Transportation Noise & Vibration Assessment

1946 Scott Street

Ottawa, Ontario

REPORT: GWE17-136 – Noise & Vibration

Prepared For:

Michael Martin
Construction Manager
Surface Developments
88 Spadina Avenue
Ottawa, ON K1Y 2C1

Prepared By:

Michael Lafortune, Environmental Scientist
Joshua Foster, P.Eng., Partner
Vincent Ferraro, M.Eng., P.Eng., Managing Principal

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EXECUTIVE SUMMARY

This document describes a transportation noise and vibration assessment performed for a proposed 12-storey condominium development at 1946 Scott Street in Ottawa, Ontario. Upon completion, the development will rise approximately 36.6 metres above local grade. The major sources of transportation noise are Scott Street and the future Light Rail Transit (LRT) line to the north of the development. 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 Project1 Studio Incorporated.

The results of the current analysis indicate that noise levels will range between 50 and 69 dBA during the daytime period (07:00-23:00) and between 42 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 69 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 (see Figure 3).

Results of the calculations also indicate that the development will require central air conditioning (or similar mechanical system), 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.

Noise levels at the rooftop amenity area were calculated to be 52 dBA. Since noise levels are below the ENCG criterion of 55 dBA no mitigation is required.

Estimated vibration levels at the nearest residences are expected to be 0.02 mm/s RMS (57.8 dBV) based on the FTA protocol and an offset distance of 42 metres between the LRT centerline and the nearest foundation edge. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.1 mm/s RMS, vibration mitigation would not be required. As vibration levels are acceptable, correspondingly regenerated noise levels are also expected to acceptable.

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1. INTRODUCTION

Gradient Wind Engineering Inc. (GWE) was retained by Surface Development to undertake a transportation noise and vibration assessment for a proposed 12-storey condominium development to be located at 1946 Scott Street in Ottawa, Ontario. This report summarizes the methodology, results, and recommendations if this assessment according to the scope of work outlined in GWE's proposal #17-199P, dated August 14, 2017. 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 Project1 Studio Incorporated, with future traffic volumes corresponding to the City of Ottawa's Official Plan (OP) roadway classifications. The ground vibration assessment was conducted according to the United States, Federal Transportation Authority (FTA) protocol.

2. TERMS OF REFERENCE

The focus of this transportation noise and vibration assessment is a proposed 12-storey condominium development located southwest of the Scott Street & West Village Private intersection. The major sources of transportation noise are Scott Street and the future Confederation Line Light Rail Transit (LRT) to the north of the development. The site is surrounded on all sides with mixed-use land, specifically commercial and residential. Figure 1 illustrates a complete site plan with surrounding context.

Upon completion, the condominium development will rise approximately 36.6 metres (m) above local grade, comprising of only common areas and dwelling units. Private terraces are located on the 7th floor terrace. These spaces along with balconies are less than 4 m deep and are therefore not considered Outdoor living areas, as per provincial and city guidelines. An outdoor amenity area is however provided on the roof.

[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

3. OBJECTIVES

The main objectives of this work are to: (i) calculate the future noise levels on the study building produced by transportation sources, (ii) provide provisional recommendations to ensure that interior noise 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 45 and 40 dBA for 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 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) 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]. 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[5].

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 classifications outlined in the City of Ottawa's Official Plan (OP) and Transportation Master Plan[6] which provides additional details on future roadway expansions. Average Annual Daily Traffic (AADT) volumes

[3] Adapted from ENCG 2016 – Tables 2.2b and 2.2c
[4] Burberry, P.B. (2014). Mitchell's Environment and Services. Routledge, Page 125
[5] MOECC, Environmental Noise Guidelines, NPC 300 – Part C, Section 7.1.3
[6] City of Ottawa Transportation Master Plan, November 2013

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.

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 Noise Predictions

Noise predictions were performed with the aid of the MOECC computerized noise assessment program, STAMSON 5.04, for road and rail analysis. Noise receptors were strategically identified at 9 locations around the study area, as illustrated in Figure 2. Roadway noise calculations were performed by treating each road 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 2, theoretical noise predictions were based on the following parameters:

- Truck traffic on all roadways was taken to comprise of 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.
- Absorptive and reflective intermediate ground surfaces based on specific source-receiver path ground characteristics.
- Site topography is accounted for in height parameters where applicable.
- Confederation Line LRT modeled as 4-car SRT source in STAMSON
- Surrounding and proposed buildings are in some cases used as barrier when the line of sight between the source and receiver is broken by the buildings.

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 (2012) 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. Curtain wall 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 4.2.1, when daytime noise levels (from road and rail sources) at the plane of the window exceed 65 dBA, calculations must be performed to evaluate the sound transmission quality of the building components to ensure acceptable indoor noise levels. The calculation procedure[7] 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 varies according to the intended use of a space

Based on published research[8], 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 site plan approval, detailed floor layouts and building elevations have not been finalized; 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).

