Railway and TTC Subway Vibration Study

Yonge Street and Birch Avenue

Proposed Mixed-use Development

8 Birch Avenue & 1198-1210 Yonge Street
City of Toronto

November 2, 2021
Project: 119-0342

Prepared for

Birch Equities Limited

Prepared by

Greg Dennis, M.Eng., P.Eng.

VALCOUSTICS
Canada Ltd.

Version History

Version #	Date	Comments
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TABLE OF CONTENTS

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TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

Railway and TTC Subway Vibration Study

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EXECUTIVE SUMMARY

Valcoustics Canada Ltd. (VCL) was retained to prepare a Railway and TTC Subway Vibration Study to support the Rezoning application submission to the City of Toronto. The topics addressed are:

- the effect of vibration generated by the existing environment on the project;
- the effect of vibration generated by the project on the environment; and
- the effect of vibration generated by the project on itself.

The proposed development will consist of a 15 storey mixed-use building with three levels of underground parking.

The significant sources of ground-borne vibration in the vicinity of the site is the rail traffic on the Toronto Transit Commission (TTC) Yonge-University Line 1 subway and the Canadian Pacific Railway (CPR) North Toronto Subdivision.

Based on the measurement results, the ground-borne vibration velocity magnitudes within the residential suites and the non-residential portions of the building are expected to be below the vibration guideline limits. Therefore, vibration mitigation is not mandatory for this site. However, as the building will provide high-end residential units, vibration isolation should be considered as part of the design to reduce the potential for vibration induced noise or small vibrations within the building.

1.0 INTRODUCTION

VCL was retained to prepare a Railway and TTC Subway Vibration Study report for the proposed development located at 8 Birch Avenue and 1198 to 1210 Yonge Street, in support of the Rezoning application to the City of Toronto.

The ground-borne vibration velocity magnitudes on site due to train pass-bys on the TTC Yonge-University Line 1 subway and CPR North Toronto Subdivision were measured and compared with the applicable vibration guideline limits to determine the need for mitigation. The results are outlined herein.

1.1 THE SITE AND SURROUNDING AREA

The site is located at 8 Birch Avenue and 1198-1210 Yonge Street, at the northwest corner of the intersection of Yonge Street and Birch Avenue in the City of Toronto.

The site is bounded by:

- existing 3-4 storey commercial buildings along Yonge Street, to the north;
- Yonge Street, with an existing 6-storey office building beyond, to the east;
- Birch Avenue, with a transformer station and the CPR Toronto North Subdivision beyond, to the south; and
- Existing 1-3 storey commercial buildings, with low-rise residential development beyond, to the west.

The site is currently occupied by low-rise mixed-use buildings, which will be demolished as part of the development.

A Key Plan is included as Figure 1.

The study is based on the architectural drawing set dated October 13, 2021, prepared by KPMB Architects. The Site / Roof Plan from the drawing set is included as Figure 2.

1.2 THE PROPOSED DEVELOPMENT

The proposed development consists of a 15-storey mixed-use building with three levels of underground parking and ground-floor retail. The retail units will be located along the east side of the ground floor, fronting onto Yonge Street and Birch Avenue. Residential suites will be located on Levels 3 to 15, with common indoor and outdoor amenity spaces at the mechanical penthouse floor.

2.0 THE EFFECT OF THE ENVIRONMENT ON THE PROJECT

2.1 VIBRATION SOURCES

The CPR North Toronto Subdivision rail corridor runs east-west, approximately 50 m to the south of the site. Rail traffic on this corridor consists of freight trains. The grade of the railway line is elevated relative to Yonge Street, as there is an underpass for the roadway.

The TTC Subway Yonge-University Line 1 subway is located below grade approximately 80 m east of the site.

Ground-borne vibration due to vehicle movements on surrounding roadways is not expected to be significant at the proposed development and thus, has not been considered further in this assessment. There are no other sources of vibration near the site.

2.2 VIBRATION GUIDELINES

At the present time there are no vibration guidelines in the land use approvals process in Ontario. In fact, there are no universally agreed on vibration criteria in general.

In lieu of any specific requirements from CPR or the TTC, the FCM/RAC guidelines have been used in this assessment, as is typical.

2.2.1 FCM/RAC Guidelines

The Federation of Canadian Municipalities and the Railway Association of Canada jointly developed "Guidelines for New Development in Proximity to Railway Operations" dated May 2013 (herein referred to as the FCM/RAC Guideline). For residential developments, the FCM/RAC Guideline recommends a maximum vibration threshold of 0.14 mm/s root mean square (RMS, using a 1 second averaging time) between 4 Hz and 200 Hz. This is equivalent to 75 dB re: 1 µ inch/sec. Appendix A includes a conversion chart for vibration velocity levels.

For the non-residential uses on Level 1 of the proposed building, there are no vibration guideline limits presented directly in the FCM/RAC Guideline. However, the FCM/RAC Guideline limits reference the International Standard Organization (ISO) 2631-2 (1989), which recommends a maximum vibration velocity, in 1/3 octave bands above 8 Hz, of 0.4 mm/s (84 dB re: 1 µ inch/sec) for office/retail use. Note, that if the overall vibration velocity does not exceed the guideline limit, then none of the 1/3 octave band vibration levels would exceed the guideline limit. Thus, showing the overall vibration velocity complies with the 1/3 octave band limit is sufficient to show compliance.

2.3 VIBRATION MEASUREMENTS

2.3.1 Measurement Locations

Continuous ground-borne vibration measurements were made on site at three (3) locations on August 13, 2020. Figure 2 shows the three vibration measurement locations.

- Location 1 – representing the northeast corner of the proposed building, approximately 80 m west of the TTC subway tracks and 85 m north of the CPR tracks.
- Location 2 – representing the southeast corner of the proposed building, approximately 80 m west of the TTC subway tracks and 45 m north of the CPR tracks.
- Location 3 – representing the southwest corner of the proposed building, approximately 110 m west of the TTC subway tracks and 54 m north of the CPR tracks.

Figure 2 shows the measurement locations.

2.3.2 Transducer Placement

Geophones were used at each location to measure the vibration velocity. At each location, the geophone was placed on the concrete sidewalk and a gravel bag was placed on top of the measurement system.

2.3.3 Data Acquisition

The vertical axis signal from each of the geophones was recorded digitally at each location, using a MetricPro Model MPV3C21 vibration data acquisition and analysis system. The geophones, as well as the vibration data acquisition and analysis system were calibrated in the office before the site visit and a sensor check was performed prior to use.

At each location, the vibration data acquisition system recorded the ground borne vibration continuously throughout the monitoring period. The system was set to monitor using a sample rate of 1024 samples per second.

The vibration signals were recorded simultaneously at Locations 1, 2 and 3 for five (5) TTC subway pass-bys and four (4) CPR freight train pass-bys.

2.3.4 DATA ANALYSIS

Time histories of the measured overall vibration velocity (using a one-second RMS) of each train pass-by were plotted and compared to the vibration criterion. The analysis procedure conforms to the guidelines recommended by FCM/RAC.

