AERCOUSTICS ENGINEERING LIMITED

TORONTO TRANSIT COMMISSION
SHEPPARD LOW FLOOR LIGHT RAIL VEHICLE MAINTENANCE & STORAGE FACILITY
ENVIRONMENTAL NOISE & VIBRATION ASSESSMENT

Project Number: 09430

Prepared For:

AECOM
300 Town Centre Blvd, Suite 300
Markham, Ontario
L3R 5Z6

Prepared By:

David Grant, B.A.Sc

Tim Preager, B.A.Sc, P.Eng

1 March 2010
Revised 5 July 2010

Marc Bracken
M.A.Sc., P.Eng.

Vince Gambino
B.A.Sc., P.Eng.

John O'Keefe
M.Sc., P.Eng. MIOA

Bob Rimrott
M.A.Sc., P.Eng.

50 Ronson Drive, Suite 165
Toronto, Canada M9W 1B3
(416)249-3361 Phone
(416)249-3613 Fax

aercoustics@aercoustics.com
www.aercoustics.com

Executive Summary

Aercoustics Engineering Limited has completed an Environmental Noise and Vibration Assessment of the proposed Toronto Transit Commission ("TTC") Low Floor Light Rail Vehicle Maintenance and Storage in support of an Environmental Summary Report with the Ministry of Environment ("MOE").

Applicable sound and vibration level limits have been established and sensitive receptors identified based on MOE criteria. Streetcar sound and vibration impact at each sensitive receptor has been predicted using empirical data collected from previous projects involving the existing TTC streetcar fleet. Noise impact predictions for other stationary noise sources within the facility (HVAC equipment, streetcar maintenance equipment, etc) are to be assessed as part of the detailed design.

Sound and vibration limits have been achieved at each sensitive receptor based on predictable worst-case hourly facility operation. Acoustic mitigation recommendations have been made, in the form of an acoustic barrier and methods to minimize wheel screech, in order to meet the applicable MOE sound level limits.

TABLE OF CONTENTS

List of Figures:

List of Tables:

List of Appendices:

1.0 INTRODUCTION

Aercoustics Engineering Limited (“AEL”) has been retained by AECOM to carry out an Environmental Noise and Vibration Assessment for the proposed TTC Low Floor Light Rail Vehicle Maintenance and Storage Facility.

The noise and vibration impact of the streetcar facility has been evaluated at this stage of the project. Noise and vibration sources at the streetcar facility are required to comply with MOE publication NPC-205/232 and ISO 2631-2, respectively. Noise and vibration impacts have been determined based on measured data and approved modelling techniques. Mitigation recommendations are made which will enable the facility to achieve compliance with the appropriate guidelines.

2.0 NOISE DESCRIPTORS

To fully comprehend this report, a description of several acoustic terms used to evaluate the noise impact of the proposed streetcar facility has been included for completeness.

SOUND PRESSURE LEVEL (SPL): A measure of sound energy emitted from a sound source. SPL is dependent on environment, and distance between the source and measurement point.

SOUND POWER LEVEL (PWL): The rate of sound energy emitted by a sound source. PWL is independent of environment, and distance between the source and measurement point.

DECIBEL (dB): A dimensionless measure of sound power level or sound pressure level

TONAL SOUND: A qualitative descriptor for sounds which have a recognizable pitch (e.x car horn, church bells, transformer humming.

LEQ: The average energy equivalent sound level as measured over a specific time interval (i.e. 20 minutes, 1 hour, 24 hours). LEQ is the value of the constant sound level which would result in exposure to the same total acoustic energy as the time varying sound. This assumes that the constant level persists over an equal time interval. This quantity can be readily measured with an integrating sound level meter.

LMAX: The maximum sound level measured over a specific interval.

INSTANTANEOUS SOUND LEVEL: The sound level observed at an instant in time, i.e. not averaged over a specified time period.

“A” WEIGHTING: The frequency weighting characteristic as specified in IEC 123 or IEC 179 and intended to approximate the relative sensitivity of the normal human ear to different frequencies (pitches) of sound.

A-WEIGHTED SOUND PRESSURE LEVEL: The sound pressure level modified by the application of the A-weighting. It is measured in decibels, A-weighted, and denoted dBA.

PERCENTILE SOUND LEVEL (i.e. L90): The "x percentile sound level", designated Lx, is the sound level exceeded x percent of a specified time period. It is measured in dBA. The L90, for instance, is the sound level exceeded 90% of the time. It is a sound level index that commonly refers to the background noise level – most often referenced to a rural setting.

OUTDOOR LIVING AREA: is the part of an outdoor area easily accessible from the building and intended for the quiet enjoyment of the outdoor environment.

POINT OF RECEPTION: An outdoor point or group of similar points on a premise where sound or vibration originating from a location external to the premise is received.

SENSITIVE POINT OF RECEPTION: A point of reception which is sensitive to noise or vibration (ex. a residence, church, campground, etc).

MOE ACOUSTICAL CLASS: defines the acoustical environment of a point of reception.

The MOE Classifications are as follows:

Class 1: *means an area with an acoustical environment typical of a major population centre, where the background noise is dominated by the urban hum*

Class 2: *means an area with an acoustical environment that has qualities representative of both Class 1 and Class 3 Areas, and in which a low ambient sound level, normally occurring only between 23:00 and 07:00 hours in Class 1 Areas, will typically be realized as early as 19:00 hours. Other characteristics which may indicated the presence of a Class 2 Area include:*

- *Absence of urban hum between 19:00 and 23:00 hours.*
- *Evening background sound level defined by natural environment and infrequent human activity*

and

- *No clearly audible sound from stationary sources other than from those under impact assessment.*

Class 3: *means a rural area with an acoustical environment that is dominated by natural sounds having little or no road traffic, such as the following:*

- *A small community with less than 1000 population*
- *Agricultural area*
- *A rural recreational area such as a cottage or a resort area; or*
- *A wilderness area*

3.0 SENSITIVE POINTS OF RECEPTION

A review of the site and surrounding land uses was completed using a combination of on-site observations as well as aerial photography. The following were determined to be the closest sensitive points of reception to the proposed site, and are indicated on Figure 1:

- Residences along Upper Rouge Trail (R1),
- Residences along Gennela Square (R2),
- The Rouge Valley Long Term Care Centre located on the south-east corner of Conlins Road and Sheppard Ave (R3),
- The proposed secondary school or residential to the east of the site(R4) ,
- The proposed elementary school or residential to the east of the site(R5),
- The Bushcamp at the zoo to the north of the site (R6).

The sensitive points of reception have been classified as shown in Table 1 below:

Table 1 – Receptor Acoustical Classifications

Receptor ID	Description	MOE Class
R1	Residences along Upper Rouge Trail	2 - Suburban
R2	Residences along Gennela Square	2 - Suburban
R3	Rouge Valley Long Term Care Centre	1 - Urban
R4	Proposed Secondary School	2 -Suburban
R5	Proposed Elementary School	2 -Suburban
R6	Toronto Zoo Bushcamp	3 - Rural

At the time of this writing, the proposed secondary (R4) and elementary (R5) schools are currently dual zoned: as institutional and potential residential development should schools not be developed. It is understood that the school boards currently own the land and that when constructed, the school buildings will be located on the easterly portion of their consists. These receptors are considered daytime receptors only at a height of 10.5m to represent a 3rd storey classroom. The receptor locations may change if residential dwellings are developed on the lands where R4 and R5 are located.

