

TABLE 2: RAILWAY TRAFFIC DATA

Segment	Train Type	Speed Limit (km/h)	Rail Traffic Counts
Arnprior-Nepean Railway	Diesel (Freight)	16	2 DAY / 0 NIGHT

4.2.3 Theoretical Railway Traffic Noise Predictions

Noise predictions were performed with the aid of the MECP rail and road noise analysis program STAMSON 5.04, which incorporates the calculation model '*Sound from Trains Environment Analysis Method'* (STEAM). Appendix A includes the STAMSON 5.04 input and output data.

The rail line was treated as a multiple-line source of noise due to its curvature. In addition to the rail traffic counts summarized in Table 2, theoretical noise predictions were based on the following parameters:

- Ground surfaces were taken to be absorptive due to the presence of soft (grass) ground.
- Topography was assumed to be a flat/gentle slope surrounding the study buildings.
- For select receptors, existing and proposed buildings were considered as barriers, partially or fully obstructing exposure to the source as illustrated by exposure angles in Figure A1.
- One locomotive was modelled per train with six cars per train.
- Whistle noise was considered at the grade-level crossing at March Road to be conservative.
- Rail lines were modelled as not welded.
- Noise receptors were strategically placed at six (6) locations around the study area (see Figure 2).
- Receptor distances and exposure angles are illustrated in Figure A1.

4.3 Indoor Noise Calculations

The difference between outdoor and indoor noise levels is the noise attenuation provided by the building envelope. According to common industry practice, complete walls and individual wall elements are rated according to the Sound Transmission Class (STC). The STC ratings of common residential walls built in conformance with the Ontario Building Code (2020) typically exceed STC 35, depending on exterior cladding, thickness and interior finish details. For example, concrete and masonry walls can achieve STC 50 or more. Curtainwall systems typically provide around STC 35, depending on the glazing elements.

Standard good quality double-glazed non-operable windows can have STC ratings ranging from 25 to 40 depending on the window manufacturer, pane thickness and inter-pane spacing. As previously mentioned, the windows are the known weak point in a partition.

According to the ENCG, when daytime noise levels (from rail sources) at the plane of the window exceed 60 dBA, calculations must be performed to evaluate the sound transmission quality of the building components to ensure acceptable indoor noise levels. The calculation procedure[8] considers:

- Window type and total area as a percentage of total room floor area
- Exterior wall type and total area as a percentage of the total room floor area
- Acoustic absorption characteristics of the room
- Outdoor noise source type and approach geometry
- Indoor sound level criteria, which vary according to the intended use of a space.

Based on published research[9], exterior walls possess specific sound attenuation characteristics that are used as a basis for calculating the required STC ratings of windows in the same partition. Due to the limited information available at the time of the study, which was prepared for a zoning by-law amendment application, final detailed floor layouts and building elevations were unavailable and therefore detailed STC calculations could not be performed at this time. As a guideline, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels + safety factor).

4.4 Stationary Noise

4.4.1 Criteria for Stationary Noise

For stationary sources, the L_{eq} is commonly calculated on an hourly interval, while for railways, the L_{eq} is calculated on the basis of a 16-hour daytime/8-hour nighttime split as previously mentioned in Section 4.2.1. Stationary sources are defined in the ENCG as "all sources of sound and vibration, whether fixed or mobile, that exist or operate on a premises, property or facility, the combined sound and vibration

[8] Building Practice Note: Controlling Sound Transmission into Buildings by J.D. Quirt, National Research Council of Canada, September 1985
[9] CMHC, Road & Rail Noise: Effects on Housing

levels of which are emitted beyond the property boundary of the premises, property or facility unless the source(s) is (are) due to construction" [10].

Noise criteria taken from the ENCG and NPC-300 apply to outdoor points of reception (POR). A POR is defined under NPC-300 as "any location on a noise-sensitive land use where noise from a stationary source is received"[11]. A POR can be located on an existing or zoned-for-future-use premises of permanent or seasonal residences, hotels/motels, nursing/retirement homes, rental residences, hospitals, campgrounds, and noise-sensitive buildings such as schools and places of worship. This applies to the plane of window and outdoor amenity spaces serving the development.

The recommended maximum noise levels for a Class 2 area in a suburban environment are outlined in Table 3 below. The study site is considered to be in a Class 2 area because it is located in proximity to existing commercial and office developments and at the end of a one-way street. These conditions indicate that the sound field is dominated by manmade sources during the daytime and evening periods and a natural environment with infrequent activity during the nighttime period. The applicable sound level limit is the higher of either the values in Table 3 or background noise levels due to sources such as transportation.

TABLE 3: EXCLUSIONARY LIMITS FOR CLASS 2 AREA

Time of Day	Class 2	
	Outdoor Points of Reception	Plane of Window
07:00 – 19:00	50	50
19:00 – 23:00	45	50
23:00 – 07:00	N/A	45

[10] City of Ottawa Environmental Noise Control Guidelines, page 10
[11] NPC-300, page 14

4.4.2 Assumptions

The adjacent office building to the immediate east located at 62 Steacie Drive has associated sources of stationary noise. To the northwest of the proposed development at 40 Station Road is a small wood processing facility, which is expected to cause intermittent sources of stationary noise. The following assumptions have been included in the analysis:

(i) The quantity, location and sound power of rooftop equipment have been assumed based on satellite imagery and Gradient Wind's experience on similar projects.

(ii) The rooftop air handling units of 62 Steacie Drive are assumed to operate continuously at 100% over a 1-hour period during the daytime period and at 50% operation during the nighttime period. This is to account for the decreased occupancy loads in the building overnight as the building is a commercial/business building.

(iii) The operations at the wood processing facility are assumed to use the following equipment: one (1) chainsaw, one (1) wood splitter. The equipment is assumed to operate concurrently for one-third (33.3%) of the 1-hour period.

(iv) The locations of the rooftop equipment and wood processing equipment can be seen in Figure 3.

4.4.3 Determination of Noise Source Power Levels

Sound power data for the rooftop equipment, which is present on the rooftop of the adjacent office building, were assumed based on Gradient Wind's experience with similar types of equipment. Sound power data for the wood processing equipment was based on published research[12] and forestry equipment spec sheets. Table 4 (below) summarizes the sound power levels assumed for each source used in the analysis.

[12] U.S. National Institute of Occupational Health and Safety - Power Tools Sound Power, 2011

TABLE 4: EQUIPMENT SOUND POWER LEVELS (dBA)

Source ID	Description	Height Above Grade / Rooftop (m)	Frequency (Hz)								
			63	125	250	500	1000	2000	4000	8000	Total
S1-5	Small RTU	1.0	-	74	76	75	74	71	64	59	81
S6-8	Medium RTU	1.0	57	70	77	81	80	76	73	69	85
S9	Chainsaw	1.0	-	-	-	-	115	-	-	-	115
S10	Wood Splitter (Engine)	1.0	-	-	-	-	103	-	-	-	103

4.4.4 Stationary Source Noise Predictions

The impact of the surrounding, existing stationary noise sources on the subject site was determined by computer modelling. Stationary noise source modelling is based on the software program *Predictor-Lima* developed from the International Standards Organization's (ISO) standard 9613 Parts 1 and 2. This computer program is capable of representing three-dimensional surfaces and the 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 MECP as part of Environmental Compliance Approvals applications.

Four (4) individual noise sensor locations were selected in the *Predictor-Lima* model to measure the noise impact at points of reception (POR) during the daytime (07:00 – 19:00) and nighttime (19:00 – 07:00) periods (see Figure 4). At Receptors 3-4, various heights were examined for a total of six (6) sensors. POR locations included the plane of windows (POWs) of each building. All mechanical equipment was represented as point sources in the model. Table 5 below contains Predictor-Lima calculation settings. These are typical settings that have been based on ISO 9613 standards and guidance from the MECP. Existing and proposed buildings were added to the model to account for screening and reflection effects from building façades. Modelling files and outputs are available upon request.

TABLE 5: 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

4.5 Ground Vibration & Ground-borne Noise

Rail 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, such as from a train. 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 millimetres 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.