2.4 RESULTS

2.4.1 Measurement Results

Table 1 summarizes the maximum overall vibration velocity magnitudes (one second RMS) due to the train pass-bys at each location.

The maximum measured overall ground-borne vibration velocity (RMS) at each location was:

- Location 1 – 0.11 mm/s;
- Location 2 – 0.15 mm/s; and
- Location 3 – 0.10 mm/s.

Appendix B shows the time histories of the vibration velocity for each train pass-by at each location in terms of one second RMS.

2.4.2 Assessment of Vibration Impact from TTC Subway Trains

The highest vibration velocities measured at Locations 1, 2 and 3 due to the TTC Subway trains were 0.03 mm/s (62 dB), 0.07 mm/s (69 dB) and 0.2 mm/s (58 dB), respectively.

The measured vibration velocities due to the TTC Subway trains at locations representative of the building foundation of the proposed building do not exceed the guideline limit of 75 dB (0.14 mm/s) limit for residential use or the 84 dB (0.4 mm/s) limit for retail use.

2.4.3 Assessment of Vibration Impact from Freight Trains on CPR Line

The highest vibration velocities measured at Locations 1, 2 and 3 due to the freight train pass-bys along the CPR tracks were 0.11 mm/s (73 dB), 0.15 mm/s (76 dB) and 0.09 mm/s (71 dB), respectively.

The measured levels comply with the 84 dB (0.4 mm/s) limit for retail uses.

At the nearest residential suites, the measured vibration level outdoors at grade would be attenuated through the propagation path up to the 3rd floor residential suites in the proposed building. Accounting for coupling loss due to soil-structure interactive, floor to floor attenuation as well as mid-span amplification, it is expected that there would be at least a 6 dB loss in vibration energy (from the measured outdoor vibration level to the expected vibration level at the second floor residential suites). Therefore, it is expected that the 75 dB vibration guideline limit for residential suites would be met.

2.5 DISCUSSION AND RECOMMENDATION

The measured vibration magnitudes from the train pass-bys are expected to be below the vibration guideline limits at the proposed building.

The above said, as the development will provide high-end units, vibration mitigation should be considered as part of the building design to help reduce vibration induced noise within the building and any small vibrations that may occur. One way to do this would be isolating the below grade foundation from the surrounding soil and backfill.

The isolation concept could be reviewed as part of the detailed engineering design.

3.0 THE EFFECT OF VIBRATION GENERATED BY THE PROJECT ON THE ENVIRONMENT

There is no anticipated ground-borne vibration generated by the proposed development once occupied that could affect the surrounding environment. However, some ground-borne vibration may be anticipated during the construction activities at the site. This will be addressed separately as part of the building permit application process as required by the City under the Toronto Municipal Code Chapter 363 "Building Construction and Demolition".

4.0 THE EFFECT OF VIBRATION GENERATED BY THE PROJECT ON ITSELF

There will be insignificant effect of the building on the occupants, except potentially in close proximity to any mechanical equipment areas. Here, the isolation of vibration will be a matter of routine engineering design of the mechanical system. With proper design, a satisfactory environment is readily achievable. This is typically determined at the building permit application process or during the detailed design or shop drawing review stages where more detailed information regarding the equipment selection is available. There are no other anticipated sources of vibration within the development.

5.0 CONCLUSION

The ground-borne vibration velocity magnitudes due to rail traffic on the TTC Yonge-University Line 1 subway and the CPR North York Subdivision within both the residential suites and the non-residential portions of the building are expected to be below the vibration guideline limits. Therefore, vibration mitigation is not mandatory for this site. However, as the site will provide high-end residential units, vibration isolation should be considered as part of the design to reduce the potential for vibration induced noise and any small vibrations within the building.

6.0 REFERENCES

1. "Guidelines for New Development in Proximity to Railway Operations", Prepared for The Federation of Canadian Municipalities and the Railway Association of Canada, May 2013.

2. "Transit Noise and Vibration Impact Assessment", Federal Transit Administration, Department of Transportation, USA, May 2006.

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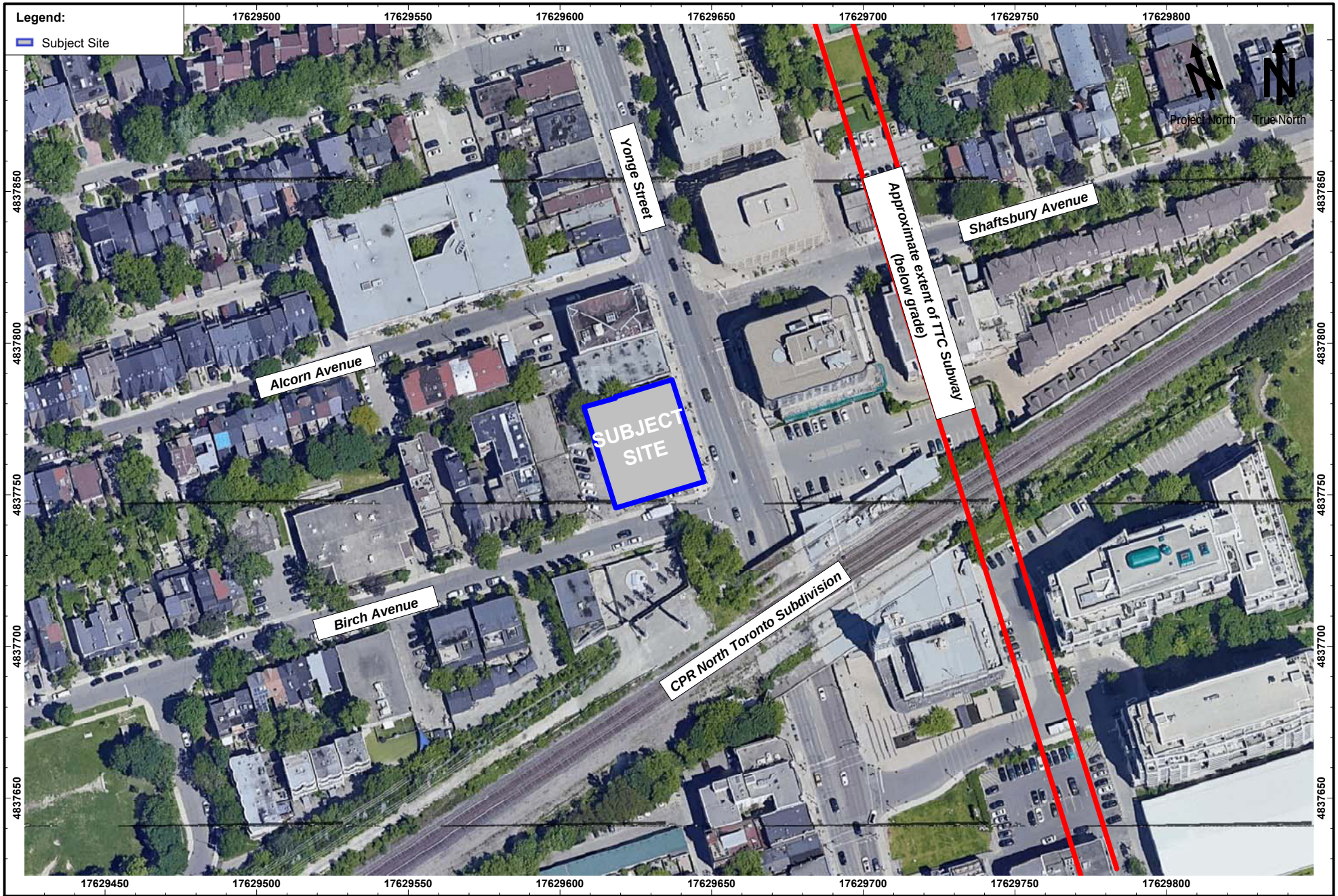
TABLE 1 SUMMARY OF MEASURED OVERALL MAXIMUM VIBRATION VELOCITY