Should institutional dwellings be erected at the locations of R4 and R5 in the future, a noise study will likely be required by the City of Toronto as part of site plan approval to ensure that sound level limits are met in accordance MOE D-Series Guideline D-6. It should be noted as per that no indoor sound level criteria is established for stationary sources since compliance with outdoor plane-of-window limits typically ensures that indoor levels are satisfactory. A noise study may also be required should residential dwellings be erected on the lands.

4.0 SOUND CRITERIA

4.1 MOE SOUND LEVEL LIMIT

Noise sources at the proposed streetcar facility are required to comply with MOE publication NPC-205/232. Noise sources located at the facility include streetcars while on TTC property, mechanical equipment associated with any building located on-site, public address systems or any other non-emergency noise-generating activity that may be associated with the proposed streetcar facility.

The noise assessment includes only activity from moving streetcars throughout the track. Secondary noise sources such as mechanical equipment related to the building structures, PA systems or any other sources are required to be in compliance with the MOE publication NPC-205 as well. The combined impact of moving streetcars and other equipment located on-site should be determined at a later date as part of the detailed design of the project.

The MOE guidelines state that the hourly equivalent sound level (LEQ) limit at a receptor is the greater of the current ambient background sound level or the minimum sound level limit applicable to the receptor's acoustical class. The MOE minimum sound level limits for Class 1, Class 2, and Class 3 given in MOE Publication NPC-205 are shown in Table 2

Table 2 – Summary of MOE Sound Level Limits

MOE Classification	Sound Level Limit (dBA)		
	Daytime (07:00 – 19:00)	Evening (19:00 – 23:00)	Night-time (23:00 – 07:00)
Class 1 – Urban	50	47	45
Class 2 – Suburban	50	45	45
Class 3 – Rural	45	40	40

If it is found through long term community ambient sound monitoring (7-10 days) or by predicted sound levels due to road traffic, that an area has an ambient sound level higher than that mentioned in Table 2, then the lowest recorded sound level from the measurement period, or lowest predicted sound level from road traffic becomes the applicable sound level limit in the area. This can typically occur in downtown major population centres or where residential receptors are located near a busy road.

4.2 COMMUNITY AMBIENT SOUND MONITORING

Two community ambient sound monitors configured to measure energy-averaged hourly equivalent sound levels for a total duration of 9 days were installed at locations M1 and M2 shown on Figure 1 from October 6th until October 15th, 2009. The location of monitor M1 was selected to represent a similar setback from Sheppard Ave as the long-term care centre facility receptor R3 at a distance of approximately 32m from the centre of the road. Similarly, the location of monitor M2 was selected to have a setback from Sheppard Ave similar to the Upper

Rouge Trail receptors R1 at a distance of approximately 370m from the centre of the road. The two locations considered together provide an understanding of how Sheppard Ave road traffic noise propagates across existing terrain, and allows interpolation and extrapolation of traffic noise at different setbacks.

The measurement results which captured the existing ambient sound levels for measurement locations M1 and M2 are presented in Figure 2a and 2b, respectively. The recorded minimum background One Hour Equivalent Sound Level (LEQ), measured by noise monitors M1 and M2, is shown in Table 3a and 3b, respectively.

Table 3a: Monitor Location M1, 32m from Sheppard Ave	
Time Period	**Minimum Leq (dBA)**
Daytime (07:00 - 19:00)	67
Evening (19:00 - 23:00)	69
Night (23:00 - 07:00)	61

Table 3b: Monitor Location M2, 370m from Sheppard Ave	
Time Period	**Minimum Leq (dBA)**
Daytime (07:00 - 19:00)	42
Evening (19:00 - 23:00)	45
Night (23:00 - 07:00)	39

It should be noted that the measured levels in Table 3a and 3b represent hourly time-weighted averages. Instantaneous sound levels can be higher (for example, as a wave of traffic passes) and lower (for example, where there is a large gap in traffic), but these average out to the values recorded.

It should also be noted that the values reported represent sound levels for the hour during the indicated time period with the lowest levels of background sound. The vast majority of the hourly measurements recorded are above the values shown in Table 3a and 3b, but these are the recorded Leq minima.

4.3 RECEPTOR SOUND LEVEL LIMITS

Sheppard Avenue road traffic noise dominates the ambient sound levels at monitor location M1, whereas natural sounds dominate sound level measurements completed at monitor location M2. The results indicate that receptor R3, which is close to Sheppard Avenue, can support higher sound level limits than the MOE minimum. The monitoring data from monitor location M2 applies to all other receptors which are further from Sheppard Avenue, and does not support higher sound level limits for these receptors.

Receptors R1,R2,R3 and R4 are located in a suburban environment and are classified as Class II receptors. Receptor R6 is located in a wilderness type area and is considered as Class III.

The resulting sound level limits for all receptors during any time of day and night are presented in Table 4. The noise impact of the proposed TTC facility on these receptors is required to meet the applicable MOE sound level limits listed.

Table 4 – Receptor Sound Level Limits

Time Period	Sound Level Limit (dBA)			
	R1 & R2	R3	R4 & R5	R6
Daytime (07:00 – 19:00)	50	67	50	45
Evening (19:00 – 23:00)	45	69	-	40
Night (23:00 – 07:00)	45	61	-	40

5.0 VIBRATION CRITERIA

Vibration sources at the streetcar facility should comply with ISO 2631-2, *Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings*. This publication sets a maximum RMS velocity limit of 0.14mm/s at frequencies between 10 and 100 Hz within residential buildings during night time. Typically, streetcars do not produce vibration levels below 10 Hz. This applies to receptors R1, R2, R3, R6 and if they are developed as residential housing or for institutional purposes, R4 and R5.

6.0 ACOUSTIC MODELLING BACKGROUND INFO

The acoustic model prepared for this report utilizes the following information:

- Site Plan Geometry
- Track Layout Geometry
- Terrain Elevation Geometry
- Streetcar Traffic Volumes and Scheduling
- Streetcar Sound Emission Data
- Acoustic Barrier Geometry
- Receptor Heights

This section will present and discuss the above background information.

6.1 *SITE PLAN AND TRACK LAYOUT*

The preliminary site plan and track layout has been provided by AECOM and is shown in Figures 3 and 4.

The track layout is significant to the production of noise because curved track has the potential to create wheel screech. Wheel screech is the result of friction between streetcar wheels and track rails. Slight curves tend to produce less noise than sharp curves.

6.2 *TERRAIN ELEVATION GEOMETRY*

For the terrain surrounding the site, a digital elevation geometry model was obtained from AECOM via Firstbase Solutions, and was downloaded on November 10, 2009.

The elevation used in the acoustical model for the proposed streetcar facility is 140m above sea level.

6.3 *STREETCAR TRAFFIC VOLUME, SCHEDULING, AND MOVEMENTS*

Streetcar traffic volumes and scheduling information has been provided by AECOM and has been included in Appendix A. This information has been distilled into worst-case hourly traffic volume by time period (day, evening, night) and is presented in Table 5.