4.5.1 Ground Vibration Criteria

In the United States, the Federal Transportation Authority (FTA) has set vibration criteria for sensitive land uses next to transit corridors. Similar standards have been developed by a partnership between the MECP and the Toronto Transit Commission[13]. These standards indicate that the appropriate criteria for residential buildings are 0.10 mm/s RMS for vibrations. For mainline railways, a document titled Guidelines for New Development in Proximity to Railway Operations[14], 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 rail line to the north, which is a heavy rail line with infrequent train passes, the 0.14 mm/s RMS vibration criteria and 35 dBA ground-borne noise criteria were adopted for this study.

4.5.2 Theoretical Ground Vibration Prediction Procedure

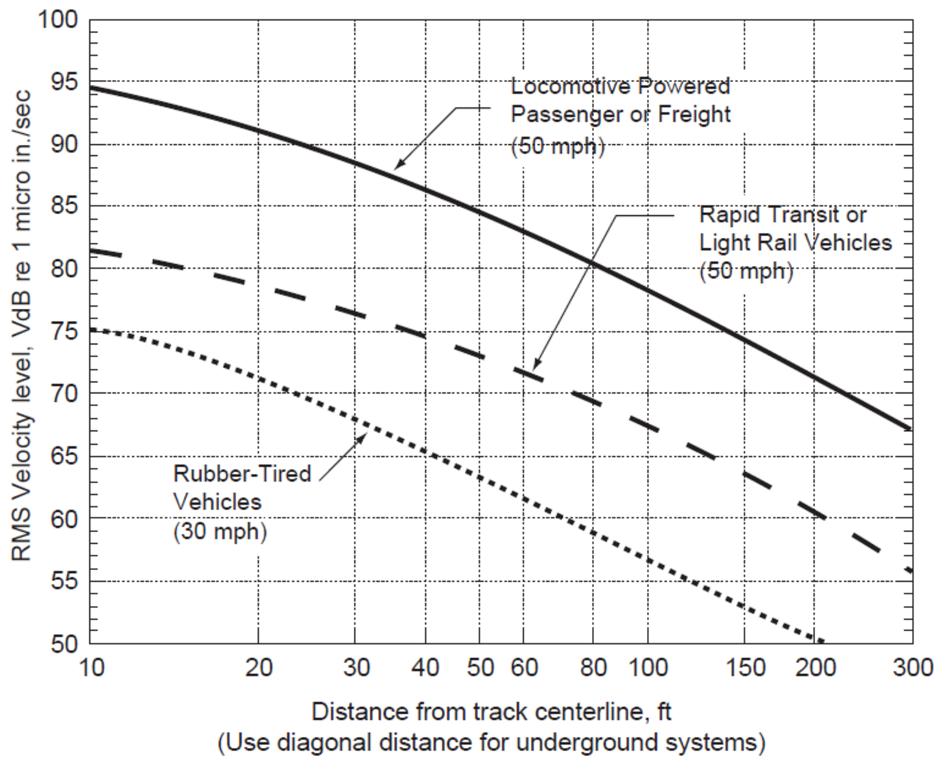
Potential vibration impacts of the existing rail line to the north were predicted using the FTA's Transit Noise and Vibration Impact Assessment[15] protocol. The FTA general vibration assessment is based on an upper bound generic set of curves that show vibration level attenuation with distance. These 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 the operating speed of the vehicle, conditions of the track, construction of the track and geology, as well as the structural type of the

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

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

[15] A. Quagliata, M. Ahearn, E. Boeker, Croof; and L. Meister, Transit Noise and Vibration Impact Assessment Manual, Federal Transit Administration, September 2018.

impacted building structures. Based on the setback distance of the closest building, initial vibration levels were deduced from a curve for freight trains at 50 miles per hour (mph) and applying an adjustment factor of -14 dBV to account for an operational speed of 9.94 mph (16 km/h). The track was assumed to be jointed with no welds. Details of the vibration calculations are presented in Appendix B.



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 Railway Noise Levels

The results of the railway noise calculations are summarized in Table 6 below. A complete set of input and output data from all STAMSON 5.04 calculations are available in Appendix A.

TABLE 6: EXTERIOR NOISE LEVELS DUE TO RAILWAY

Receptor Number	Height Above Local Grade (m)	Plane of Window Receptor Location	STAMSON 5.04 Noise Level (dBA)			
			Including Whistle Noise		Excluding Whistle Noise	
			Day	Night	Day	Night
Outdoor Living Area						
1	13.5	West Rooftop Amenity Area	45	0	45	0
2	13.5	East Rooftop Amenity Area	42	0	42	0
Plane of Window						
3	10.5	West Façade	38	0	38	0
4	10.5	Northwest Façade	44	0	44	0
5	10.5	North Façade	51	0	46	0
6	10.5	Northeast Façade	61	0	44	0
7	10.5	East Façade	57	0	40	0

**Whistle noise is not included in outdoor noise impact assessment*[16]

The results of the current analysis indicate that noise levels will range between 38 and 61 dBA with whistle noise, and 40 to 46 dBA without whistle noise during the daytime period (07:00-23:00). As there are no trains operating during the nighttime, the nighttime noise levels associated with the railway are zero. The highest noise level (i.e. 61 dBA) while considering whistle noise occurs along the northeast façade of the building, which is nearest and most exposed to the rail line and the grade-level crossing at March Road. Without the consideration of whistle noise, the highest noise level (i.e. 46 dBA) occurs along the north façade, which is nearest and most exposed to the rail line.

[16] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 3

5.2 Stationary Noise Levels

The anticipated noise levels are based on the assumptions outlined in Section 4.3.2. Expected noise levels received at the proposed building are summarized in Table 7.

TABLE 7: NOISE LEVELS FROM STATIONARY SOURCES

Receptor Number	Height Above Local Grade (m)	Plane of Window Receptor Location	Noise Level (dBA)		Meets ENCG Class 2 Criteria	
			Day	Night	Day	Night
Building A						
1a	1.5	Level 1, South Façade	34	28	Yes	Yes
1b	10.5	Level 4, South Façade	40	36	Yes	Yes
2a	1.5	Level 1, East Façade	36	32	Yes	Yes
2b	10.5	Level 4, East Façade	44	41	Yes	Yes
3	13.5	Rooftop Amenity	47	N/A*	Yes	Yes
Building B						
4	10.5	Level 4, South Façade	36	21	Yes	Yes
5	10.5	Level 4, North Façade	**65**	10	**NO**	Yes

**Noise levels during the nighttime are not considered for OLA's*

Noise levels from rooftop HVAC equipment on the adjacent office building at 62 Steacie Drive (Receptors 1-3) were found to be within the acceptable sound level limits. However, noise levels from the wood processing facility at 40 Station Road were found to exceed the sound level limits. Thus, mitigation will be required. Investigation into the placement of a 4.5-metre-tall noise barrier on the edge of the property line nearest to the source proved ineffective in reducing noise levels at the plane of window on the upper floors. Therefore, the necessary mitigation will be achieved through upgraded building components, as outlined in Section 5.3. Noise contours at 10.5 metres above grade can be seen in Figures 6 and 7 for daytime and nighttime conditions, respectively.

5.3 Noise Control Measures

The noise levels predicted due to railway traffic at the north façade exceed the criteria listed in Section 4.2 for building components, whereas the noise levels predicted due to stationary noise from the wood processing facility exceed the criteria for building components on the north façades of Buildings A and B. As discussed in Section 4.3, the anticipated STC requirements for windows have been estimated based on the overall noise reduction required for each intended use of space (STC = outdoor noise level – targeted indoor noise levels + safety factor). As per the City of Ottawa requirements, detailed STC calculations will be required to be completed prior to the building permit application for each unit type. The STC requirements for the windows are summarized below for various units within the development (see Figure 5):

- **Bedroom Windows**

(i) Bedroom windows of buildings A and B facing north will require a minimum STC of 30.

(ii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2020) requirements.

- **Living Room Windows**

(i) All living room windows are to satisfy Ontario Building Code (OBC 2020) requirements.

- **Exterior Walls**

(i) Exterior wall components on the north façades of buildings A and B will require a minimum STC of 45, which will be achieved with brick cladding or an acoustical equivalent according to NRC test data[17].