Pass-by #	Train Details		Maximum Vibration Velocity(1) (mm/s)		
	Time	Direction(2)	Location 1(3)	Location 2(3)	Location 3(3)
Freight #1	11:11:06 – 11:17:06	WB	0.08	0.11	0.06
TTC Subway #1	11:16:05 – 11:16:25	NB	0.02	0.07	0.01
TTC Subway #2	11:16:50 – 11:17:10	NB	0.03	0.03	0.02
TTC Subway #3	11:17:20 – 11:17:40	SB	0.03	0.04	0.02
TTC Subway #4	11:17:50 – 11:18:10	SB & NB	0.02	0.02	0.01
TTC Subway #5	11:18:28 – 11:18:50	NB	0.03	0.07	0.02
Freight #2	13:56:57 – 14:03:57	WB	0.09	0.09	0.10
Freight #3	14:41:01 – 14:42:01	WB	0.10	0.09	0.06
Freight #4	16:33:03 – 16:35:58	WB	0.11	0.15	0.09

Notes:

(1) Maximum RMS (one second averaging) vibration. See Appendix B for time history plots of vibration velocity.
(2) Vibration data not available.
(3) NB = northbound, SB = southbound, WB = westbound.



VALCOUSTICS Canada Ltd.
consulting acoustical engineers

Title: **Key Plan**	Date: **Nov 1, 2021**	Figure: **1**
Project Name: **Yonge Street and Birch Avenue, Toronto**	Project No.: **1190342.000**	

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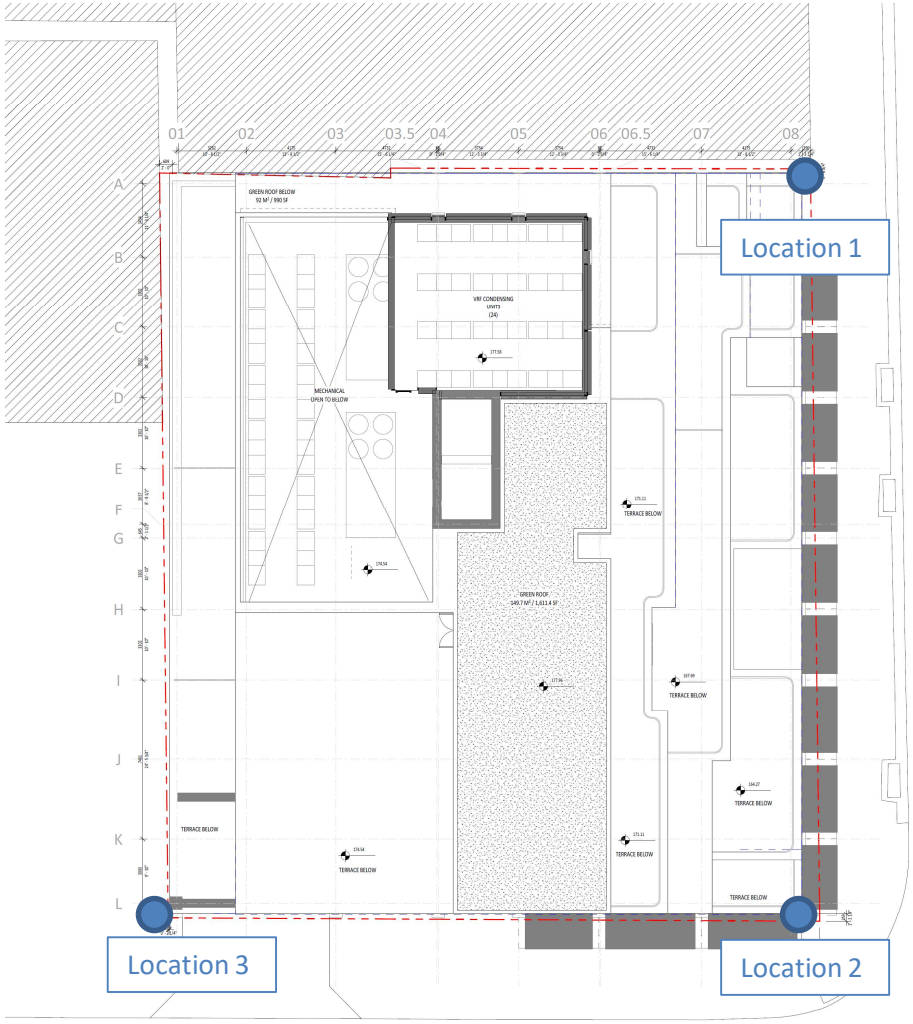
Date Plotted: 01.06.21



1 SITE / ROOF PLAN

Key

- Vibration Monitoring Location

VALCOUSTICS Canada Ltd.	Title: Site / Roof Plan	Date: 2021-11-01	Figure: 2
	Project Name: Yonge Street and Birch Avenue, Toronto	Project No.: 119-0342	