Table 5 – Worst-Case Hourly Streetcar Traffic Volumes

Time Period	Worst Case Hour	Number of Cars Exiting/Entering Proposed Facility During Worst-Case Hour*
Day (0700-1900)	0900-1000	14 Entering
Evening (1900-2300)	2200-2300	20 Entering
Night (2300-0700)	0600-0700	53 Exiting

*Note that some streetcar trains consist of 3 cars, while others consist of 1 car. See Appendix A for details.

As shown in the Figure 3 site plan, there are 12 storage tracks at the proposed facility. There are a variety of routes that streetcars can take to enter and exit the facility. It has been assumed, for the purpose of the acoustic model, that all streetcars take the route which results in the greatest noise impact at a given receptor.

The streetcar route, shown in Figure 4, has been determined to have the greatest noise impact on all sensitive receptors. It should be noted that other routes are possible but that they either have a lower noise impact, or they are not intended to be used for high volume traffic except in emergency cases.

An area of the site, indicated in Figure 3, has been reserved for future storage track expansion. The future expansion will not result in a higher worst-case traffic volume hour for any of the three time periods considered.

6.4 STREETCAR SOUND EMISSION DATA

Streetcar sound emission data used in the acoustical model is based on measurements of moving streetcars at the TTC Roncesvalles Streetcar Storage Facility performed by Aercoustics in 2006 and 2008. Multiple measurements were taken of each of the following scenarios: Streetcars moving along straight, slightly curved, and sharply curved track.

The results were used to determine a sound power level for each track section type, and are summarized in Table 6.

Table 6 – Streetcar Track Segment Sound Power Levels

Track Segment Type	Sound Power Level (dBA)
Straight	102
Slightly Curved	115
Sharply Curved	120

The streetcars proposed to be used within the Sheppard facility are a newer model than those measured at the TTC Roncesvalles Streetcar Storage Facility, however the data measured from the latter is the best locally available to date. Once prototype vehicles or manufacturer sound data is available for the newer vehicles, it is recommended the acoustical study be revised based on measurement data of the newer streetcars.

6.5 ACOUSTIC BARRIER GEOMETRY

An acoustic barrier is proposed to be installed along the north and east border of the site. The barrier location and heights are indicated on Figure 4. The barrier height at the south end of the east barrier can be stepped gradually from 6m to 2m. Acoustic Barriers may consist of an acoustic fence, an earth berm, or a combination of an acoustic fence and earth berm. The barrier should be free of gaps or penetrations and should have a minimum surface density of 20kg per square meter.

6.6 RECEPTOR HEIGHTS

The noise impact at each sensitive point of reception is predicted at a specific height. These heights vary based on the nature of the receptor and the time period being analyzed. For a two storey house, for example, standard practice is to use a receptor height of 1.5m above ground during the day, and 4.5m during the evening and night. This is based on the ubiquity of second storey bedrooms where the height represents the middle of a bedroom window. A height of 10.5m is used for the proposed schools to represent the third storey classroom window.

The receptor height used for each receptor in each time period is shown in Table 7.

Table 7 – Summary of Receptor Heights

Receptor ID	Description	Receptor Height (m)	
		Day (0700-1900)	Evening and Night (1900-0700)
R1	Residences along Upper Rouge Trail	1.5	4.5
R2	Residences along Gennela Square	1.5	4.5
R3	Rouge Valley Long Term Care Centre	7.5	7.5
R4	Proposed Secondary School	10.5	-
R5	Proposed Elementary School	10.5	-
R6	Toronto Zoo Bushcamp	1.5	1.5

7.0 NOISE IMPACT PREDICTIONS

The noise impact predictions were performed using the DataKustik CadnaA environmental noise prediction software. The calculations are based on established prediction methods found in ISO 9613-2: A Standard for Outdoor Noise Propagation standard. The noise impact predictions assumed downwind propagation conditions as defined by the standard. The calculation method and modeling parameters are in accordance with the MOE’s predictable worst-case requirements.

Tables 8 and 9 summarize the predicted sound levels at each receptor due to streetcar noise at the Sheppard facility. Table 8 shows predicted levels with mitigation only from the acoustic barriers described in Section 6.5. Table 9 shows predicted levels with the acoustic barriers in addition to a reduction of the noise level generated by wheel screech on sharp turns. Noise impacts that exceed the sound level limit are underlined and hi-lighted in red.

Wheel screech is considered to be a tonal sound, and incurs a 5dB noise impact penalty, as per MOE standards. This is due to the fact that tonal sound is more easily perceived by the human ear. All noise impacts listed include this 5dB penalty.

Table 8 – Noise Impact Summary (Acoustic Barriers with Wheel Screeching)

Receptor ID	Receptor Description	Noise Impact (Leq) (dBA)			Sound Level Limit (Leq) (dBA)		
		Day (0700-1900)	Evening (1900-2300)	Night (2300-0700)	Day (0700-1900)	Evening (1900-2300)	Night (2300-0700)
R1	Residences along Upper Rouge Trail	50	52	56	50	45	45
R2	Residences along Gennela Square	45	48	52	50	45	45
R3	Rouge Valley Long Term Care Centre	62	64	67	67	69	61
R4	Proposed Secondary School	51	N/A	N/A	50	45	45
R5	Proposed Elementary School	52	N/A	N/A	50	45	45
R6	Toronto Zoo Bushcamp	38	40	44	45	40	40

Table 9 – Noise Impact Summary (Acoustic Barriers with Slight Wheel Screeching)

Receptor ID	Receptor Description	Noise Impact (Leq) (dBA)			Sound Level Limit (Leq) (dBA)		
		Day (0700-1900)	Evening (1900-2300)	Night (2300-0700)	Day (0700-1900)	Evening (1900-2300)	Night (2300-0700)
R1	Residences along Upper Rouge Trail	39	41	45	50	45	45
R2	Residences along Gennela Square	32	35	40	50	45	45
R3	Rouge Valley Long Term Care Centre	54	56	60	67	69	61
R4	Proposed Secondary School	41	N/A	N/A	50	45	45
R5	Proposed Elementary School	43	N/A	N/A	50	45	45
R6	Toronto Zoo Bushcamp	26	27	32	45	40	40

Sound levels which exceed the limits are indicated in red and underlined. Sample noise contours are provided in Appendix B.

As demonstrated in Table 9, the sound level limits at all sensitive receptors are satisfied provided that the reduction of wheel screeching occurs and schools are erected within the lands where R4 and R5 are located.

The worst-case predicted instantaneous sound level during a streetcar curved pass-by is 44dBA in the worst-case location at the area of the elementary school property likely to be used as open play area or school fields. A similar result is expected in the area of proposed secondary school yard likely to be used as open play area or school fields. This level is within the MOE daytime sound level limits.

Indoor sound level prediction calculations have been performed for the schools (R4 and R5) for the condition of open windows in a west-facing classroom, and with slight screeching. The predicted instantaneous indoor sound level during a pass-by in this scenario is 38dBA. This level is consistent with typical background noise levels in classrooms.

The indoor sound level is dependent upon actual design of the proposed school and may change depending on the number and area of operable windows that face the facility.

8.0 VIBRATION IMPACT PREDICTIONS

The vibration impact predictions are based on empirical data collected from previous projects involving the existing fleet of TTC Streetcars. The data collected represents a total of approximately 20 streetcar pass-bys where vibration measurements were performed at varying distances and with different types of track, i.e. cast-in place, encapsulated in rubber.