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

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 the 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 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 cosmetic structural damage is (10 mm/s RMS or 112 dBV), at least one hundred times higher than the perception threshold level.

4.4.1 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[9]. These standards indicate that the appropriate criteria for residential buildings are 0.1 mm/s RMS for vibrations. For main line railways, a document titled *Guidelines for New Development in Proximity to Railway Operations*[10] 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 a LRT corridor which has frequent events, the 0.1 mm/s RMS (71 dBV) vibration criteria is used for the subject site.

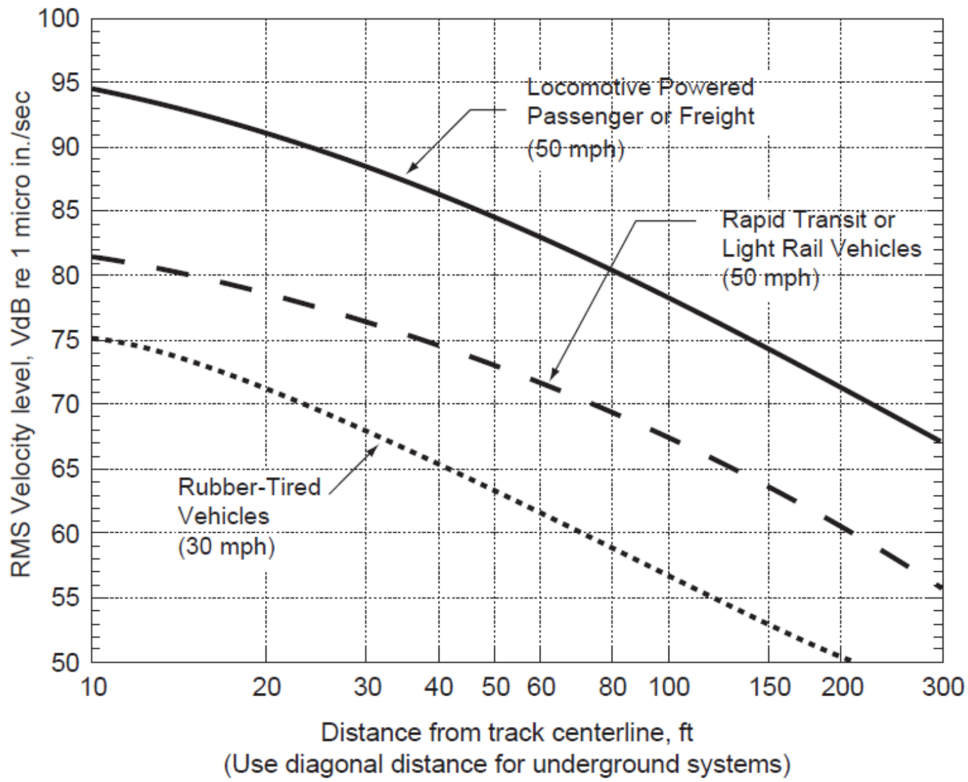
4.4.2 Theoretical Ground Vibration Prediction Procedure

Potential vibration impacts of the future LRT were predicted using the FTA's Transit Noise and Vibration Impact Assessment[11] 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 vehicles, conditions of the track, construction of the track and geology; as well as the structural type of the impacted building structures. Based on the setback distance of the nearest foundation, initial vibration levels were deduced from a curve for LRT trains at 50 miles per hour (mph) (80 km/h).

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

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

[11] 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 Noise Levels

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

TABLE 3: EXTERIOR NOISE LEVELS DUE TO ROAD TRAFFIC

Receptor Number	Plane of Window Receptor Location	Noise Level (dBA)	
		Day	Night
1	Ground Level – East Façade	65	58
2	6th Floor – North Façade	69	61
3	6th Floor – East Façade	65	58
4	8th Floor – North Façade	68	60
5	12th Floor – North Façade	69	61
6	12th Floor – East Façade	64	56
7	12th Floor – South Façade	50	42
8	12th Floor – West Façade	66	59
9	Rooftop Amenity Area	52	45

The results of the current analysis indicate that noise levels will range between 50 and 69 dBA during the daytime period (07:00-23:00) and between 42 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 69 dBA) occurs along the north façade which is nearest and most exposed to Scott Street and the future Confederation Line LRT.

Noise levels at the rooftop amenity area were calculated to be 52 dBA. Since noise levels are below the ENCG criterion of 55 dBA no mitigation is required.