The STC requirements apply to windows, doors, spandrel panels and curtainwall elements. Exterior wall components on these façades are recommended to have a minimum STC of 45, where a window/wall system is used. A review of window supplier literature indicates that the specified STC ratings can be achieved by a variety of window systems having a combination of glass thickness and inter-pane spacing. We have specified an example window configuration, however, several manufacturers and various combinations of window components, such as those proposed, will offer the necessary sound attenuation rating. It is the responsibility of the manufacturer to ensure that the specified window achieves the required STC. This can only be assured by using window configurations that have been certified by laboratory testing. The requirements for STC ratings assume that the remaining components of the

[17] J.S. Bradley and J.A. Birta. Laboratory Measurements of the Sound Insulation of Building Façade Elements, National Research Council October 2000.

building are constructed and installed according to the minimum standards of the Ontario Building Code. The specified STC requirements also apply to swinging and/or sliding patio doors.

Additionally, predicted noise levels due to transportation and stationary sources at the rooftop amenity areas meet NPC-300 sound level limits. Therefore, mitigation is not required for the OLA's.

5.4 Ground Vibrations & Ground-borne Noise Levels

Based on an offset distance of 43m and the nearest building foundation (northeast corner of Building A), the estimated vibration level at the nearest point of reception is expected to be 0.025 mm/s RMS (60 dBV) based on the FTA protocol. Details of the calculation are provided in Appendix B. Since predicted vibration levels are below the criterion of 0.14 mm/s RMS, no mitigation will be required.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 38 and 61 dBA with whistle noise, and 40 to 46 dBA without whistle noise during the daytime period (07:00-23:00). As there are no trains operating during the nighttime, the nighttime noise levels associated with the railway are zero. The highest noise level (i.e. 61 dBA) while considering whistle noise occurs along the northeast façade of the building, which is nearest and most exposed to the rail line and the grade-level crossing at March Road. Without the consideration of whistle noise, the highest noise level (i.e. 46 dBA) occurs along the north façade, which is nearest and most exposed to the rail line. Building components with a higher Sound Transmission Class (STC) rating will be required where exterior noise levels exceed 60 dBA, as indicated in Figure 5.

The following Type D Warning Clause[18] will be required in all Agreements of Lease, Purchase and Sale for Building A, as summarized below:

Type D:

> *"This dwelling unit has been supplied with a central air conditioning system which will allow windows and exterior doors to remain closed, thereby ensuring that the indoor*

[18] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 8

sound levels are within the sound level limits of the Municipality and the Ministry of the Environment."

Regarding stationary noise, sources from rooftop HVAC units at 62 Steacie Drive, and sources from wood processing equipment at 40 Station Road were assessed for their impact on the proposed development. The adjacent office building at 62 Steacie Drive is equipped with small and medium rooftop air handling units. The wood processing facility to the west of the site at 40 Station Road is assumed to intermittently operate a chainsaw and wood splitter. Stationary noise sources associated with commercial/industrial operations at 413 March Road and 447 March Road are not expected to have any significant impacts on the study building, due to the setback distances of 200 metres and 400 metres, respectively.

The results of the stationary noise assessment indicate that the noise levels produced by the rooftop HVAC equipment of 62 Steacie Drive fall below the stationary noise criteria of 50 dBA and 45 dBA for daytime and nighttime, at the plane of window of the proposed buildings. The noise produced by wood processing operations at 40 Station Road is expected to exceed these criteria at the north façades of Buildings A and B. The preferred method of noise mitigation specified by the ENCG is source-based mitigation, however, this option is not considered viable. Investigation into placement of a 4.5-metre-tall noise barrier on the edge of the property line nearest to the wood processing noise sources proved ineffective in reducing noise levels at the plane of window on the upper floors. Therefore, noise mitigation will be achieved through enhanced construction quality such as brick cladding (or acoustical equivalent) and multipane windows along the north façades of Buildings A and B, as indicated in Figure 5.

The following Type E Warning Clause[19] will be required in all Agreements of Lease, Purchase, and Sale as summarized below:

Type E:

"Purchasers/tenants are advised that due to the proximity of the adjacent industry facility, noise from the industry facility may at times be audible."

[19] MECP, Environmental Noise Guidelines, NPC 300 – Part C, Section 8

Estimated vibration levels due to railway activity in the area are expected to fall below the criterion of 0.14 mm/s RMS at the nearest building foundation (northeast corner of Building A) to the rail line. Thus, mitigation for vibrations is not required.

The office building at 62 Steacie Drive and the residential community to the south are the nearest noise-sensitive points of reception to the development. With regard to stationary noise impacts of the development's mechanical equipment, we recommend placing the mechanical equipment (i.e. air handling units, cooling towers, generators) on the rooftop or in a mechanical penthouse to reduce the line-of-sight exposure and with the intake/exhaust louvres pointed away from the noise-sensitive areas. Given the setback distance between the development and the residential community (approximately 95 metres to the closest residence), in addition to the proposed buildings having a higher elevation than the adjacent office building, the development is expected to be compatible with the surrounding existing land uses with noise control features considered.

This concludes our environmental noise and vibration 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.

Sincerely,

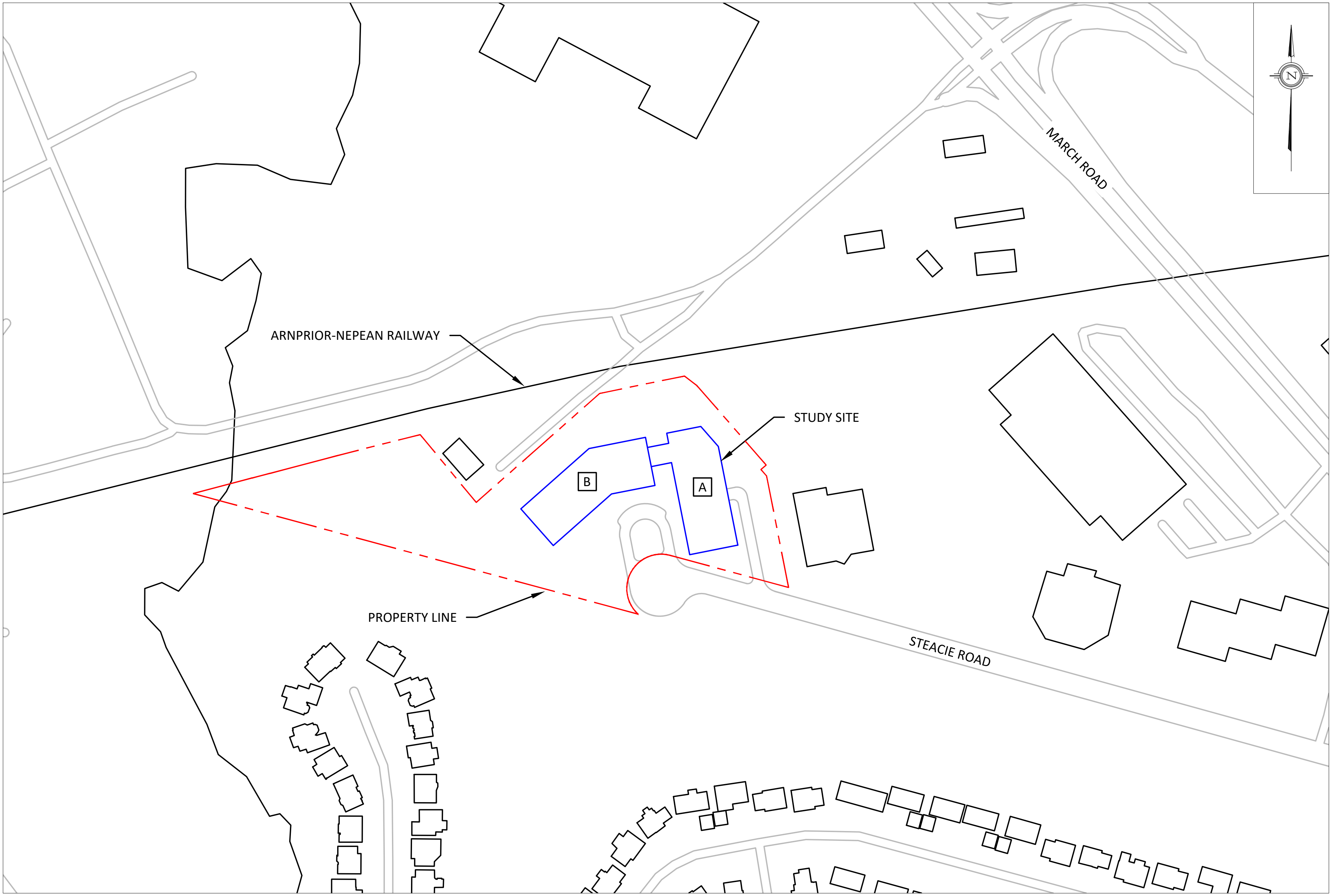
Gradient Wind Engineering Inc.