Vibrations from streetcar pass-bys are significantly affected by the condition of the wheels, the corrugation of the rail, and the presence of any switches and/or rail joints in proximity to a receptor. Soil conditions can also affect the vibration impact at the receptor. Based on the collected data, the dominant energy produced by streetcar vibrations is in the 40 and 50 Hz frequency range.

Streetcars produce significant vibration levels within a distance of approximately 40m from the centre of the tracks. If the track is not properly maintained or if rail joints are in poor condition, the potential for vibration impact at greater distances may exist.

The closest sensitive receptor to vibration for the facility is located at a distance of approximately 80m from the closest track. As such, no significant vibration impact is expected at any receptor in the area provided that the rail tracks are properly maintained. Table 10 summarizes the results of the vibration impact predictions.

Table 10 – Vibration Impact Prediction Results			
Receptor	**Vibration Impact (mm/s)**	**Vibration Limit (mm/s)**	**Compliance?**
All	< 0.14 mm/s	0.14	Yes

9.0 DISCUSSION AND RECOMMENDATIONS

9.1 NOISE MITIGATION

In Table 8, the predicted noise impact at each receptor is dominated by wheel screech sound, originating from streetcars travelling along sharply curved sections of track.

Consequently, it is recommended that the impact of wheel screech be significantly reduced by the uses of mitigation approaches that could include: Turning enclosures, track-based technologies, and vehicle technologies such as resilient wheels, and/or on-car lubrication.

Track-based technologies currently available on the market are designed to reduce wheel screech. Some of these technologies are a form of lubrication that are applied to the track surface or directly to the wheel, while others involve fabricating track rails using special materials and methods. As mentioned above, turning enclosures, if properly oriented and constructed, could also be used to contain and attenuate wheel screech noise.

The design will need to employ mitigation measures in order to minimize wheel screech. It is recommended that one or more detailed empirical studies be undertaken for various noise reduction technologies, in order to evaluate their acoustic performance, as well as the operational and administrative feasibility of any solution.

9.2 NOISE IMPACT AT PROPOSED SCHOOLS

The predicted impact of 38dBA within an open-windowed classroom is consistent with typical background noise criteria for such spaces generated by building activities such as HVAC equipment and noise intrusion from adjacent classrooms. It is expected that during a classroom lesson, the teacher and students will be able to communicate effectively to each other without being distracted by sounds generated by well maintained streetcars. Streetcar activity will likely still be audible during quiet times in the classroom. In the event that audible sounds from the facility are distracting occupants of either school, keeping windows closed during quiet times is recommended. During the design stage of the schools, consideration could be given to orientation of the buildings such that classrooms do not face the facility.

The predicted instantaneous impact of 44dBA in the playground area is quieter than levels generated by most playground occupants. At these levels, the facility will likely not interfere with outdoor activities such as gym class, sports events or recess.

9.3 NOISE IMPACT AT CITY OF TORONTO ZOO OVERNIGHT BUSHCAMP

It is understood that the bushcamp is meant to simulate a wilderness experience throughout the night and that there is a concern that "city" sounds in the low-background-noise area will interfere with the experience. The predicted impact of 32dBA at night satisfies the MOE sound level limit for a receptor located in a rural environment, which is the most stringent official criteria applicable. The impact is in the range of what would be expected during birds singing outside, a quiet rural environment, or even a library setting or private study.

10.0 CONCLUSIONS

Aercoustics Engineering Limited has completed an Environmental Noise and Vibration Assessment of the proposed TTC Low Floor Light Rail Vehicle Fleet Replacement Facility in support of an Environmental Summary Report with the MOE.

Sensitive noise and vibration receptors have been identified, and sound level limits have been established based on measured ambient sound levels in conjunction with MOE publication NPC-205/232. Vibration limits for sensitive receptors have been established based on ISO standard 2631-2.

Streetcar noise impact at each sensitive receptor has been predicted using Cadnaa modelling software, for two scenarios: With wheel screech and with partial wheel screech. Noise impact predictions for other stationary noise sources within the facility (HVAC equipment, streetcar maintenance equipment, etc) are to be assessed as part of the detailed design.

Streetcar vibration impact has been predicted using empirical data collected during previous projects and is not expected to be perceptible at any sensitive point of reception.

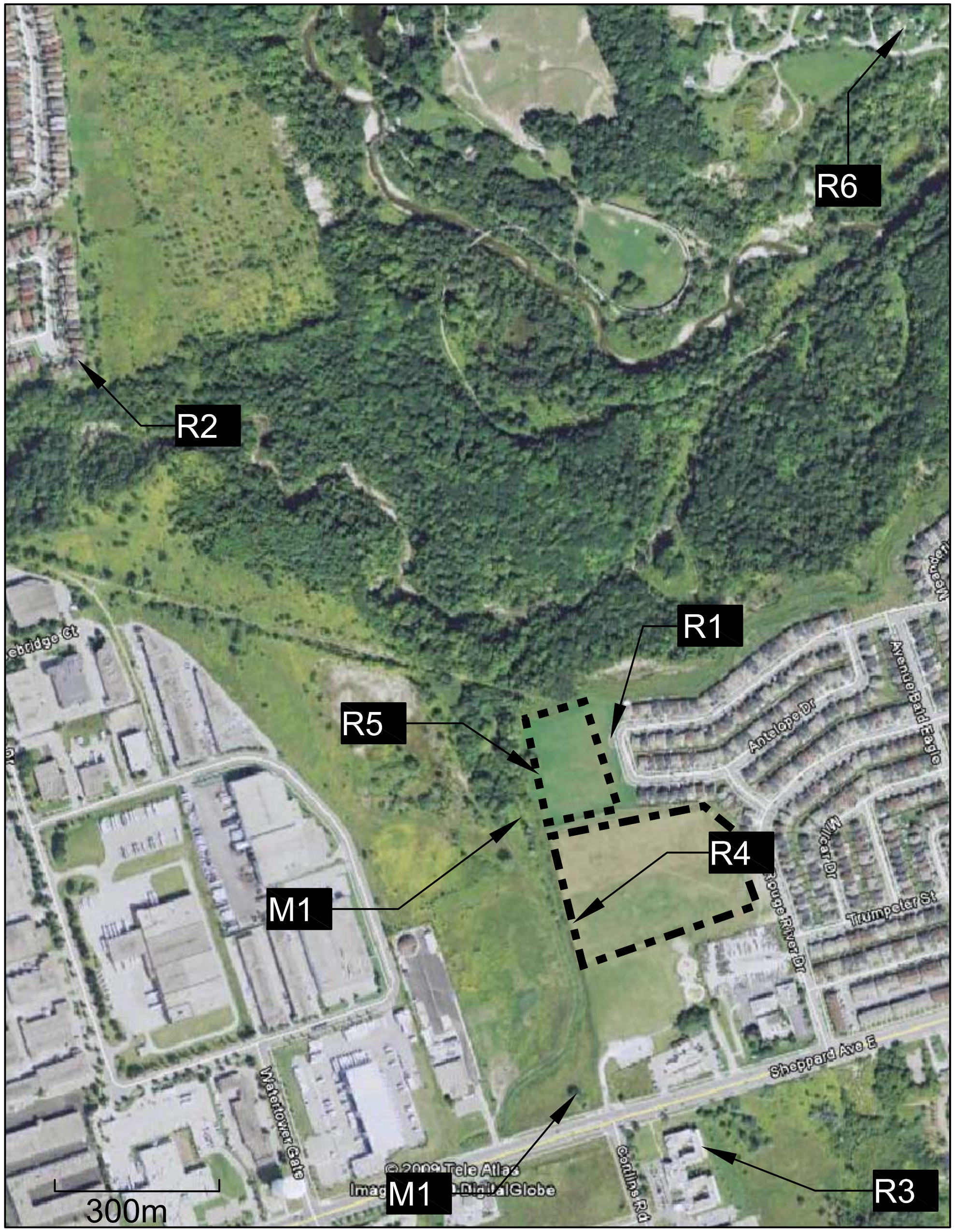
It is the conclusion of this report that, with the reduction of wheel screech, the MOE and ISO standard sound and vibration limits at each sensitive receptor can be satisfied for streetcar operations at the proposed site.