5.2 Noise Control Measures

The noise levels predicted due to roadway traffic exceed the criteria listed in Section 4.2.1 for building components. 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). As per city of Ottawa requirements, detailed STC calculations will be required to be completed prior to building permit application for each unit type. The STC requirements for the windows are summarized below for various units within the development (see Figure 3):

- **Bedroom Windows**

(i) Bedroom windows facing north will require a minimum STC of 32

(ii) Bedroom windows facing west will require a minimum STC of 29

(iii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2012) requirements

- **Living Room Windows**

(i) Living room windows facing north will require a minimum STC of 27

(ii) Living room windows facing west will require a minimum STC of 24

(iii) All other bedroom windows are to satisfy Ontario Building Code (OBC 2012) requirements

- **Exterior Walls**

(i) Exterior wall components on these façades are recommended to have a minimum STC of 45, where a window / wall system is used. Wall assemblies meeting STC 45 would include steel stud walls a minimum of 92 mm deep filled with batt insulation, exterior dense glass sheeting, and 16 mm gypsum board on either inside

The STC requirements would 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 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. The two-storey existing heritage building will make use of the as-built wall and window assemblies, and is assumed to conform to the ENCG for retail and office use.

Results of the calculations also indicate that the development will require central air conditioning (or similar mechanical system), which will allow occupants to keep windows closed and maintain a comfortable living environment. In addition to ventilation requirements, Warning Clauses will also be required be placed on all Lease, Purchase and Sale Agreements, as summarized in Section 6.

5.3 Ground Vibrations & Ground-borne Noise Levels

Estimated vibration levels at the nearest residences are expected to be 0.02 mm/s RMS (57.8 dBV) based on the FTA protocol and an offset distance of 42 metres between the railway centerline and the nearest foundation edge. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.1 mm/s RMS, vibration mitigation would not be required. As vibration levels are acceptable, correspondingly regenerated noise levels are also expected to acceptable.

6. CONCLUSIONS AND RECOMMENDATIONS

The results of the current analysis indicate that noise levels will range between 50 and 69 dBA during the daytime period (07:00-23:00) and between 42 and 61 dBA during the nighttime period (23:00-07:00). The highest noise level (i.e. 69 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 (see Figure 3).

Results of the calculations also indicate that the development will require central air conditioning (or similar mechanical system), which will allow occupants to keep windows closed and maintain a comfortable living environment. The following Warning Clause[12] will also be required be placed on all Lease, Purchase and Sale Agreements, as summarized below:

> *"Purchasers/tenants are advised that despite the inclusion of noise control features in the development and within the building units, sound levels due to increasing roadway traffic may, on occasion, interfere with some activities of the dwelling occupants as the sound levels exceed the sound level limits of the City and the Ministry of the Environment and Climate Change. To help address the need for sound attenuation, this development includes:*
>
> - *STC rated multi-pane glazing elements and spandrel panels*
>   - *North façade bedroom/living room: STC 32/27 respectively*
>   - *West façade bedroom/living room: STC 29/24 respectively*
> - *STC rated exterior walls*
>   - *North and west façade: STC 45*
>
> *This dwelling unit has also been designed with air conditioning (or similar mechanical system). Air conditioning will allow windows and exterior doors to remain closed, thereby ensuring that the indoor sound levels are within the sound level limits of the City and the Ministry of the Environment and Climate Change.*

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

To ensure that provincial sound level limits are not exceeded, it is important to maintain these sound attenuation features."

Noise levels at the rooftop amenity area were calculated to be 52 dBA. Since noise levels are below the ENCG criterion of 55 dBA no mitigation is required.

Estimated vibration levels at the nearest residences are expected to be 0.02 mm/s RMS (57.8 dBV) based on the FTA protocol and an offset distance of 42 metres between the railway centerline and the nearest foundation edge. Details of the calculation are provided in Appendix B. Since predicted vibration levels do not exceed the criterion of 0.1 mm/s RMS, vibration mitigation would not be required. As vibration levels are acceptable, correspondingly regenerated noise levels are also expected to acceptable.

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.

Sincerely,

Gradient Wind Engineering Inc.