APPENDIX A

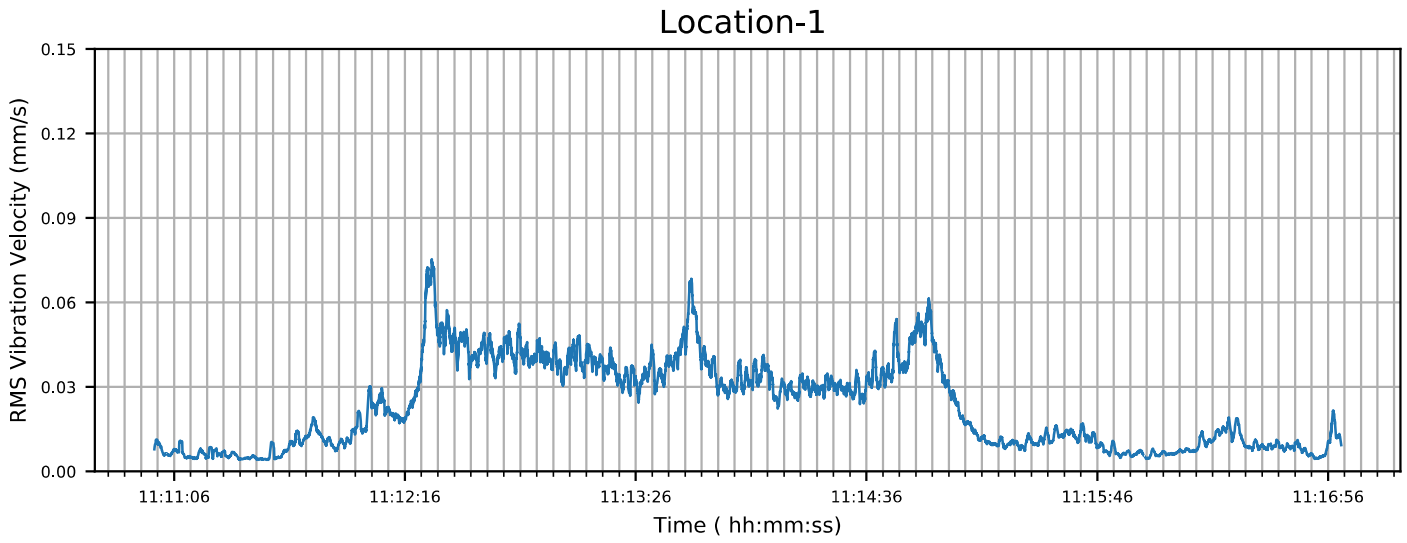
CONVERSION CHART FOR VIBRATION VELOCITY LEVELS

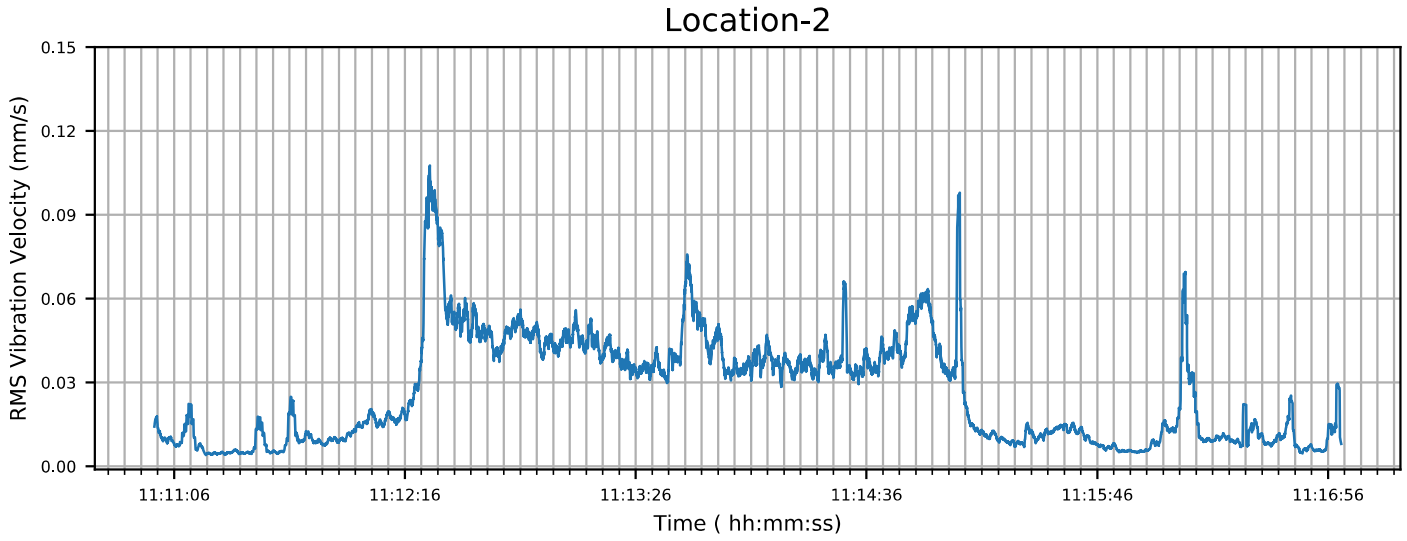
CONVERSION TABLE FROM VIBRATION VELOCITY LEVEL IN DECIBELS (dB re: 1 micro-inch/sec) TO PHYSICAL UNITS (mm/sec)

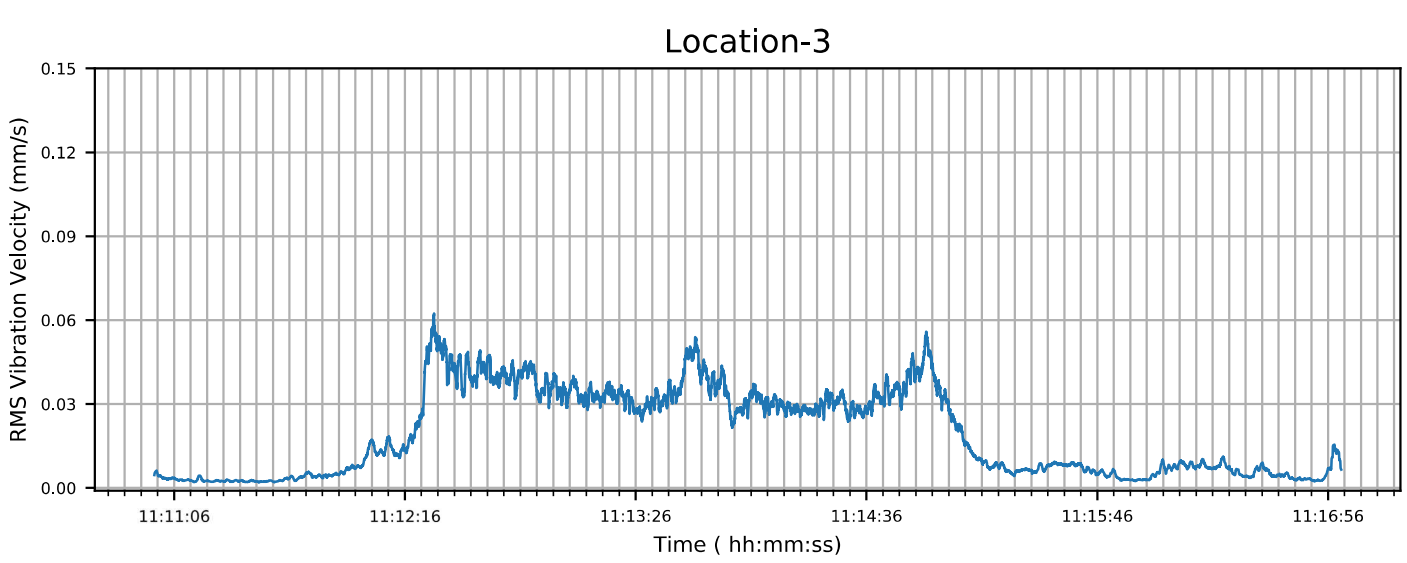
Vibration Velocity Level in dB (re 1 μ inch/sec.)	Vibration Velocity in mm/s
46	.005
47	.006
48	.006
49	.007
50	.008
51	.009
52	.010
53	.011
54	.013
55	.014
56	.016
57	.018
58	.020
59	.023
60	.025
61	.028
62	.032
63	.036
64	.040
65	.045
66	.051
67	.057
68	.064
69	.072
70	.080
71	.090
72	.101
73	.113
74	.127
75	.143
76	.160
77	.180
78	.202
79	.226
80	.254
81	.285
82	.320
83	.359
84	.403
85	.452
86	.507