11.0 REFERENCES

1. MOE, NPC-205. "Sound Level Limits for Stationary Noise Sources in Class 1 & 2 Areas (URBAN)." October 1995.

2. MOE, NPC-232. "Sound Level Limits for Stationary Sources in Class 3 Areas (RURAL)." October 1995.

3. ISO, 2631-2. "Evaluation of human exposure to whole-body vibration – Part 2: Continuous and shock-induced vibration in buildings (1 to 80Hz)" 1989



AERCOUSTICS
ENGINEERING LIMITED

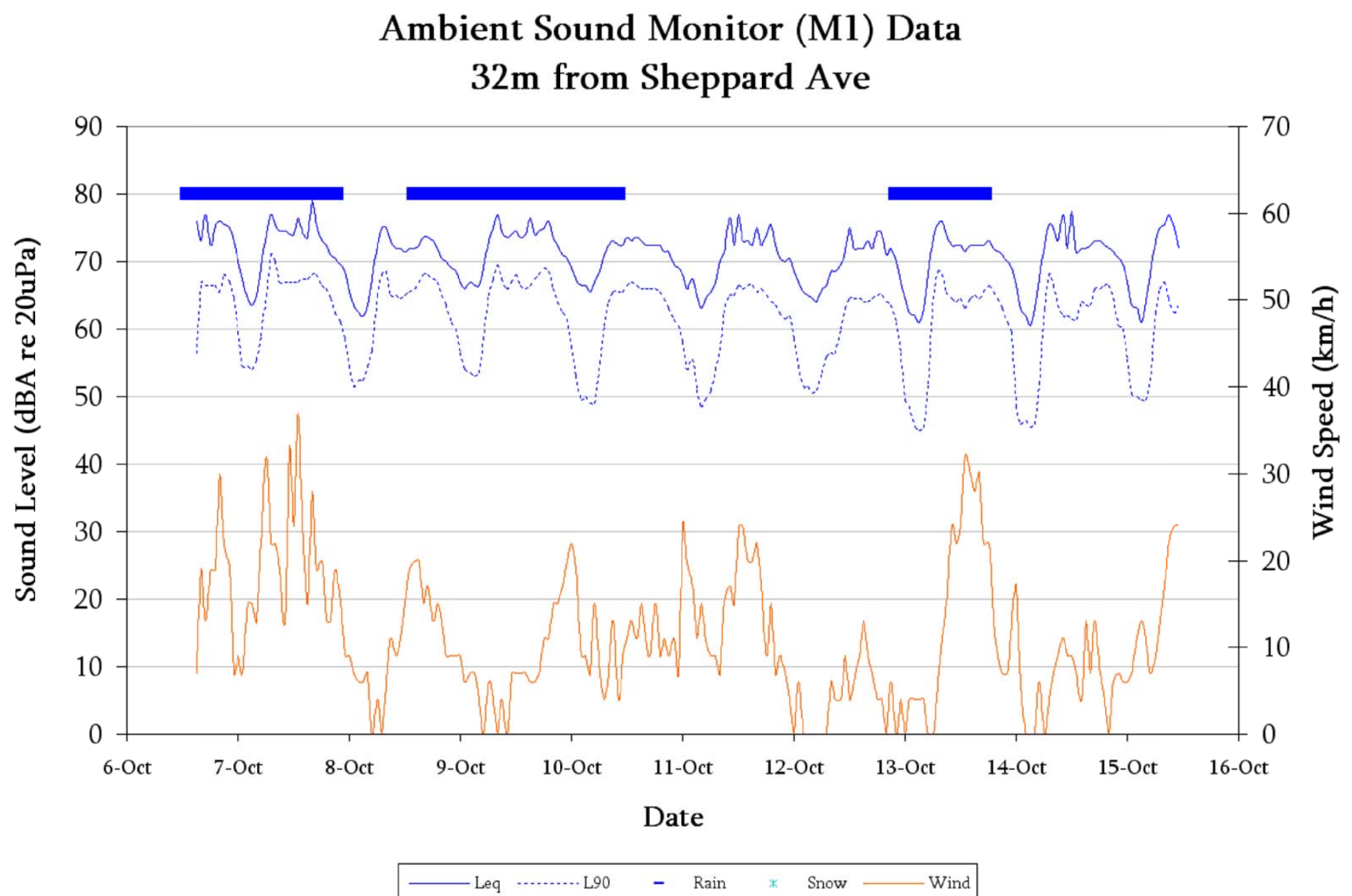
50 Ronson Drive
Suite 165
Toronto Canada
M9W 1B3
(416)249-3361