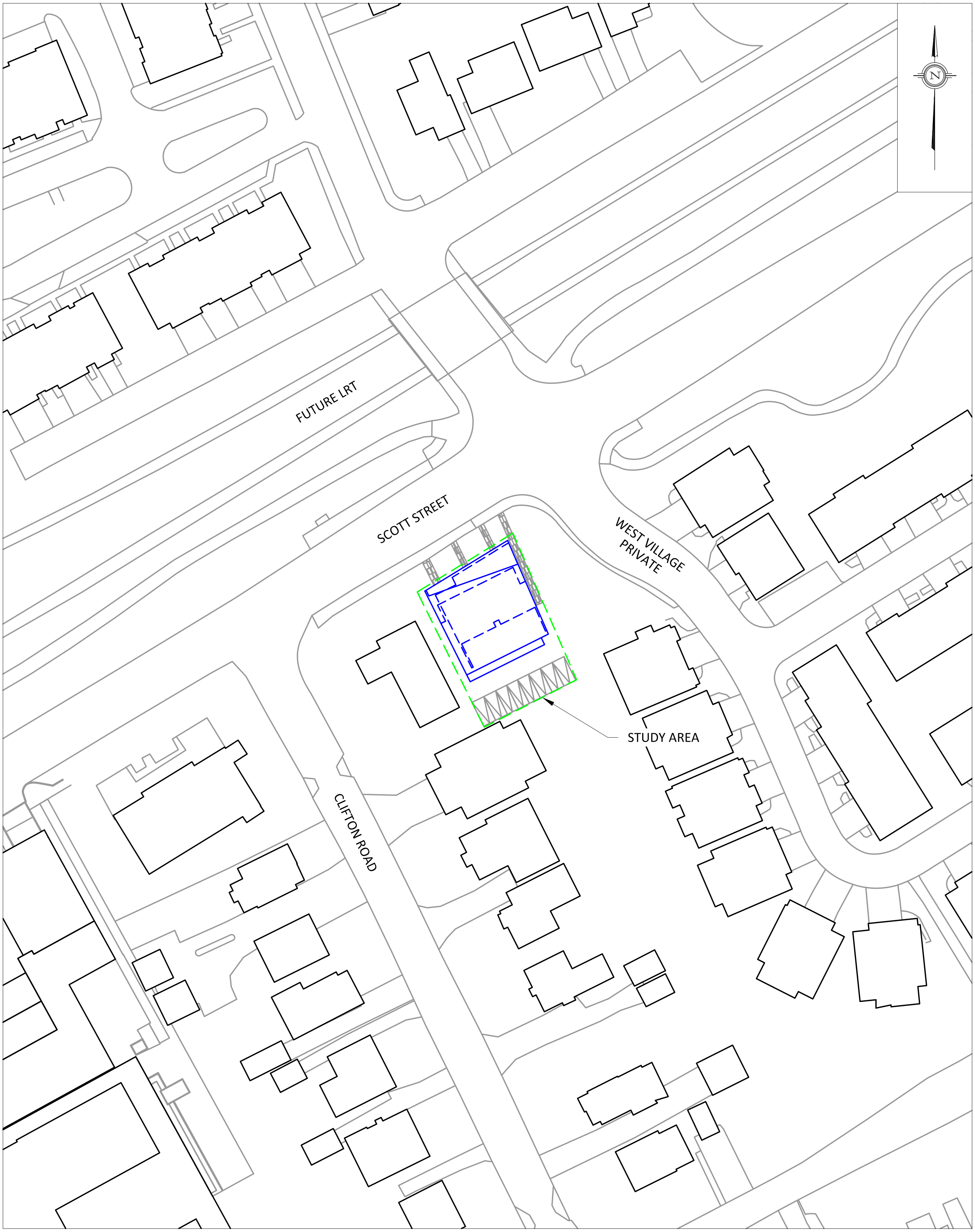
Michael Lafortune
Environmental Scientist