LICENSED PROFESSIONAL ENGINEER
J. R. FOSTER
100155655
March 5, 2024
PROVINCE OF ONTARIO

Adam Bonello, BASc.
Junior Environmental Scientist

Joshua Foster, P.Eng.
Lead Engineer

Gradient Wind File #20-123



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PROJECT: 100 STEACIE ROAD, OTTAWA TRANSPORTATION NOISE ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:3000 (APPROX.)	DRAWING NO. GW20-123-1	
DATE: MARCH 6, 2024	DRAWN BY: A.B.	

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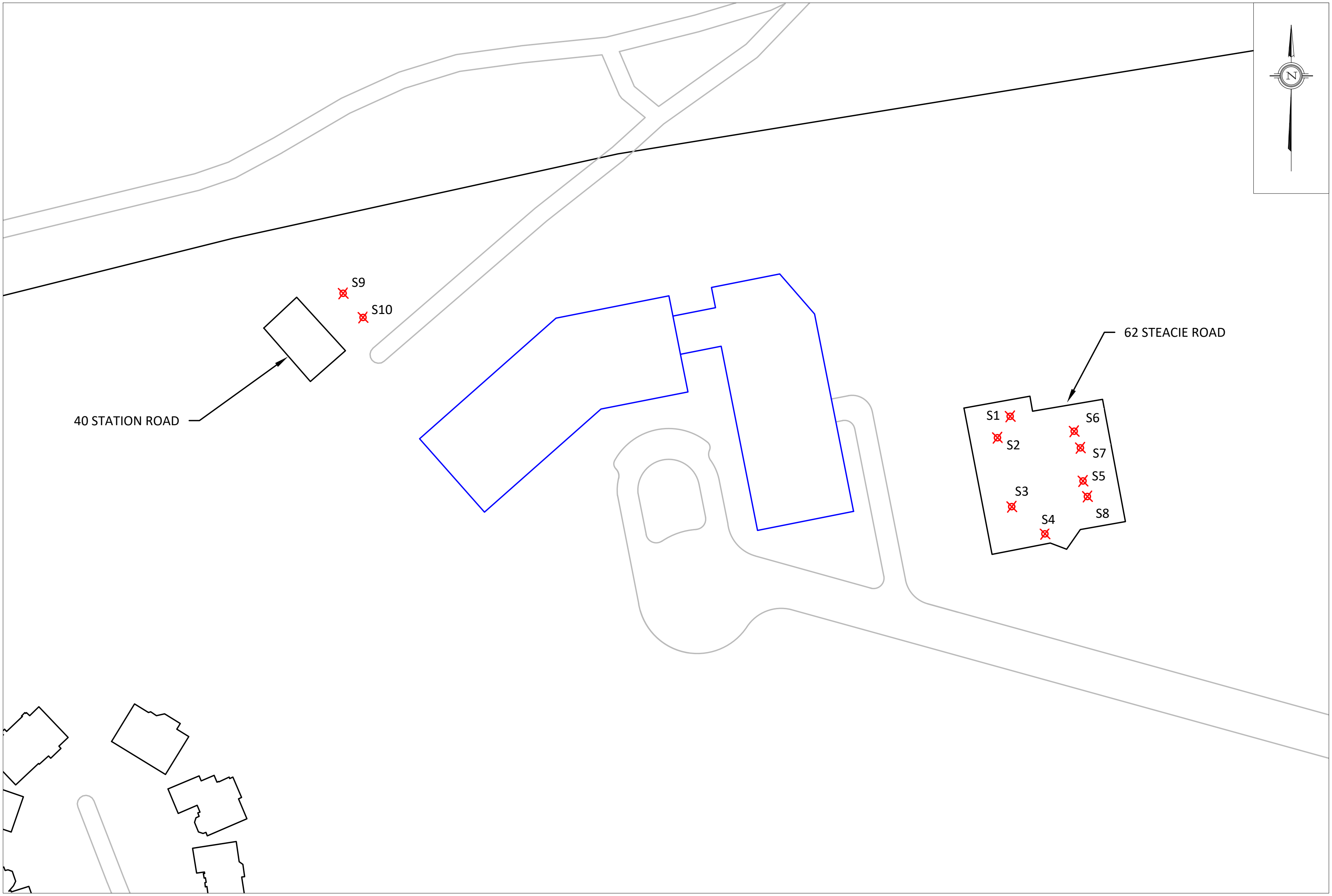
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW20-123-2
DATE	MARCH 6, 2024	DRAWN BY	A.B.

DESCRIPTION

FIGURE 2:
TRAFFIC NOISE RECEPTOR LOCATIONS



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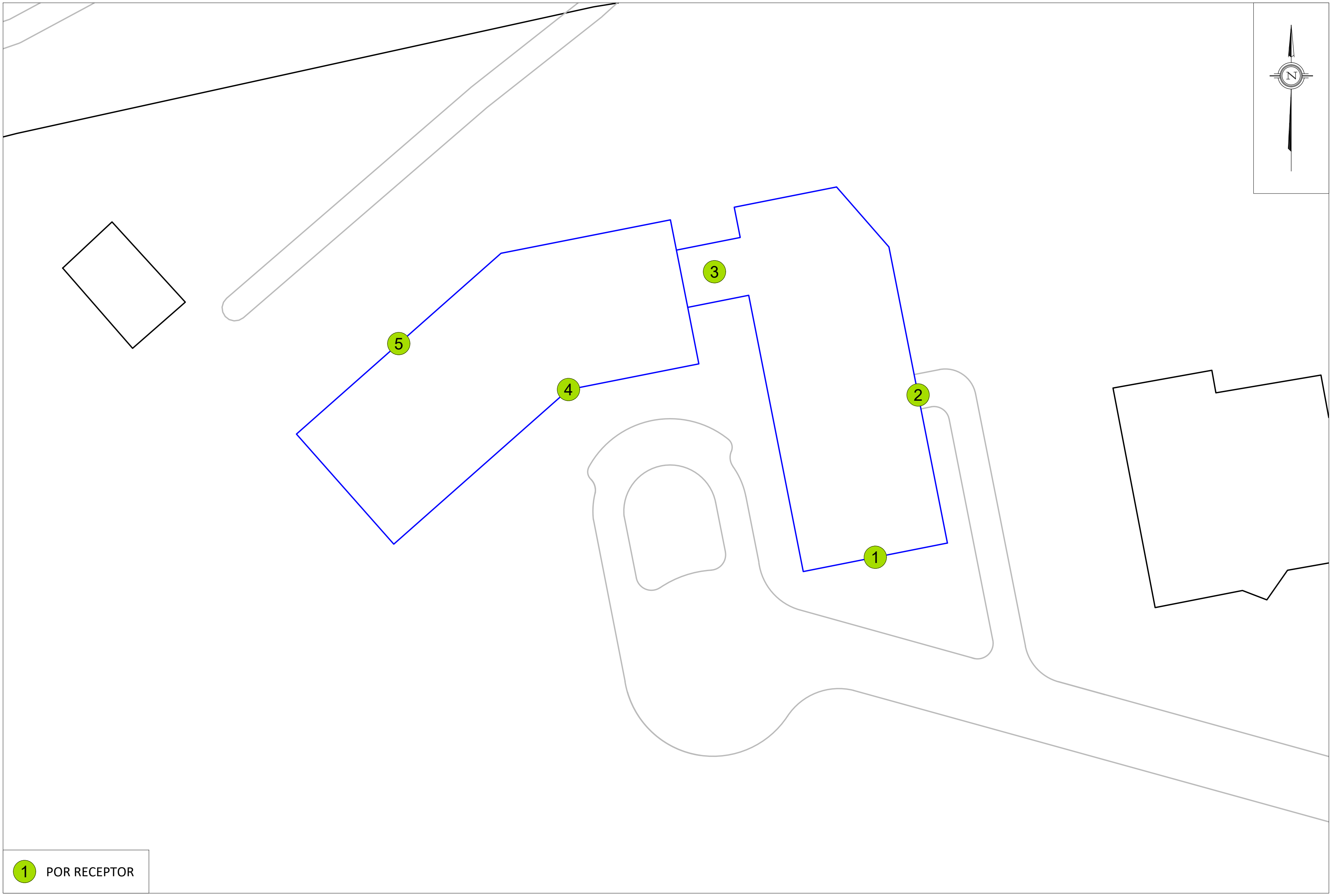
SCALE	1:1500 (APPROX.)	DRAWING NO.	GW20-123-3
DATE	MARCH 6, 2024	DRAWN BY	A.B.