TTC Sheppard Environmental Assessment
Figure 1: Area Location Map

Drawn	Eng.	Drawing
DG	TP	Area Location Map

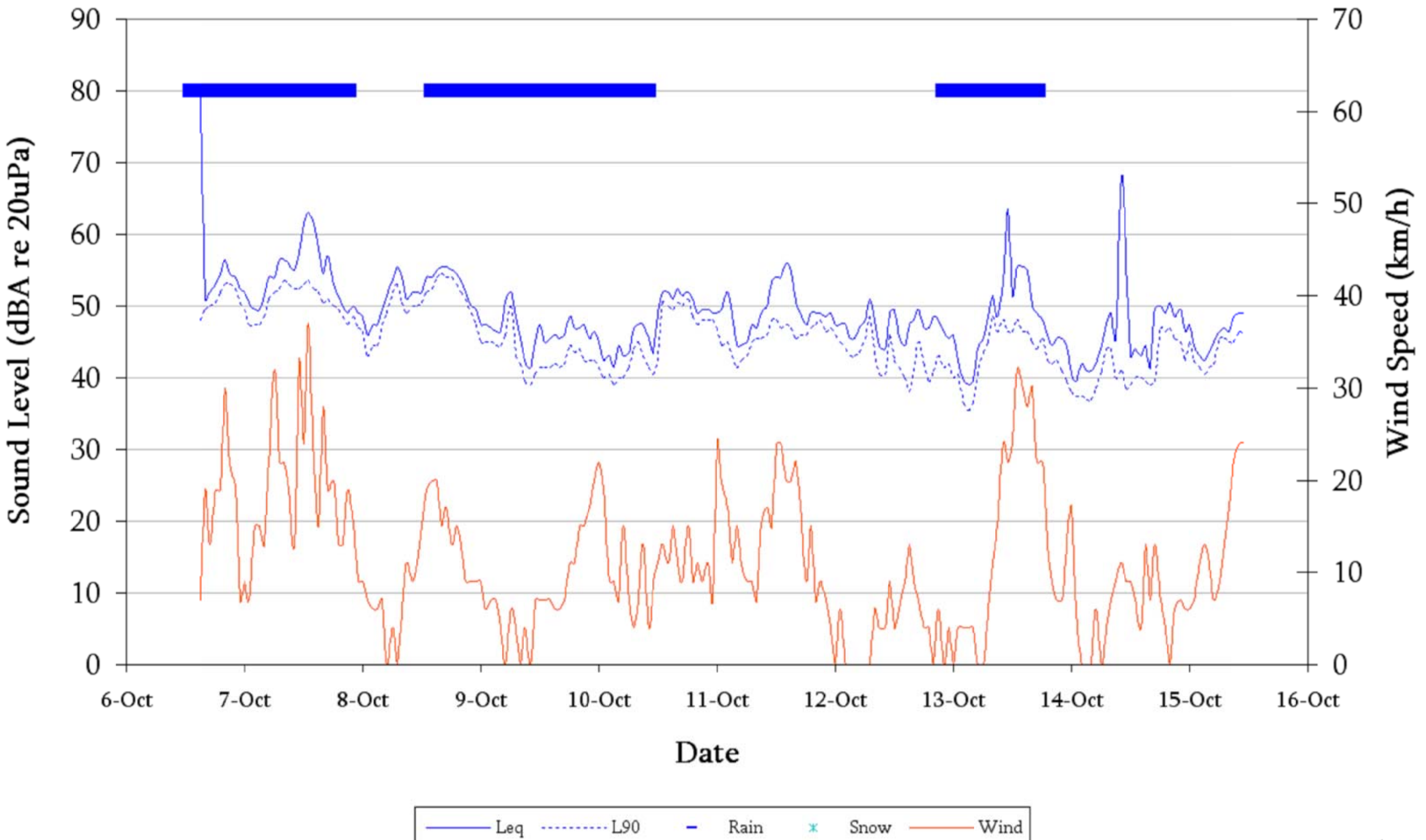
The scope of the work outlined in this document is limited to the acoustic noise & vibration control aspects of the design. Contractor to verify all dimensions.

Scale	Figure
AS SHOWN	1

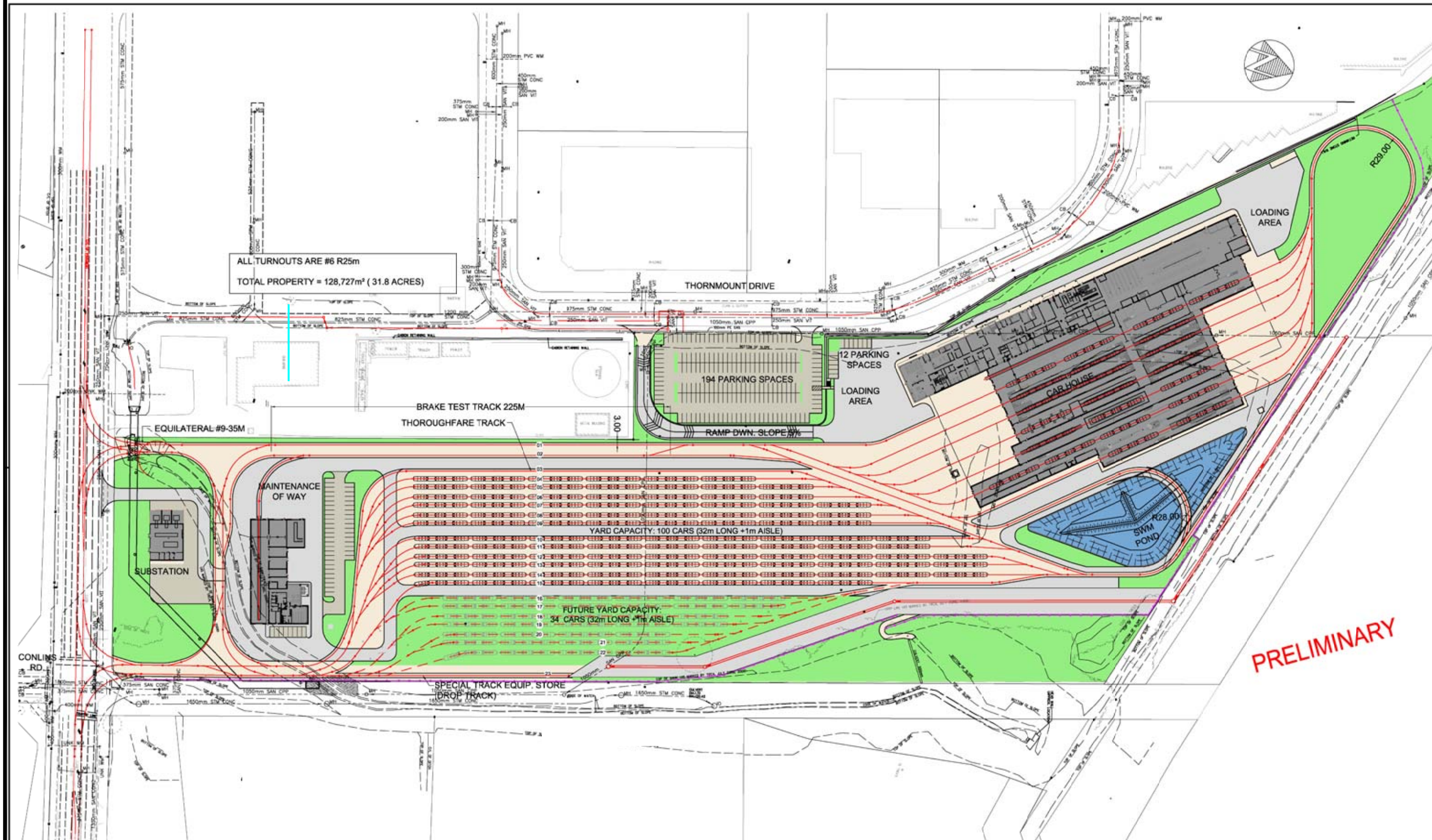


AERCOUSTICS ENGINEERING LIMITED	50 Ronson Drive Suite 165 Toronto Canada M9W 1B3 (416)249-3361	TTC Sheppard Environmental Assessment Figure 2a: Ambient Sound Monitor (M1) Data	Drawn DG	Eng. TP	Drawing Sound Monitor Data
			The scope of the work outlined in this document is limited to the acoustic noise & vibration control aspects of the design. Contractor to verify all dimensions.		Scale NTS · Figure 2a