Joshua Foster, P.Eng.
Partner

LICENSED PROFESSIONAL ENGINEER
V. M. FERRARO
PROVINCE OF ONTARIO
AUG 25 2017

Vincent Ferraro, M.Eng., P.Eng.
Managing Principal

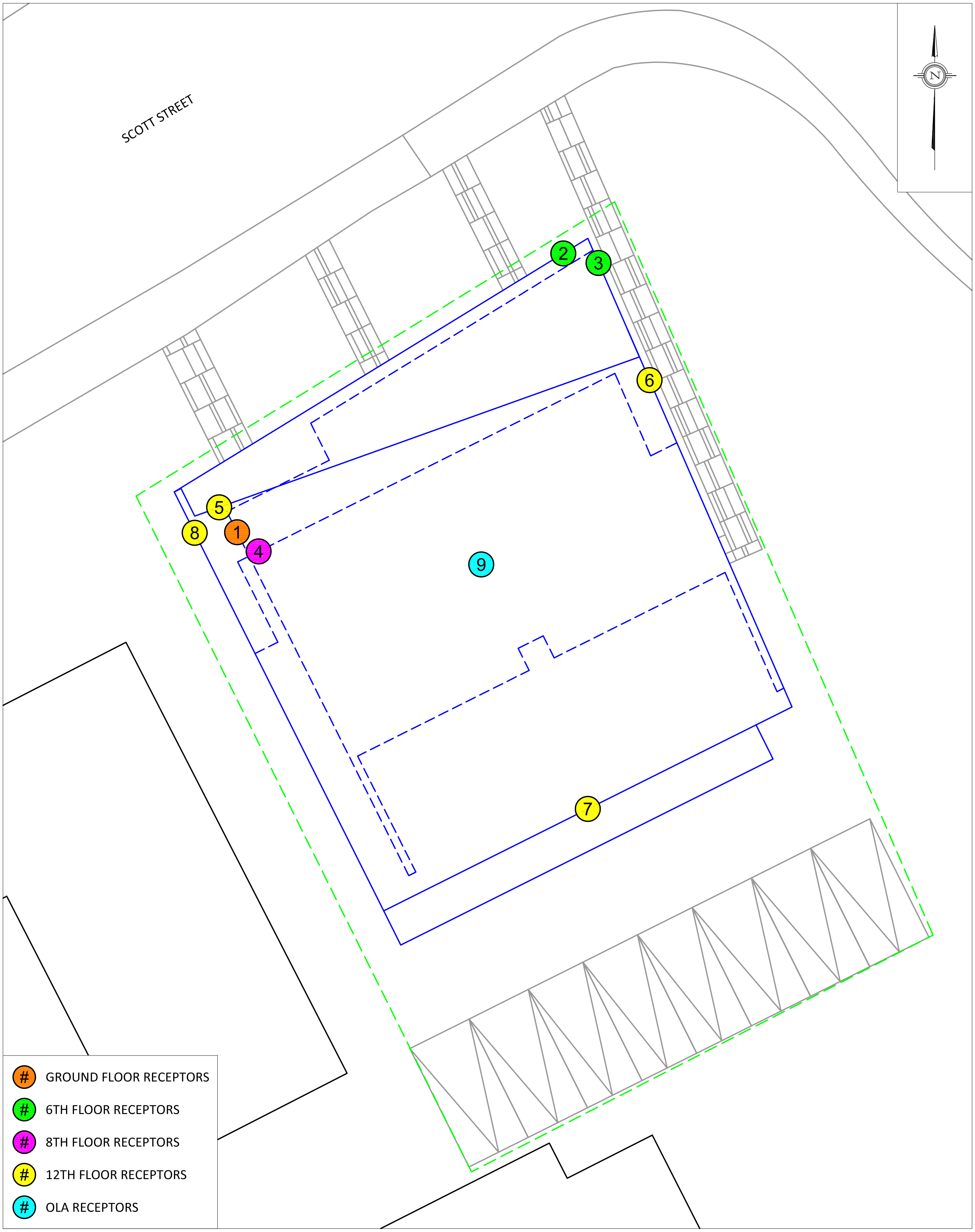
GWE17-136 – Noise & Vibration



127 Walgreen Road
Ottawa, Ontario
(613) 836 0934

GWE GRADIENTWIND ENGINEERING INC

PROJECT: 1946 SCOTT STREET, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		DESCRIPTION: FIGURE 1: SITE PLAN AND SURROUNDING CONTEXT
SCALE: 1:1000 (APPROX.)	DRAWING NO.: GWE17-136-1	
DATE: AUGUST 24, 2017	DRAWN BY: M.L	



127 Walgreen Road
Ottawa, Ontario
(613) 836 0934
GRADIENT WIND ENGINEERING INC

PROJECT		DESCRIPTION
1946 SCOTT STREET, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		FIGURE 2: RECEPTOR LOCATIONS
SCALE: 1:200 (APPROX.)	DRAWING NO.: GWE17-136-2	
DATE: AUGUST 24, 2017	DRAWN BY: M.L	

127 Walgreen Road
Ottawa, Ontario
(613) 836 0934
GRADIENT WIND ENGINEERING INC

PROJECT		DESCRIPTION
1946 SCOTT STREET, OTTAWA TRANSPORTATION NOISE AND VIBRATION ASSESSMENT		FIGURE 3: WINDOW STC REQUIREMENTS
SCALE: 1:200 (APPROX.)	DRAWING NO.: GWE17-136-3	
DATE: AUGUST 24, 2017	DRAWN BY: M.L	