DESCRIPTION

FIGURE 3:
EXISTING STATIONARY NOISE SOURCES



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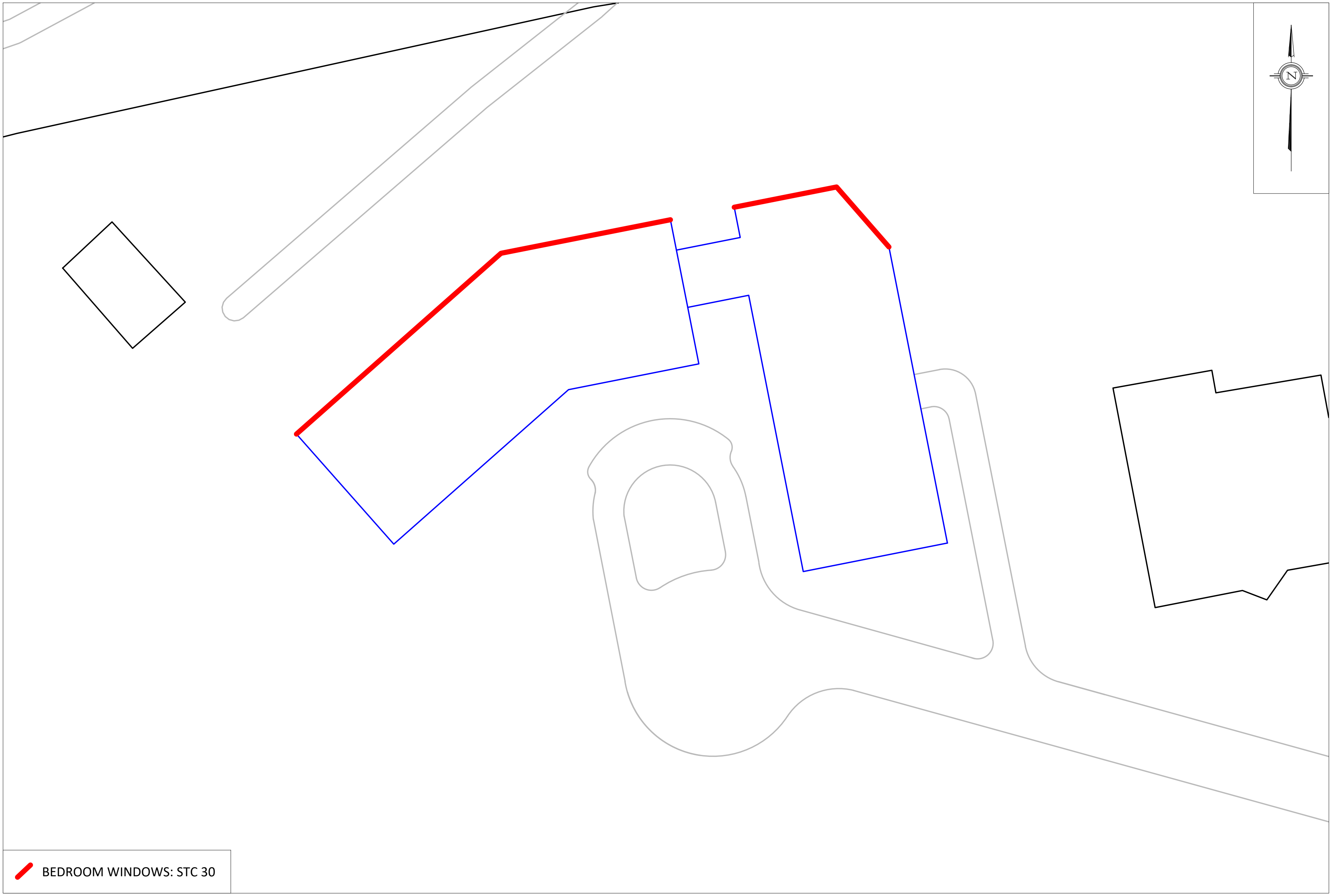
PROJECT	100 STEACIE ROAD, OTTAWA TRANSPORTATION NOISE ASSESSMENT
SCALE	1:1000 (APPROX.)
DRAWING NO.	GW20-123-4
DATE	MARCH 6, 2024
DRAWN BY	A.B.
DESCRIPTION	FIGURE 4: STATIONARY NOISE RECEPTORS



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PROJECT	100 STEACIE ROAD, OTTAWA TRANSPORTATION NOISE ASSESSMENT		
SCALE	1:1000 (APPROX.)	DRAWING NO.	GW20-123-5
DATE	MARCH 6, 2024	DRAWN BY	A.B.

DESCRIPTION

FIGURE 5:
WINDOW STC REQUIREMENTS

FIGURE 6: STATIONARY NOISE CONTOURS – DAYTIME PERIOD (10.5 METRES ABOVE GRADE)

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

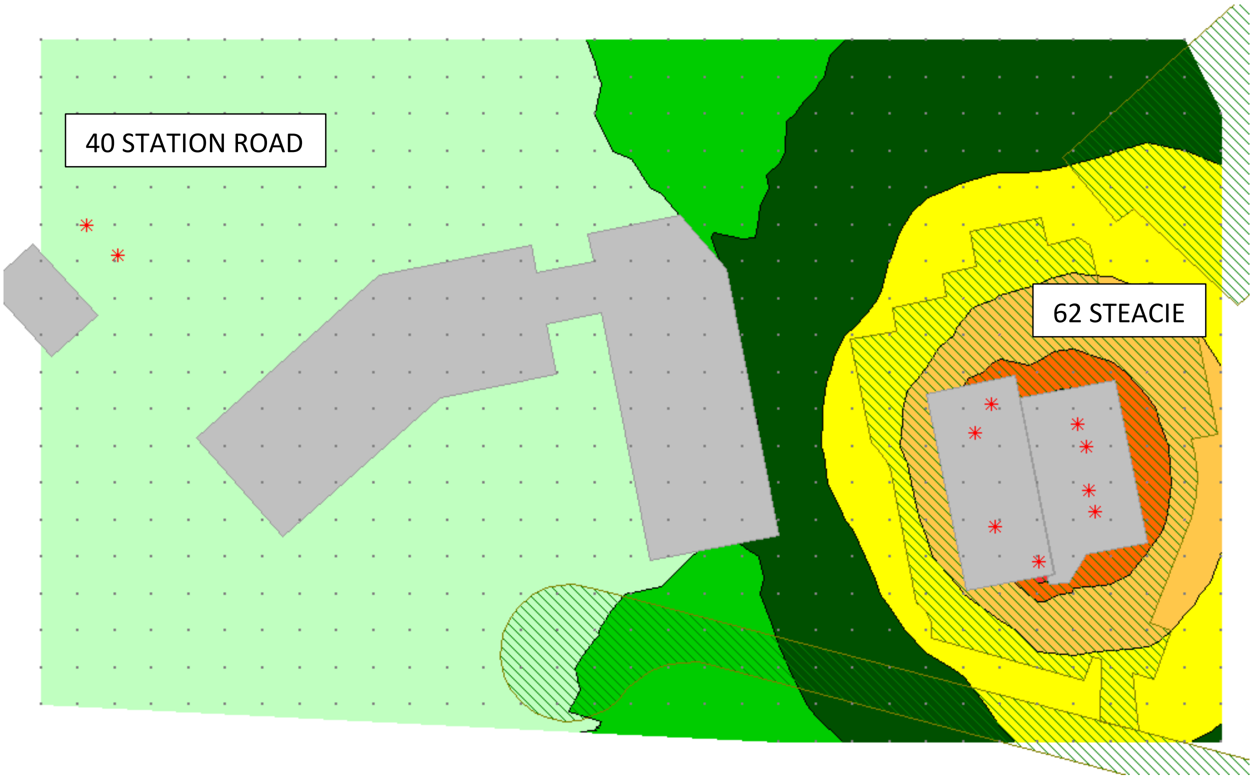
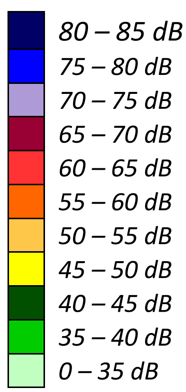
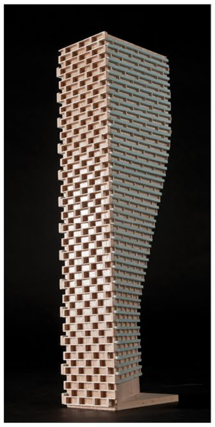
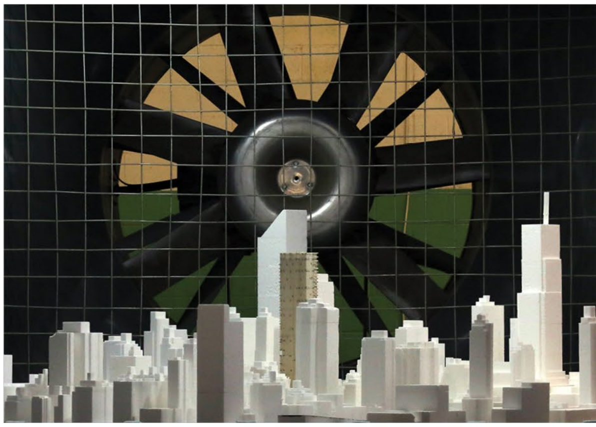