APPENDIX B

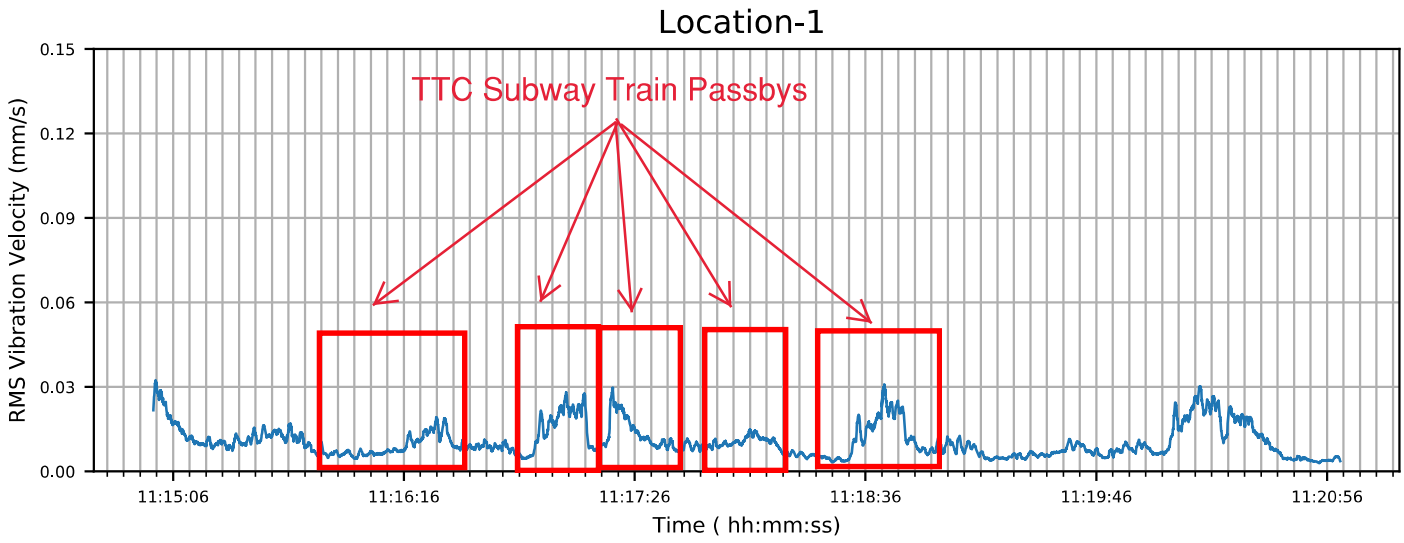
VIBRATION VELOCITY TIME HISTORIES

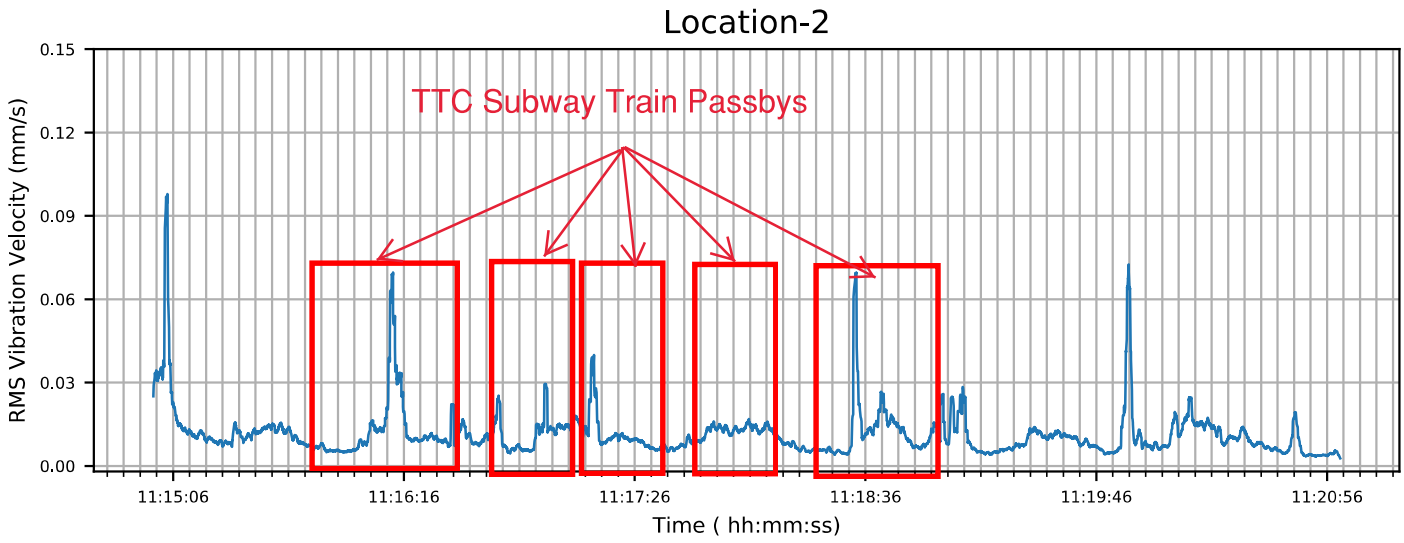


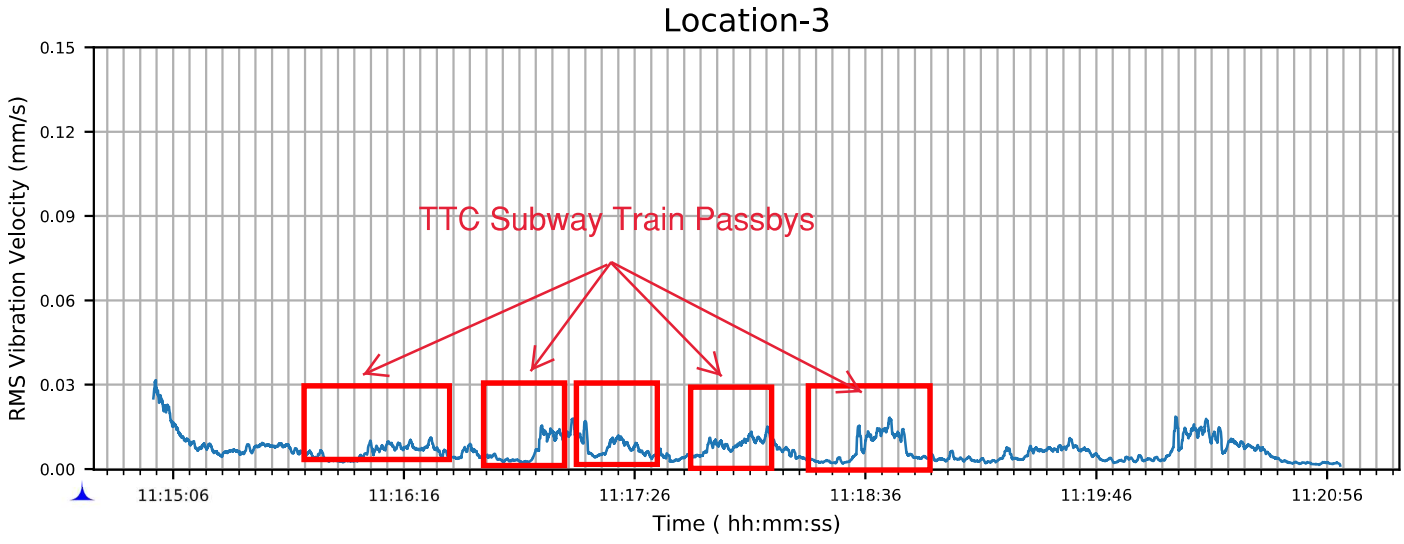