APPENDIX A

STAMSON 5.04 - INPUT AND OUTPUT DATA

```
STAMSON 5.0        NORMAL REPORT        Date: 18-08-2017 13:09:11
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   5.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  16.00 / 16.00  m
Receiver height           :   1.50 / 1.50   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 + 65.42 + 0.00) = 65.42 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      5   0.00  68.48   0.00  -0.28  -2.78   0.00   0.00   0.00  65.42
----------------------------------------------------------------------------

Segment Leq : 65.42 dBA

Total Leq All Segments: 65.42 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 57.83 + 0.00) = 57.83 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      5   0.00  60.88   0.00  -0.28  -2.78   0.00   0.00   0.00  57.83
----------------------------------------------------------------------------

Segment Leq : 57.83 dBA

Total Leq All Segments: 57.83 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   5.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  44.00 / 44.00  m
Receiver height           :   1.50 / 1.50   m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 5.00 deg
Barrier height            :   6.00 m
Barrier receiver distance :  38.00 / 38.00  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 !        1.50 !        1.45 !        -4.55

RT/Custom (0.00 + 40.67 + 0.00) = 40.67 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  63.44  -4.67  -2.78   0.00   0.00 -15.31  40.67
----------------------------------------------------------------------

Segment Leq : 40.67 dBA

Total Leq All Segments: 40.67 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 !        1.50 !        1.45 !        -4.55

RT/Custom (0.00 + 34.14 + 0.00) = 34.14 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  56.91  -4.67  -2.78   0.00   0.00 -15.31  34.14
----------------------------------------------------------------------

Segment Leq : 34.14 dBA

Total Leq All Segments: 34.14 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 65.43
                         (NIGHT): 57.85
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:17
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           : -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  :  15.00 / 15.00  m
Receiver height           :  17.10 / 17.10  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 + 68.48 + 0.00) = 68.48 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   0.00   0.00   0.00   0.00   0.00  68.48
----------------------------------------------------------------------------

Segment Leq : 68.48 dBA

Total Leq All Segments: 68.48 dBA


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

Source height = 1.50 m

ROAD (0.00 + 60.88 + 0.00) = 60.88 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   0.00   0.00   0.00   0.00   0.00  60.88
----------------------------------------------------------------------------

Segment Leq : 60.88 dBA

Total Leq All Segments: 60.88 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  :  42.00 / 42.00  m
Receiver height           :  17.10 / 17.10  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 :  35.00 / 35.00  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 !       17.10 !        4.27 !        -1.73

RT/Custom (0.00 + 50.57 + 0.00) = 50.57 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -4.47   0.00   0.00   0.00  -8.39  50.57
----------------------------------------------------------------------

Segment Leq : 50.57 dBA

Total Leq All Segments: 50.57 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 !       17.10 !        4.27 !        -1.73

RT/Custom (0.00 + 44.04 + 0.00) = 44.04 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -4.47   0.00   0.00   0.00  -8.39  44.04
----------------------------------------------------------------------

Segment Leq : 44.04 dBA

Total Leq All Segments: 44.04 dBA



TOTAL Leq FROM ALL SOURCES (DAY): 68.55
                         (NIGHT): 60.97
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:22
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           :   8.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  15.00 / 15.00  m
Receiver height           :  17.10 / 17.10  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 + 65.07 + 0.00) = 65.07 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     8     90   0.00  68.48   0.00   0.00  -3.41   0.00   0.00   0.00  65.07
----------------------------------------------------------------------------

Segment Leq : 65.07 dBA

Total Leq All Segments: 65.07 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 57.47 + 0.00) = 57.47 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
---------------------------------------------------------------------------
     8     90   0.00  60.88   0.00   0.00  -3.41   0.00   0.00   0.00  57.47
---------------------------------------------------------------------------

Segment Leq : 57.47 dBA

Total Leq All Segments: 57.47 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           :   8.00 deg   90.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  43.00 / 43.00  m
Receiver height           :  17.10 / 17.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :   8.00 deg   Angle2 : 90.00 deg
Barrier height            :   6.00 m
Barrier receiver distance :  37.00 / 37.00  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 !       17.10 !        3.65 !        -2.35

RT/Custom (0.00 + 45.52 + 0.00) = 45.52 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     8     90   0.00  63.44  -4.57  -3.41   0.00   0.00  -9.93  45.52
----------------------------------------------------------------------

Segment Leq : 45.52 dBA

Total Leq All Segments: 45.52 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 !       17.10 !        3.65 !        -2.35

RT/Custom (0.00 + 38.99 + 0.00) = 38.99 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     8     90   0.00  56.91  -4.57  -3.41   0.00   0.00  -9.93  38.99
----------------------------------------------------------------------

Segment Leq : 38.99 dBA

Total Leq All Segments: 38.99 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 65.12
                         (NIGHT): 57.53
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:27
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   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           :  23.10 / 23.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  18.60 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 !       23.10 !       19.29 !        19.29

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  -4.23  63.71*
   -90     90   0.00  68.48   0.00  -0.54   0.00   0.00   0.00   0.00  67.94
----------------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 67.94 dBA

Total Leq All Segments: 67.94 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 !       23.10 !       19.29 !        19.29

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  -4.23  56.11*
   -90     90   0.00  60.88   0.00  -0.54   0.00   0.00   0.00   0.00  60.34
----------------------------------------------------------------------------

 * Bright Zone !

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  :  45.00 / 45.00  m
Receiver height           :  23.10 / 23.10  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 :  38.00 / 38.00  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 !       23.10 !        4.95 !        -1.05