FIGURE 7: STATIONARY NOISE CONTOURS – NIGHTTIME PERIOD (10.5 METRES ABOVE GRADE)

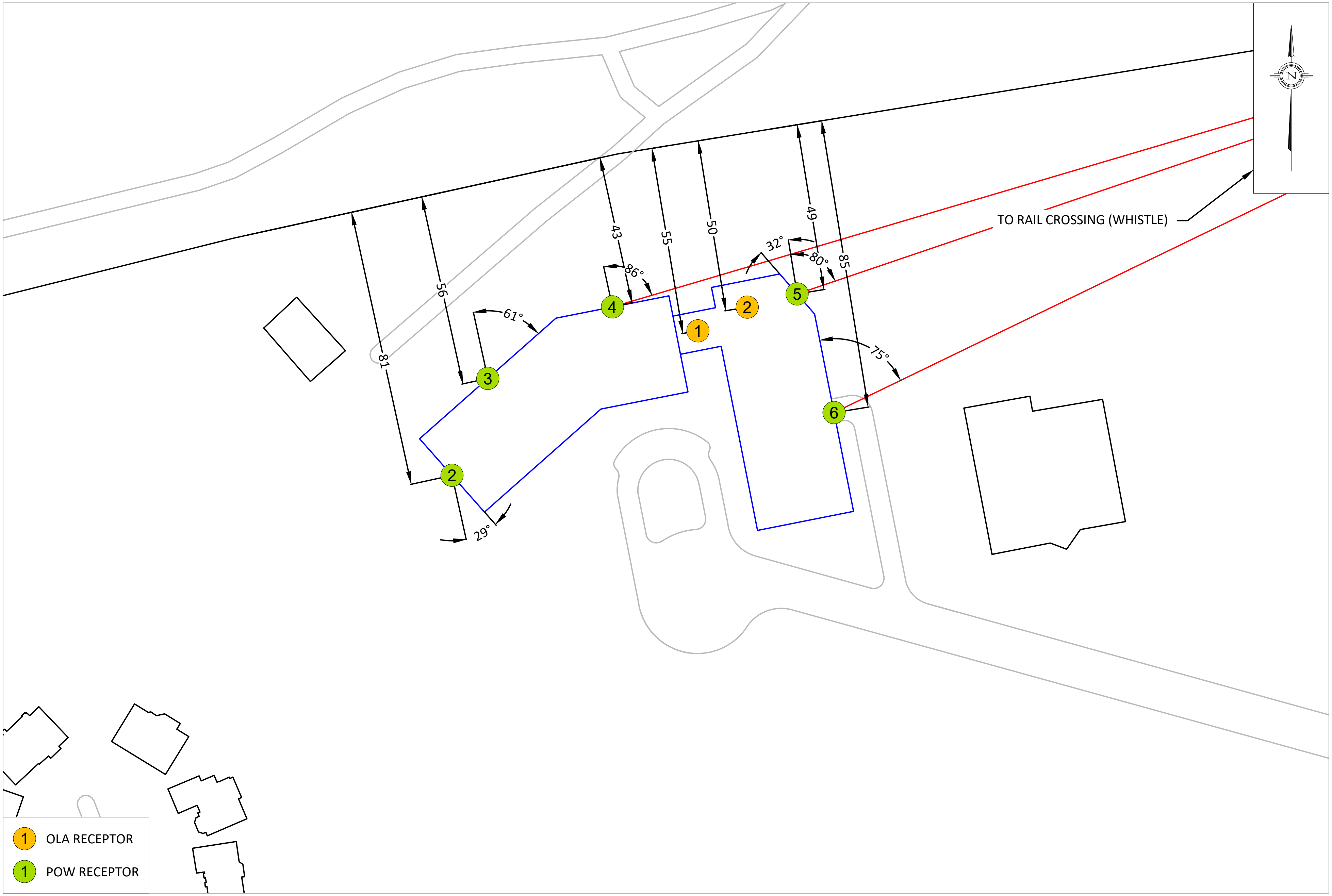






APPENDIX A

STAMSON 5.04 – INPUT AND OUTPUT DATA



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PROJECT	100 STEACIE ROAD, OTTAWA TRANSPORTATION NOISE ASSESSMENT		
SCALE	1:1500 (APPROX.)	DRAWING NO.	GW20-123-A1
DATE	MARCH 6, 2024	DRAWN BY	A.B.