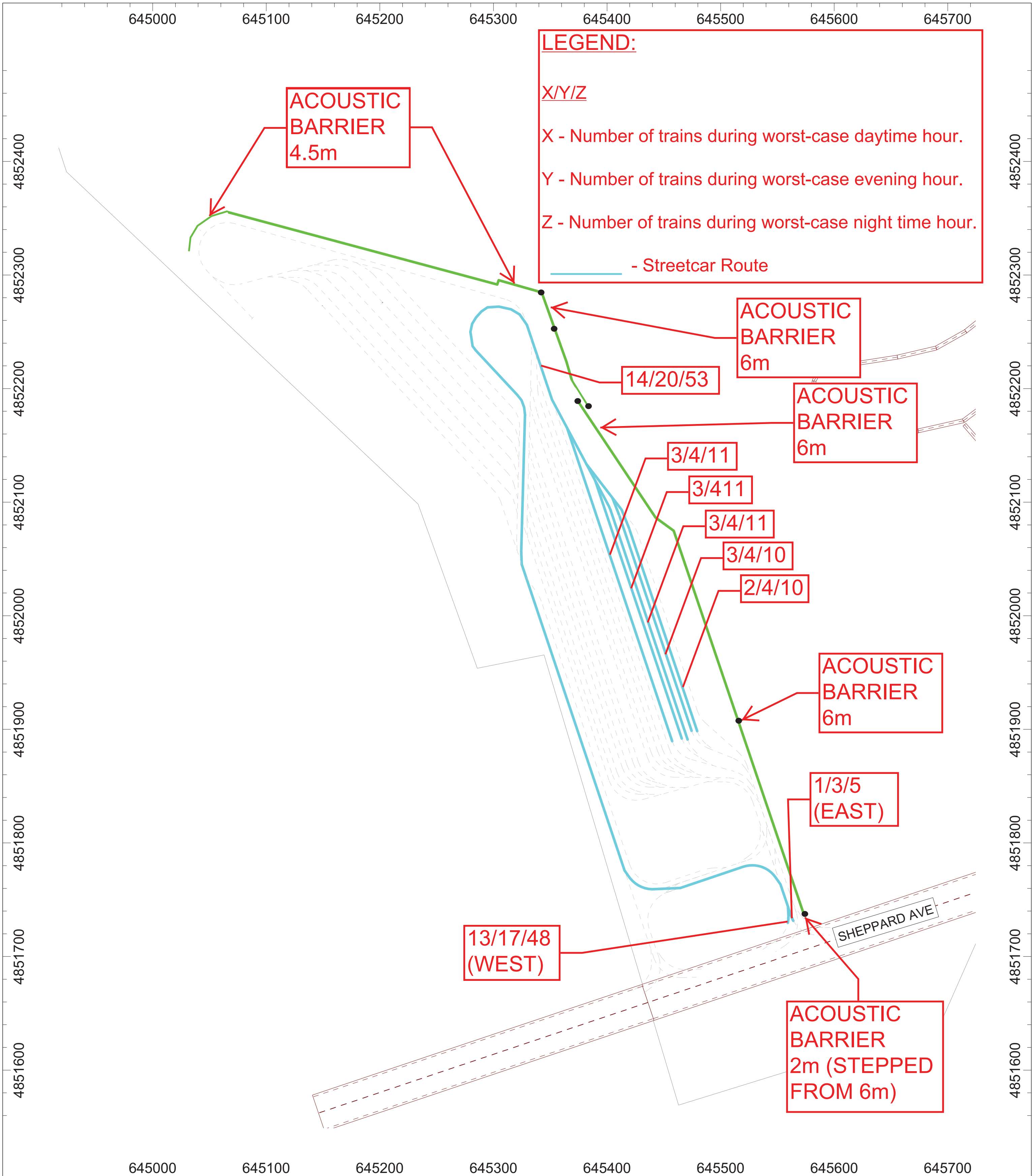
Ambient Sound Monitor (M2) Data
370m from Sheppard Ave



AERCOUSTICS ENGINEERING LIMITED	50 Ronson Drive Suite 165 Toronto Canada M9W 1B3 (416)249-3361	TTC Sheppard Environmental Assessment Figure 2b: Ambient Sound Monitor (M2) Data	Drawn DG	Eng. TP	Drawing Sound Monitor Data
			The scope of the work outlined in this document is limited to the acoustic noise & vibration control aspects of the design. Contractor to verify all dimensions.		Scale NTS Figure 2b



AERCOUSTICS ENGINEERING LIMITED	50 Ronson Drive Suite 165 Toronto Canada M9W 1B3 (416)249-3361	TTC Sheppard Environmental Assessment Figure 3: Site Plan	Drawn: DG Eng.: TP The scope of the work outlined in this document is limited to the acoustic noise & vibration control aspects of the design. Contractor to verify all dimensions.	Drawing: Site Plan Scale: NTS Figure: 3



AERCOUSTICS ENGINEERING LIMITED

50 Ronson Drive
Suite 165
Toronto Canada
M9W 1B3
(416)249-3361

TTC Sheppard Environmental Assessment
Figure 4 - Streetcar Route

Drawn: DG	Eng: TP	Drawing: Streetcar Route
The scope of the work outlined in this document is limited to the acoustic noise a & vibration control aspects of the design. Contractor to verify all dimensions.	Scale: NTS	Figure 4