RT/Custom (0.00 + 52.19 + 0.00) = 52.19 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -4.77   0.00   0.00   0.00  -6.48  52.19
----------------------------------------------------------------------

Segment Leq : 52.19 dBA

Total Leq All Segments: 52.19 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 !       23.10 !        4.95 !        -1.05

RT/Custom (0.00 + 45.66 + 0.00) = 45.66 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -4.77   0.00   0.00   0.00  -6.48  45.66
----------------------------------------------------------------------

Segment Leq : 45.66 dBA

Total Leq All Segments: 45.66 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 68.05
                         (NIGHT): 60.49
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:32
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  :  15.00 / 15.00  m
Receiver height           :  35.10 / 35.10  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 + 68.48 + 0.00) = 68.48 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   0.00   0.00   0.00   0.00   0.00  68.48
----------------------------------------------------------------------------

Segment Leq : 68.48 dBA

Total Leq All Segments: 68.48 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 60.88 + 0.00) = 60.88 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   0.00   0.00   0.00   0.00   0.00  60.88
----------------------------------------------------------------------------

Segment Leq : 60.88 dBA

Total Leq All Segments: 60.88 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  :  43.00 / 43.00  m
Receiver height           :  35.10 / 35.10  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 :  37.00 / 37.00  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 !       35.10 !        6.17 !         0.17

RT/Custom (0.00 + 58.86 + 0.00) = 58.86 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -4.57   0.00   0.00   0.00  -4.97  53.90*
   -90     90   0.00  63.44  -4.57   0.00   0.00   0.00   0.00  58.86
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 58.86 dBA

Total Leq All Segments: 58.86 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 !       35.10 !        6.17 !         0.17

RT/Custom (0.00 + 52.33 + 0.00) = 52.33 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -4.57   0.00   0.00   0.00  -4.97  47.37*
   -90     90   0.00  56.91  -4.57   0.00   0.00   0.00   0.00  52.33
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 52.33 dBA

Total Leq All Segments: 52.33 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 68.93
                         (NIGHT): 61.45
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:37
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r6.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           :   8.00 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           :  35.10 / 35.10  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 + 63.82 + 0.00) = 63.82 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     8     90   0.00  68.48   0.00  -1.25  -3.41   0.00   0.00   0.00  63.82
----------------------------------------------------------------------------

Segment Leq : 63.82 dBA

Total Leq All Segments: 63.82 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 56.22 + 0.00) = 56.22 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
     8     90   0.00  60.88   0.00  -1.25  -3.41   0.00   0.00   0.00  56.22
----------------------------------------------------------------------------

Segment Leq : 56.22 dBA

Total Leq All Segments: 56.22 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           :   8.00 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           :  35.10 / 35.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            :   8.00 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 !       35.10 !        5.57 !        -0.43

RT/Custom (0.00 + 49.74 + 0.00) = 49.74 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     8     90   0.00  63.44  -5.05  -3.41   0.00   0.00  -5.23  49.74
----------------------------------------------------------------------

Segment Leq : 49.74 dBA

Total Leq All Segments: 49.74 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 !       35.10 !        5.57 !        -0.43

RT/Custom (0.00 + 43.21 + 0.00) = 43.21 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
     8     90   0.00  56.91  -5.05  -3.41   0.00   0.00  -5.23  43.21
----------------------------------------------------------------------

Segment Leq : 43.21 dBA

Total Leq All Segments: 43.21 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 63.99
                         (NIGHT): 56.43
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:42
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r7.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  :  35.00 / 35.00  m
Receiver height           :  35.10 / 35.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  36.60 m
Barrier receiver distance :   1.00 / 1.00   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 !       35.10 !       34.14 !        34.14

ROAD (0.00 + 48.77 + 0.00) = 48.77 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  -3.68   0.00   0.00   0.00 -16.03  48.77
----------------------------------------------------------------------------

Segment Leq : 48.77 dBA

Total Leq All Segments: 48.77 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 !       35.10 !       34.14 !        34.14

ROAD (0.00 + 41.18 + 0.00) = 41.18 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  -3.68   0.00   0.00   0.00 -16.03  41.18
----------------------------------------------------------------------------

Segment Leq : 41.18 dBA

Total Leq All Segments: 41.18 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   :  63.00 / 63.00  m
Receiver height            :  35.10 / 35.10  m
Topography                 :      2       (Flat/gentle slope; with barrier)
Barrier angle1             : -90.00 deg   Angle2 : 90.00 deg
Barrier height             :  36.60 m
Barrier receiver distance  :   1.00 / 1.00   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 !       35.10 !       34.46 !        34.46

RT/Custom (0.00 + 41.70 + 0.00) = 41.70 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  63.44  -6.23   0.00   0.00   0.00 -15.51  41.70
----------------------------------------------------------------------

Segment Leq : 41.70 dBA

Total Leq All Segments: 41.70 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 !       35.10 !       34.46 !        34.46

RT/Custom (0.00 + 35.17 + 0.00) = 35.17 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90     90   0.00  56.91  -6.23   0.00   0.00   0.00 -15.51  35.17
----------------------------------------------------------------------

Segment Leq : 35.17 dBA

Total Leq All Segments: 35.17 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 49.55
                         (NIGHT): 42.15
```

```
STAMSON 5.0        NORMAL REPORT        Date: 17-08-2017 11:11:49
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r8.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   5.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  15.00 / 15.00  m
Receiver height           :  35.10 / 35.10  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 + 65.70 + 0.00) = 65.70 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      5   0.00  68.48   0.00   0.00  -2.78   0.00   0.00   0.00  65.70
----------------------------------------------------------------------------

Segment Leq : 65.70 dBA

Total Leq All Segments: 65.70 dBA
```