DESCRIPTION

FIGURE A1:
RECEPTOR DISTANCE AND EXPOSURE ANGLES

```
STAMSON 5.0        NORMAL REPORT        Date: 06-03-2024 09:25:42
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  55.00 / 55.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      2       (Flat/gentle slope; with barrier)
No Whistle
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  12.00 m
Barrier receiver distance :   5.00 / 5.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       4.00 !       13.50 !       12.64 !        12.64
       0.50 !       13.50 !       12.32 !        12.32

LOCOMOTIVE (0.00 + 45.02 + 0.00) = 45.02 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  52.53  -5.64   0.00   0.00   0.00  -3.27  43.62*
   -90     90   0.22  52.53  -6.91  -0.60   0.00   0.00   0.00  45.02
----------------------------------------------------------------------

 * Bright Zone !

WHEEL (0.00 + 29.89 + 0.00) = 29.89 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
```

```
---------------------------------------------------------------------
   -90      90    0.00   38.23  -5.64    0.00    0.00    0.00  -4.64   27.94*
   -90      90    0.33   38.23  -7.50   -0.83    0.00    0.00   0.00   29.89
---------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 45.15 dBA

Total Leq All Segments: 45.15 dBA

Results segment # 1: AN Rail (night)
------------------------------------

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+---------------
       4.00 !       13.50 !       12.64 !        12.64
       0.50 !       13.50 !       12.32 !        12.32

LOCOMOTIVE (0.00 + -7.51 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
---------------------------------------------------------------------
   -90      90    0.00    0.00  -5.64    0.00    0.00    0.00  -3.27   -8.91*
   -90      90    0.22    0.00  -6.91   -0.60    0.00    0.00   0.00   -7.51
---------------------------------------------------------------------

 * Bright Zone !

WHEEL (0.00 + -8.34 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
---------------------------------------------------------------------
   -90      90    0.00    0.00  -5.64    0.00    0.00    0.00  -4.64 -10.29*
   -90      90    0.33    0.00  -7.50   -0.83    0.00    0.00   0.00   -8.34
---------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 45.15
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 06-03-2024 09:26:29
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  50.00 / 50.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      2       (Flat/gentle slope; with barrier)
No Whistle
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  12.00 m
Barrier receiver distance :   8.00 / 8.00   m
Source elevation          :   0.00 m
Receiver elevation        :   0.00 m
Barrier elevation         :   0.00 m
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       4.00 !       13.50 !       11.98 !        11.98
       0.50 !       13.50 !       11.42 !        11.42

LOCOMOTIVE (0.00 + 42.30 + 0.00) = 42.30 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  52.53  -5.23   0.00   0.00   0.00  -5.00  42.30
----------------------------------------------------------------------

WHEEL (0.00 + 27.29 + 0.00) = 27.29 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  38.23  -5.23   0.00   0.00   0.00  -5.71  27.29
----------------------------------------------------------------------
```

```
Segment Leq : 42.43 dBA

Total Leq All Segments: 42.43 dBA

Results segment # 1: AN Rail (night)
------------------------------------

Barrier height for grazing incidence
------------------------------------
Source      ! Receiver    ! Barrier     ! Elevation of
Height  (m) ! Height  (m) ! Height  (m) ! Barrier Top  (m)
------------+-------------+-------------+--------------
       4.00 !       13.50 !       11.98 !        11.98
       0.50 !       13.50 !       11.42 !        11.42

LOCOMOTIVE (0.00 + -10.23 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00   0.00  -5.23   0.00   0.00   0.00  -5.00 -10.23
----------------------------------------------------------------------

WHEEL (0.00 + -10.94 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00   0.00  -5.23   0.00   0.00   0.00  -5.71 -10.94
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 42.43
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 31-01-2024 16:31:55
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2            : -90.00 deg   -29.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   :  81.00 / 81.00  m
Receiver height            :  13.50 / 13.50  m
Topography                 :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle            :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 37.97 + 0.00) = 37.97 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90    -29   0.22  52.53  -8.97  -5.59   0.00   0.00   0.00  37.97
----------------------------------------------------------------------

WHEEL (0.00 + 22.53 + 0.00) = 22.53 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90    -29   0.33  38.23  -9.74  -5.96   0.00   0.00   0.00  22.53
----------------------------------------------------------------------

Segment Leq : 38.09 dBA

Total Leq All Segments: 38.09 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -14.56 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90    -29   0.22   0.00  -8.97  -5.59   0.00   0.00   0.00 -14.56
----------------------------------------------------------------------
```

```
WHEEL (0.00 + -15.70 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90    -29   0.33   0.00  -9.74  -5.96   0.00   0.00   0.00 -15.70
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 38.09
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 31-01-2024 16:33:34
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train             ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type              !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -90.00 deg   61.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  56.00 / 56.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 44.32 + 0.00) = 44.32 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     61   0.22  52.53  -7.01  -1.20   0.00   0.00   0.00  44.32
----------------------------------------------------------------------

WHEEL (0.00 + 29.24 + 0.00) = 29.24 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     61   0.33  38.23  -7.61  -1.37   0.00   0.00   0.00  29.24
----------------------------------------------------------------------

Segment Leq : 44.45 dBA

Total Leq All Segments: 44.45 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -8.21 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     61   0.22   0.00  -7.01  -1.20   0.00   0.00   0.00  -8.21
----------------------------------------------------------------------
```

```
WHEEL (0.00 + -8.98 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     61   0.33   0.00  -7.61  -1.37   0.00   0.00   0.00  -8.98
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 44.45
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 31-01-2024 16:33:15
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

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

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -90.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  43.00 / 43.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 46.33 + 0.00) = 46.33 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.22  52.53  -5.60  -0.60   0.00   0.00   0.00  46.33
----------------------------------------------------------------------

WHEEL (0.00 + 31.31 + 0.00) = 31.31 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.33  38.23  -6.08  -0.83   0.00   0.00   0.00  31.31
----------------------------------------------------------------------

Segment Leq : 46.46 dBA

Total Leq All Segments: 46.46 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -6.20 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.22   0.00  -5.60  -0.60   0.00   0.00   0.00  -6.20
----------------------------------------------------------------------
```

```
WHEEL (0.00 + -6.92 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.33   0.00  -6.08  -0.83   0.00   0.00   0.00  -6.92
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 46.46
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 31-01-2024 16:34:19
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r6.te                Time Period: Day/Night 16/8 hours
Description:

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -29.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  49.00 / 49.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 43.98 + 0.00) = 43.98 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.22  52.53  -6.30  -2.25   0.00   0.00   0.00  43.98
----------------------------------------------------------------------

WHEEL (0.00 + 28.96 + 0.00) = 28.96 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.33  38.23  -6.84  -2.43   0.00   0.00   0.00  28.96
----------------------------------------------------------------------

Segment Leq : 44.11 dBA

Total Leq All Segments: 44.11 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -8.55 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.22   0.00  -6.30  -2.25   0.00   0.00   0.00  -8.55
----------------------------------------------------------------------
```

```
WHEEL (0.00 + -9.27 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.33   0.00  -6.84  -2.43   0.00   0.00   0.00  -9.27
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 44.11
                         (NIGHT):  0.00
```

```
STAMSON 5.0         NORMAL REPORT        Date: 31-01-2024 16:34:43
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r7.te                    Time Period: Day/Night 16/8 hours
Description:

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains      ! Speed !# loc !# Cars! Eng  !Cont
Type             !             !(km/h) !/Train!/Train! type !weld
-----------------+-------------+-------+------+------+------+----
  1. Train       !   2.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!  No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  85.00 / 85.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
No Whistle
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 39.69 + 0.00) = 39.69 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.22  52.53  -9.23  -3.61   0.00   0.00   0.00  39.69
----------------------------------------------------------------------

WHEEL (0.00 + 24.36 + 0.00) = 24.36 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.33  38.23 -10.02  -3.85   0.00   0.00   0.00  24.36
----------------------------------------------------------------------

Segment Leq : 39.82 dBA

Total Leq All Segments: 39.82 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -12.84 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.22   0.00  -9.23  -3.61   0.00   0.00   0.00 -12.84
----------------------------------------------------------------------
```

```
WHEEL (0.00 + -13.86 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.33   0.00 -10.02  -3.85   0.00   0.00   0.00 -13.86
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 39.82
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 05-02-2024 10:34:02
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r5w.te                  Time Period: Day/Night 16/8 hours
Description: WHISTLE

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train             ! Trains       ! Trains       ! Speed !# loc !# Cars! Eng
!Cont
Type              !  (Left)      !  (Right)     !(km/h) !/Train!/Train! type
!weld
-----------------+-------------+-------------+--------+------+------+------+--
--
  1. Train       !   1.0/0.0   !   1.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!
No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2            : -90.00 deg   90.00 deg
Wood depth                 :      0       (No woods.)
No of house rows           :      0 / 0
Surface                    :      1       (Absorptive ground surface)
Receiver source distance   :  43.00 / 43.00  m
Receiver height            :  13.50 / 13.50  m
Topography                 :      1       (Flat/gentle slope; no barrier)
Whistle Angle              :     86 deg   Track 1
Reference angle            :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 46.33 + 0.00) = 46.33 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.22  52.53  -5.60  -0.60   0.00   0.00   0.00  46.33
----------------------------------------------------------------------

WHEEL (0.00 + 31.31 + 0.00) = 31.31 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.33  38.23  -6.08  -0.83   0.00   0.00   0.00  31.31
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 48.10 + 0.00) = 48.10 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
    79     86   0.22  69.62  -5.60 -15.91   0.00   0.00   0.00  48.10
----------------------------------------------------------------------

RIGHT WHISTLE (0.00 + 40.61 + 0.00) = 40.61 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
```

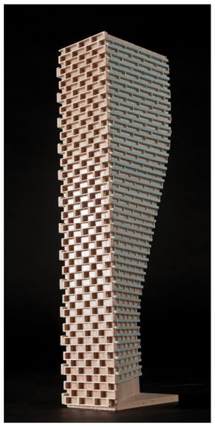
```
    86      88    0.22   69.62   -5.60 -23.41    0.00    0.00    0.00   40.61
----------------------------------------------------------------------

Segment Leq : 50.81 dBA

Total Leq All Segments: 50.81 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -6.20 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      90    0.22    0.00   -5.60  -0.60    0.00    0.00    0.00   -6.20
----------------------------------------------------------------------

WHEEL (0.00 + -6.92 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      90    0.33    0.00   -6.08  -0.83    0.00    0.00    0.00   -6.92
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 48.10 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
    79      86    0.22    0.00   -5.60 -15.91    0.00    0.00    0.00   48.10
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 50.81
                          (NIGHT):  0.00
```