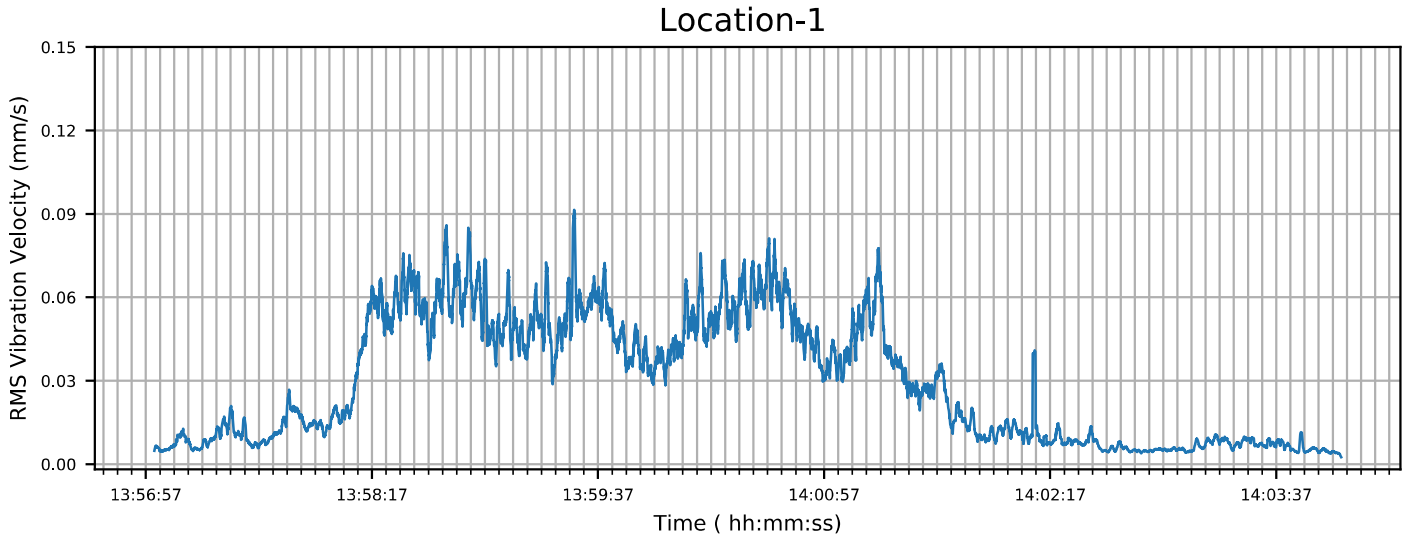
	Title	Measurement Date	Figure
VALCOUSTICS Canada Ltd.	Time History - Freight train #1	Aug 13, 2020	B1
	Project Name	Project Num.	
	Yonge Street and Birch Avenue	119-0342	