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

Source height = 1.50 m

ROAD (0.00 + 58.11 + 0.00) = 58.11 dBA
Angle1 Angle2  Alpha RefLeq  P.Adj  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------------
   -90      5   0.00  60.88   0.00   0.00  -2.78   0.00   0.00   0.00  58.11
----------------------------------------------------------------------------

Segment Leq : 58.11 dBA

Total Leq All Segments: 58.11 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   5.00 deg
Wood depth                :      0       (No woods.)
No of house rows          :      0 / 0
Surface                   :      2       (Reflective ground surface)
Receiver source distance  :  43.00 / 43.00  m
Receiver height           :  35.10 / 35.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 5.00 deg
Barrier height            :   6.00 m
Barrier receiver distance :  37.00 / 37.00  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 !       35.10 !        6.17 !         0.17

RT/Custom (0.00 + 56.09 + 0.00) = 56.09 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  63.44  -4.57  -2.78   0.00   0.00  -4.96  51.12*
   -90      5   0.00  63.44  -4.57  -2.78   0.00   0.00   0.00  56.09
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 56.09 dBA

Total Leq All Segments: 56.09 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 !       35.10 !        6.17 !         0.17

RT/Custom (0.00 + 49.56 + 0.00) = 49.56 dBA
Angle1 Angle2  Alpha RefLeq  D.Adj  F.Adj  W.Adj  H.Adj  B.Adj SubLeq
----------------------------------------------------------------------
   -90      5   0.00  56.91  -4.57  -2.78   0.00   0.00  -4.96  44.59*
   -90      5   0.00  56.91  -4.57  -2.78   0.00   0.00   0.00  49.56
----------------------------------------------------------------------

 * Bright Zone !

Segment Leq : 49.56 dBA

Total Leq All Segments: 49.56 dBA

TOTAL Leq FROM ALL SOURCES (DAY): 66.15
                         (NIGHT): 58.68
```

```
STAMSON 5.0        NORMAL REPORT        Date: 24-08-2017 15:45:32
MINISTRY OF ENVIRONMENT AND ENERGY / NOISE ASSESSMENT

Filename: r9.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  :  23.00 / 23.00  m
Receiver height           :  38.10 / 38.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  36.60 m
Barrier receiver distance :   6.00 / 6.00   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 !       38.10 !       28.55 !        28.55

ROAD (0.00 + 50.86 + 0.00) = 50.86 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  -1.86   0.00   0.00   0.00 -15.76  50.86
----------------------------------------------------------------------------

Segment Leq : 50.86 dBA

Total Leq All Segments: 50.86 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 !       38.10 !       28.55 !        28.55

ROAD (0.00 + 43.26 + 0.00) = 43.26 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  -1.86   0.00   0.00   0.00 -15.76  43.26
----------------------------------------------------------------------------

Segment Leq : 43.26 dBA

Total Leq All Segments: 43.26 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           :  38.10 / 38.10  m
Topography                :      2       (Flat/gentle slope; with barrier)
Barrier angle1            : -90.00 deg   Angle2 : 90.00 deg
Barrier height            :  36.60 m
Barrier receiver distance :   6.00 / 6.00   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 !       38.10 !       32.87 !        32.87

RT/Custom (0.00 + 45.60 + 0.00) = 45.60 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 -12.61  45.60
----------------------------------------------------------------------

Segment Leq : 45.60 dBA

Total Leq All Segments: 45.60 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 !       38.10 !       32.87 !        32.87

RT/Custom (0.00 + 39.07 + 0.00) = 39.07 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 -12.61  39.07
----------------------------------------------------------------------

Segment Leq : 39.07 dBA

Total Leq All Segments: 39.07 dBA


TOTAL Leq FROM ALL SOURCES (DAY): 51.99
                         (NIGHT): 44.66
```

APPENDIX B

FTA VIBRATION CALCULATIONS

Possible Vibration Impacts on 1945 Scott Street
Perdicted using FTA General Assesment

Train Speed 70 km/h 43.5 mph

	Distance from C/L	
	(m)	(ft)
LRT	41.7	136.8

Vibration

From FTA Manual Fig 10-1

Vibration Levels at distance from track	65	dBV re 1 micro in/sec

Adjustment Factors FTA Table 10-1

Speed reference 50 mph	-1.2	Operating Speed 70 km/h (43.5 mph)
Vehicle Parameters	0	Assume soft primary suspension, Wheels run true
Track Condition	0	None
Track Treatments	0	None
Type of Transit Structure	0	None
Efficient vibration Propagation	0	None
Vibration Levels at Fdn	64	0.039
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	57.8	dBV or 0.020 mm/s
Noise Level in dBA	7.8	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.