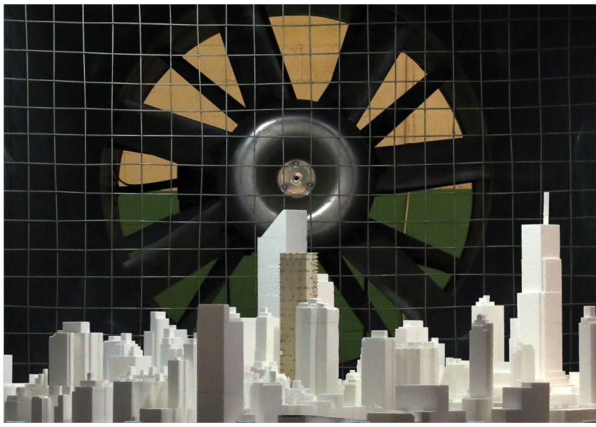
```
STAMSON 5.0        NORMAL REPORT        Date: 05-02-2024 10:34:38
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r6w.te                  Time Period: Day/Night 16/8 hours
Description: WHISTLE

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train             ! Trains       ! Trains       ! Speed !# loc !# Cars! Eng
!Cont
Type              !  (Left)      !  (Right)     !(km/h) !/Train!/Train! type
!weld
-----------------+-------------+-------------+--------+------+------+------+--
--
  1. Train        !   1.0/0.0    !   1.0/0.0    !  16.0 !  1.0 !  6.0 !Diesel!
No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           : -29.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  49.00 / 49.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
Whistle Angle             :     80 deg   Track 1
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 43.98 + 0.00) = 43.98 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.22  52.53  -6.30  -2.25   0.00   0.00   0.00  43.98
----------------------------------------------------------------------

WHEEL (0.00 + 28.96 + 0.00) = 28.96 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     90   0.33  38.23  -6.84  -2.43   0.00   0.00   0.00  28.96
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 60.84 + 0.00) = 60.84 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29     80   0.22  69.62  -6.30  -2.48   0.00   0.00   0.00  60.84
----------------------------------------------------------------------

RIGHT WHISTLE (0.00 + 46.38 + 0.00) = 46.38 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
```

```
    80      86   0.22  69.62  -6.30 -16.94   0.00   0.00   0.00  46.38
----------------------------------------------------------------------

Segment Leq : 61.08 dBA

Total Leq All Segments: 61.08 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -8.55 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29      90   0.22   0.00  -6.30  -2.25   0.00   0.00   0.00  -8.55
----------------------------------------------------------------------

WHEEL (0.00 + -9.27 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29      90   0.33   0.00  -6.84  -2.43   0.00   0.00   0.00  -9.27
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 60.84 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -29      80   0.22   0.00  -6.30  -2.48   0.00   0.00   0.00  60.84
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 61.08
                         (NIGHT):  0.00
```

```
STAMSON 5.0        NORMAL REPORT        Date: 05-02-2024 10:35:00
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r7w.te                    Time Period: Day/Night 16/8 hours
Description: WHISTLE

Rail data, segment # 1: AN Rail (day/night)
-------------------------------------------
Train            ! Trains       ! Trains       ! Speed !# loc !# Cars! Eng
!Cont
Type             !  (Left)      !  (Right)     !(km/h) !/Train!/Train! type
!weld
-----------------+-------------+-------------+--------+------+------+------+--
--
  1. Train       !   1.0/0.0   !   1.0/0.0   !  16.0 !  1.0 !  6.0 !Diesel!
No

Data for Segment # 1: AN Rail (day/night)
-----------------------------------------
Angle1   Angle2           :   0.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      1       (Absorptive ground surface)
Receiver source distance  :  85.00 / 85.00  m
Receiver height           :  13.50 / 13.50  m
Topography                :      1       (Flat/gentle slope; no barrier)
Whistle Angle             :     75 deg   Track 1
Reference angle           :   0.00

Results segment # 1: AN Rail (day)
----------------------------------

LOCOMOTIVE (0.00 + 39.69 + 0.00) = 39.69 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.22  52.53  -9.23  -3.61   0.00   0.00   0.00  39.69
----------------------------------------------------------------------

WHEEL (0.00 + 24.36 + 0.00) = 24.36 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.33  38.23 -10.02  -3.85   0.00   0.00   0.00  24.36
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 56.25 + 0.00) = 56.25 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     75   0.22  69.62  -9.23  -4.14   0.00   0.00   0.00  56.25
----------------------------------------------------------------------

RIGHT WHISTLE (0.00 + 45.35 + 0.00) = 45.35 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
```

```
    75     83   0.22  69.62  -9.23 -15.04   0.00   0.00   0.00  45.35
----------------------------------------------------------------------

Segment Leq : 56.68 dBA

Total Leq All Segments: 56.68 dBA

Results segment # 1: AN Rail (night)
------------------------------------

LOCOMOTIVE (0.00 + -12.84 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.22   0.00  -9.23  -3.61   0.00   0.00   0.00 -12.84
----------------------------------------------------------------------

WHEEL (0.00 + -13.86 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     90   0.33   0.00 -10.02  -3.85   0.00   0.00   0.00 -13.86
----------------------------------------------------------------------

LEFT WHISTLE (0.00 + 56.25 + 0.00) = 0.00 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     0     75   0.22   0.00  -9.23  -4.14   0.00   0.00   0.00  56.25
----------------------------------------------------------------------

Segment Leq : 0.00 dBA

Total Leq All Segments: 0.00 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 56.68
                         (NIGHT):  0.00
```





APPENDIX B

FTA VIBRATION CALCULATIONS

127 WALGREEN ROAD, OTTAWA, ON, CANADA K0A 1L0 | 613 836 0934
GRADIENTWIND.COM

GW20-123 01-Feb-24

Possible Vibration Impacts
Predicted using FTA General Assesment

Train Speed 16 km/h 9.94 mph

	Distance from C/L	
	(m)	(ft)
Nylene	43.0	141.1

Vibration

From FTA Manual Fig 10-1

Vibration Levels at distance from track	75	dBV re 1 micro in/sec

Adjustment Factors FTA Table 10-1

Speed reference 50 mph	-14	Speed Limit of 16 km/h (9.94 mph)
Vehicle Parameters	0	Assume Soft primary suspension, Weels run true
Track Condition	5	Assume Jointed Track
Track Treatments	0	None
Type of Transit Structure	0	None
Efficient vibration Propagation	0	None
Vibration Levels at Fdn	66	
Coupling to Building Foundation	-10	3-4 storey masonry
Floor to Floor Attenuation	-2.0	Ground Floor Ocupied
Amplification of Floor and Walls	6	
Total Vibration Level	60	dBV or 0.025 mm/s
Noise Level in dBA	25	dBA

Table 6-11 Source Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Source Factor	Adjustment to Propagation Curve			Comment
		Reference Speed		
Speed	Vehicle Speed	50 mph	30 mph	Vibration level is approximately proportional to 20log(speed/speed$_{ref}$), see Eq. 6-4.
	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.
Track Conditions (not additive, apply greatest value only)				
Worn or Corrugated Track	+10 dB			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. If there are adjustments for vehicle parameters and the track is worn or corrugated, only include one adjustment.
Special Trackwork within 200 ft	+10 dB (within 100 ft) +5 dB (between 100 and 200 ft)			Wheel impacts at special trackwork will greatly increase vibration levels. The increase will be less at greater distances from the track. Do not include an adjustment for special trackwork more than 200 ft away.
Jointed Track	+5 dB			Jointed track can cause higher vibration levels than welded track.
Uneven Road Surfaces	+5 dB			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.

*Mill scale on a new rail is a slightly corrugated condition caused by certain steel mill techniques.

Table 6-12 Path Adjustment Factors for Generalized Predictions of GB Vibration and Noise

Path Factor	Adjustment to Propagation Curve		Comment
Resiliently Supported Ties (Low-Vibration Track, LVT)	-10 dB		Resiliently supported tie systems have been found to provide very effective control of low-frequency vibration.
Track Structure (not additive, apply greatest value only)			
Type of Transit Structure	Relative to at-grade tie & ballast:		In general, 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.
	Elevated structure	-10 dB	
	Open cut	0 dB	
	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.	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.
	50 ft	+2 dB	
	100 ft	+4 dB	
	150 ft	+6 dB	
	200 ft	+9 dB	
Coupling to building foundation	Wood-Frame Houses	-5 dB	In general, the heavier the building construction, the greater the coupling loss.
	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	