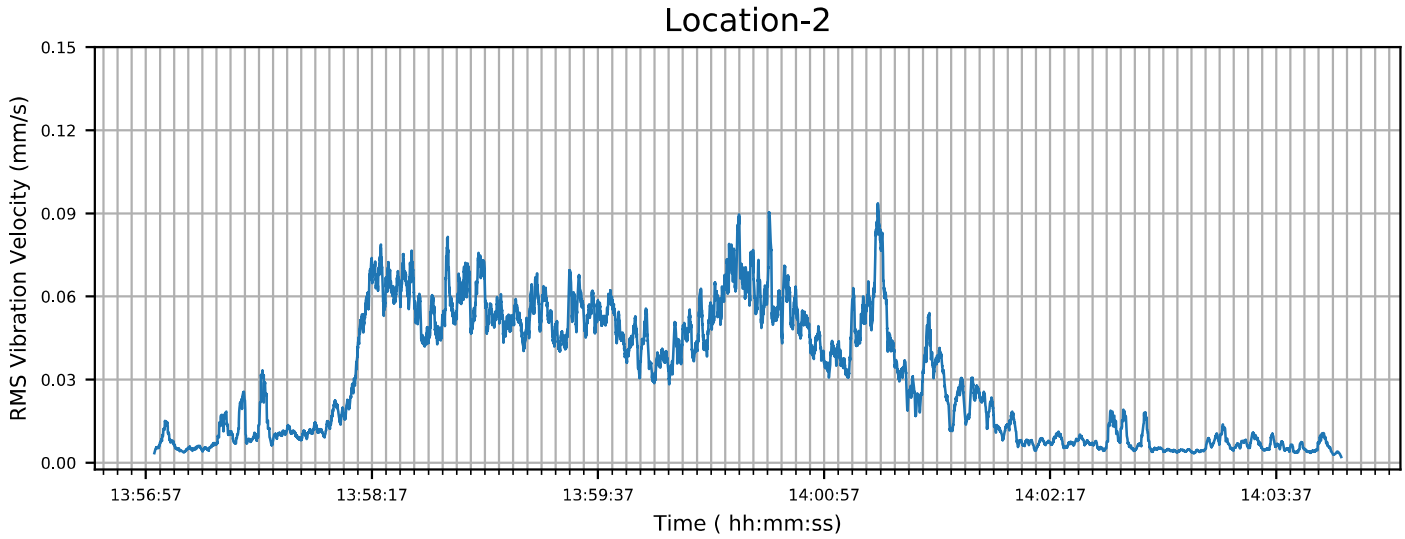


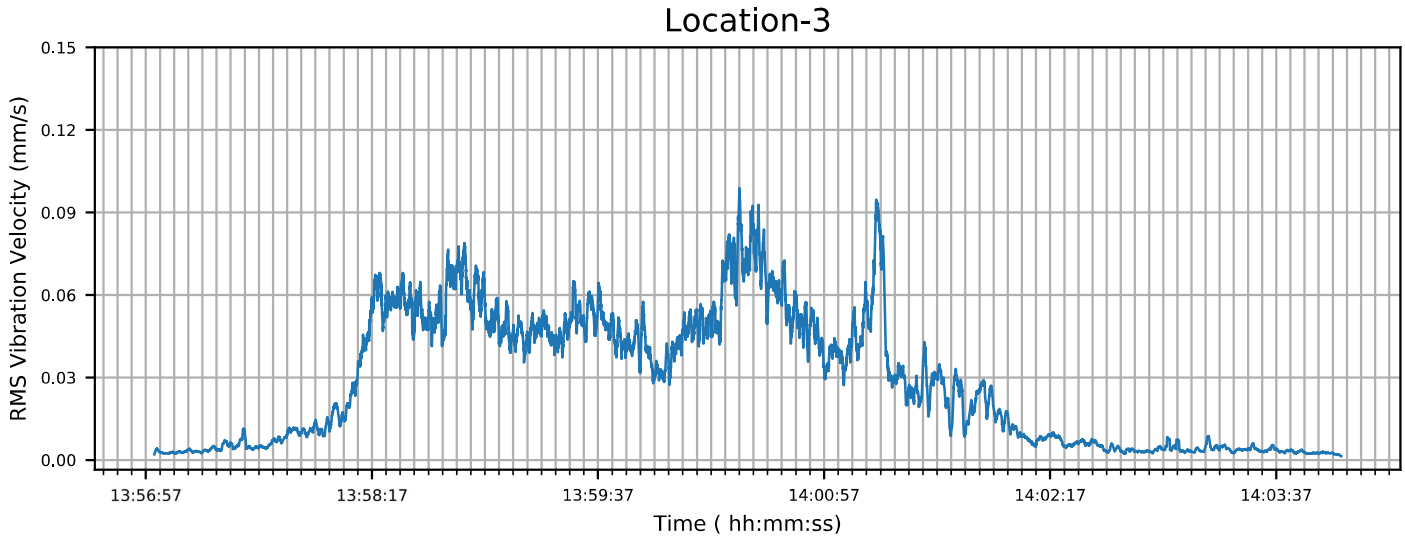




VALCOUSTICS Canada Ltd.	Title: Time History - TTC Subway #1 to #5	Measurement Date: Aug 13, 2020	Figure: B2
	Project Name: Yonge Street and Birch Avenue	Project Num.: 119-0342	







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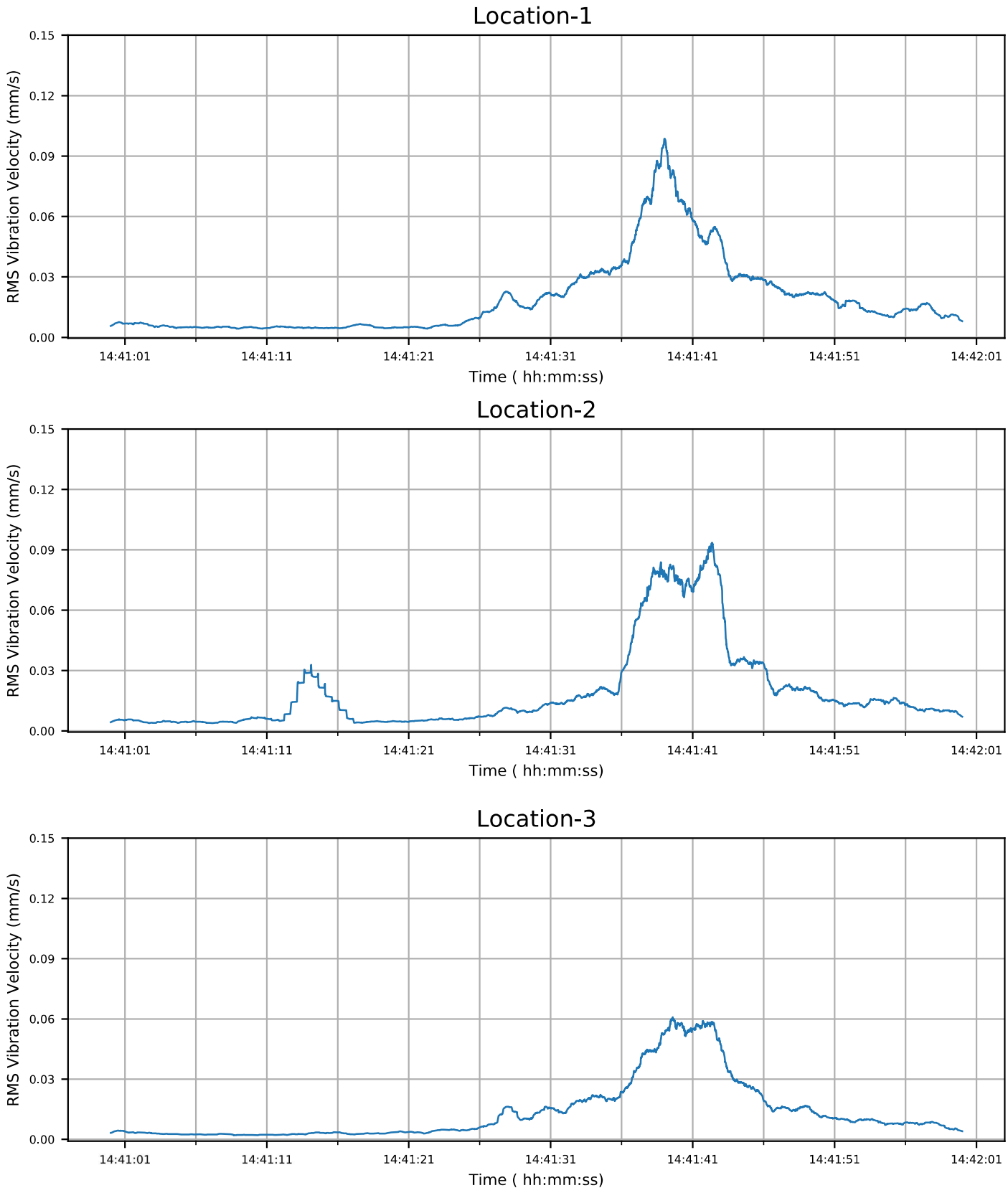