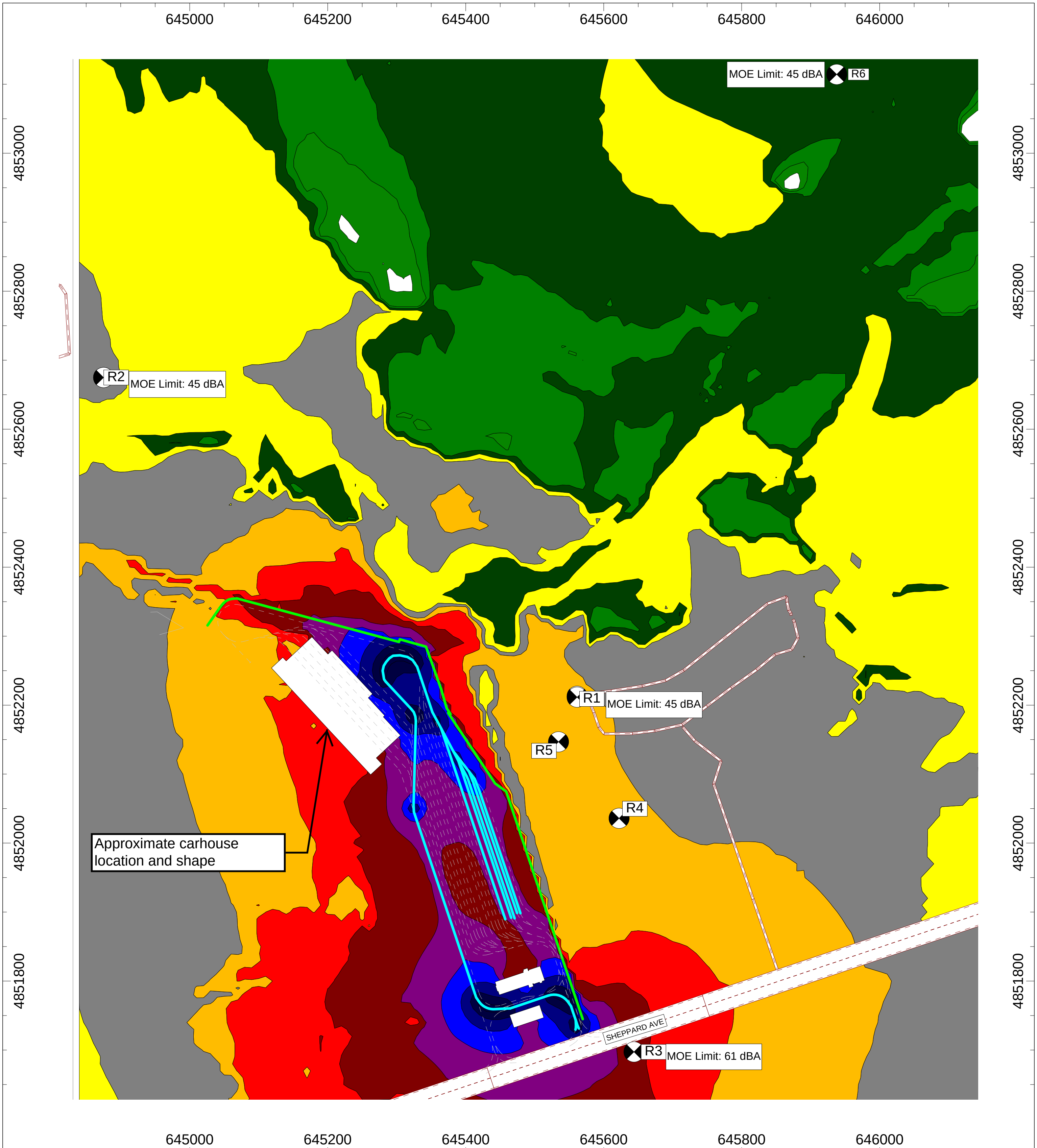
Appendix A

Streetcar Traffic Volume Scheduling

STREET CAR VOLUMES			
Time Period	**Analysis Period**	**Number of TRAINS**	**Direction**
Early AM	5:00 – 6:00 am	3	Leave Carhouse -> Meadowvale
		7	Leave Carhouse -> Don Mills Stn.
		6	Leave Carhouse -> Sheppard/Progress
AM	6:00 – 7:00 am	5	Leave Carhouse -> Meadowvale
		15	Leave Carhouse -> Don Mills Stn.
		11	Leave Carhouse -> Sheppard/Progress
Between AM & Midday	9:00 – 10:00 am	1	Return Meadowvale -> Carhouse
		1	Return Don Mills Stn. -> Carhouse
		4	Return Sheppard/Progress -> Carhouse
Between Midday & PM	2:00 – 3:00 pm	0	Leave Carhouse -> Meadowvale
		0	Leave Carhouse -> Don Mills Stn.
		4	Leave Carhouse -> Sheppard/Progress
Between PM & Early Evening	7:00 – 8:00 pm	1	Return Meadowvale -> Carhouse
		1	Return Don Mills Stn. -> Carhouse
		3	Return Sheppard/Progress -> Carhouse
Between Early Evening & Late Evening	10:00 – 11:00 pm	3	Return Meadowvale -> Carhouse
		8	Return Don Mills Stn. -> Carhouse
		3	Return Sheppard/Progress -> Carhouse
Late Evening	1:00 – 2:00 am	4	Return Meadowvale -> Carhouse
		11	Return Don Mills Stn. -> Carhouse
		11	Return Sheppard/Progress -> Carhouse
***Trains on Route 3 (Sheppard/Progress) consists of 3 cars per train**			

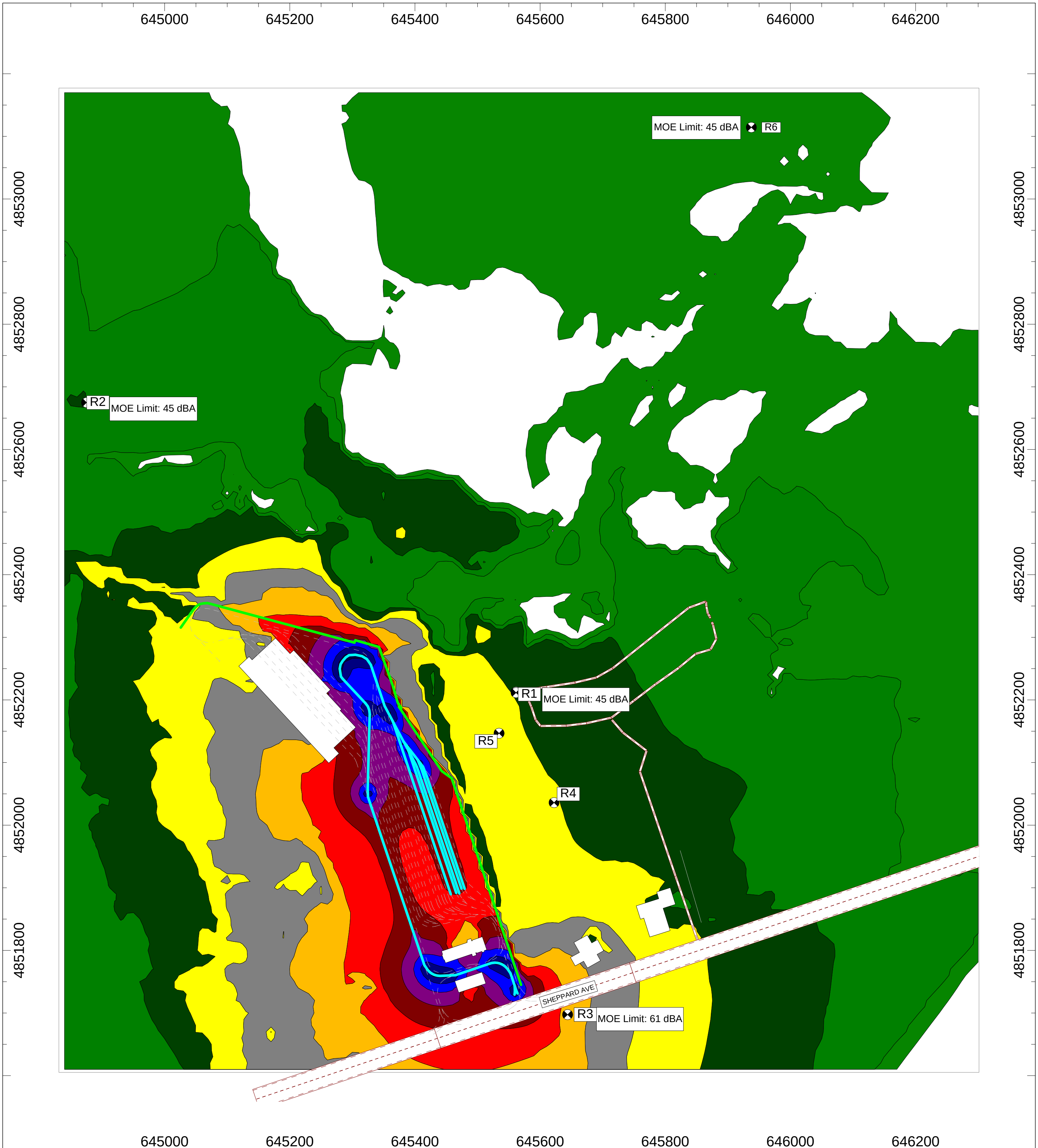
APPENDIX B

Sample Cadnaa Contours



TTC Sheppard Environmental Assessment
Appendix B - Sample Cadnaa Contours
Night-time (2300-0700), With Screeching
Receptor Height: 4.5m

	> -99.0 dB
	> 35.0 dB
	> 40.0 dB
	> 45.0 dB
	> 50.0 dB
	> 55.0 dB
	> 60.0 dB
	> 65.0 dB
	> 70.0 dB
	> 75.0 dB
	> 80.0 dB
	> 85.0 dB



TTC Sheppard Environmental Assessment
Appendix B - Sample Cadnaa Contours
Nighttime (2300-0700), Slight Screeching
Receptor Height: 4.5m