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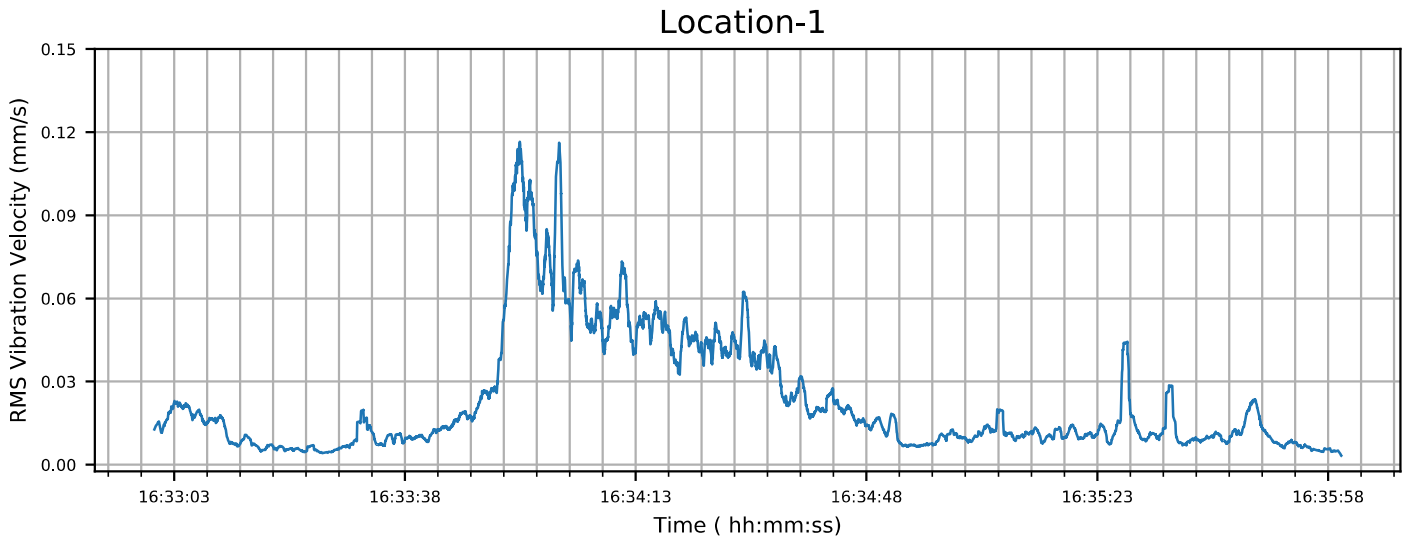

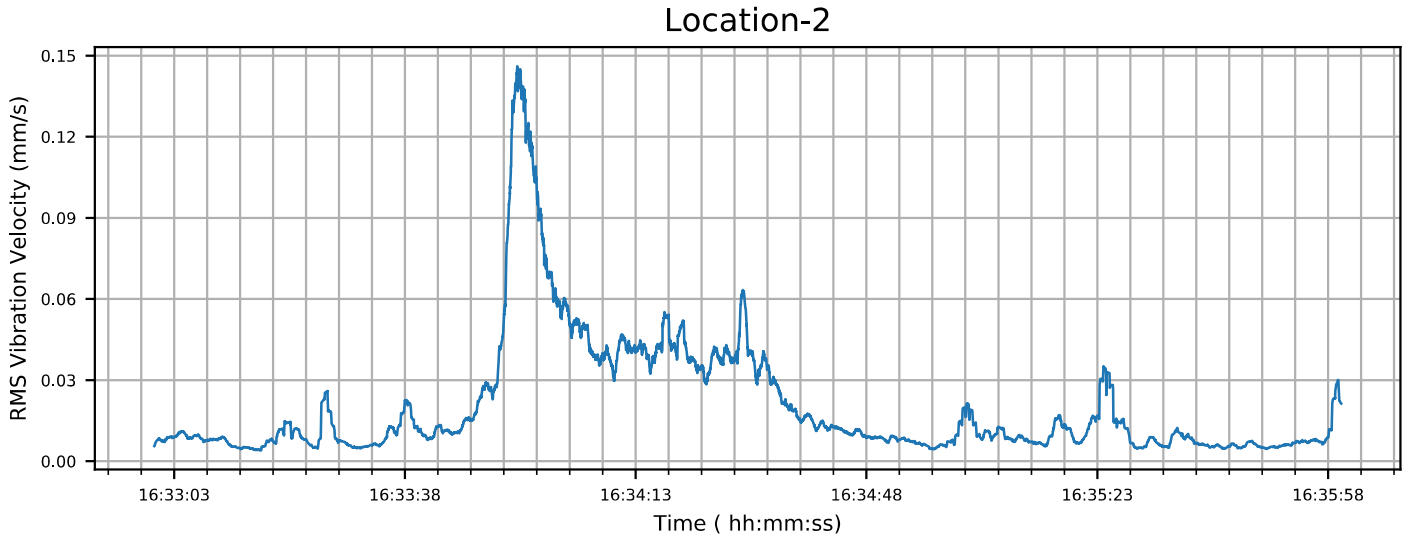

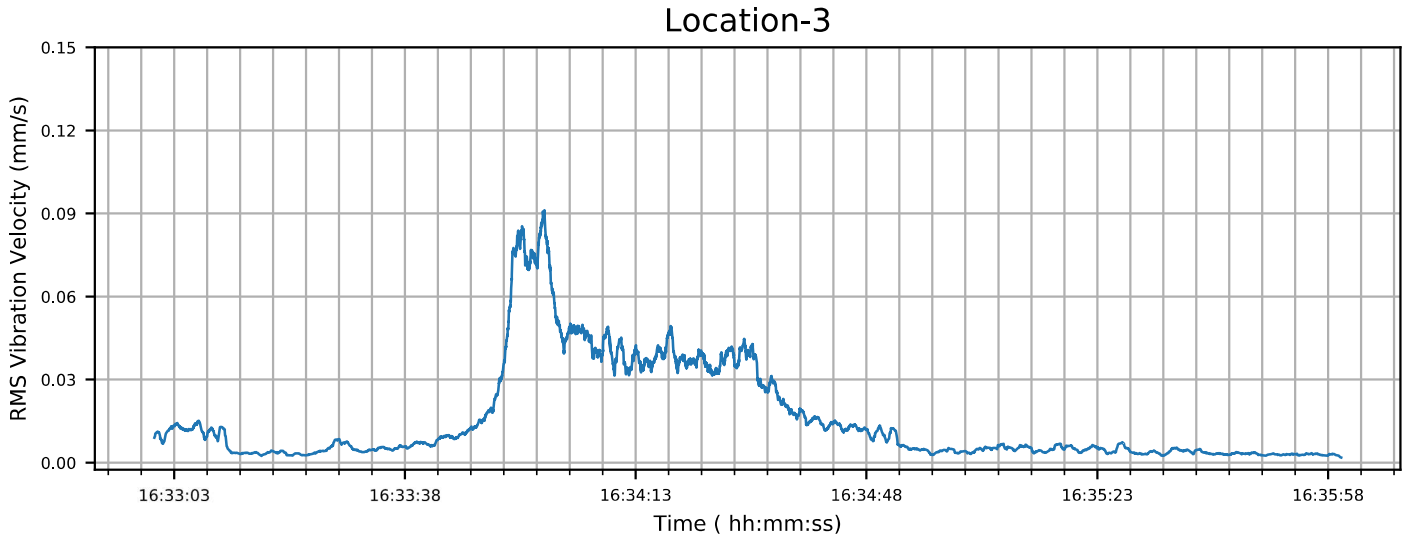

VALCOUSTICS Canada Ltd.	Title: Time History - Freight #4	Measurement Date: Aug 13, 2020	Figure: B5
	Project Name: Yonge Street and Birch Avenue	Project Num.: 119-0342	