



July 15, 2026

The Sterling Hall School c/o CS&P Architects Inc.
99 Cartwright Avenue
Toronto, Ontario
M6A 1V4

Attention: Mr. Rob Buwalda

Subject: Multichannel Analysis of Surface Waves (MASW) Test
The Sterling Hall School
99 Cartwright Avenue
Toronto, ON

Englobe reference: 02210387.007

Dear Rob,

This letter provides a summary of the results of the on-site Multichannel Analysis of Surface Waves (MASW) test conducted for the shear wave velocity (V_s) measurement at the above-referenced site, completed by Frontwave Geophysics Inc., retained by Englobe Corp. (herein referred to as "Englobe").

The Ministry of Municipal Affairs and Housing (MMAH) has adopted the 2024 Ontario Building Code (OBC) that came into effect on January 1, 2025. The 2024 OBC is further harmonized with 2020 National Building Code (NBC) of Canada. This includes the use of the new 6th Generation Seismic Hazard Model for determining seismic hazard, which was developed for the 2020 NBC.

The 2024 OBC provides seismic hazard values based on Site Designation. The Site Designation (X) shall be X_v , where V is the value of the average shear wave velocity, $\bar{V}_{s30}$, calculated from in-situ measurements of the shear wave velocity in top 30 m of the ground profile except for the four (4) specific ground profiles as set out in the Table 4.1.8.4.-A of 2024 OBC, where Site Designation shall be determined in accordance with Table 4.1.8.4.-A.

The 2024 OBC also provided alternative methods to determine the Site Designation (X_s), if $\bar{V}_{s30}$ calculated from in situ measurements is not available. In this case, the Site Designation shall be X_s , where S is the original Site Class determined using energy-corrected average standard penetration resistance ($\bar{N}_{60}$) or the average undrained shear strength ($\bar{S}_u$) in the top 30 m of the site stratigraphy below the foundation level in accordance with Table 4.1.8.4.-B (with associated notes). There are six Site Classes (S) from A to F, decreasing in ground stiffness from A, hard rock, to E, soft soil; with site class F used to denote problematic soils (e.g., sites underlain by thick peat deposits and/or liquefiable soils). Note that providing a Site Designation based on a Site Class approach (i.e., without direct measurement of shear wave velocities) will generally result in higher seismic demand for the site.

At this site, Frontwave Geophysics Inc. was retained by Englobe to conduct a site-specific Multichannel Analysis of Surface Waves (MASW) test on February 21, 2026, to establish the Site Seismic Designation based on the direct measurement of the in-situ shear wave velocity. Frontwave Geophysics conducted site-specific shear wave velocity soundings in the area. The test results measuring the minimum, maximum,

and average shear wave velocity (V_{s30}) in the 30 m soil below the foundation level are provided in the Frontwave Geophysics report provided in Appendix A and summarized in the table below along with the recommended Site Designation as per 2024 Ontario Building Code.

Depth (m)	Minimum V_{s30} (m/s)	Average V_{s30} (m/s)	Maximum V_{s30} (m/s)	OBC 2024 Site Designation
0 to 30	422	453	481	X ₄₅₃
3 to 33	443	481	515	X ₄₈₁

Based on the tests conducted on site, Site Designation X₄₅₃ is recommended for this site.

We trust the foregoing information is sufficient for your present requirements. If you have any questions, or if we can be of further assistance, please do not hesitate to contact us.

Yours truly,

Englobe Corp.




Rattan Singh, M.Eng., P.Eng.
Project Manager, Geotechnical Engineering – GTA




Seth Zhang, M.Eng., M.Sc., P.Eng.
Team Lead, Geotechnical Engineering – GTA

Appendices

Appendix A MASW Test Report

Revisions and publications log

REVISION No.	DATE	DESCRIPTION
0A	February 25, 2026	Draft Memo
00	July 15, 2026	Final Memo

Distribution

1 original + 1 copy + 1 PDF copy	The Sterling Hall School c/o CS&P Architects Inc.
----------------------------------	---

Property and Confidentiality

This report has been prepared by Englobe Corp. (“Englobe”) for the exclusive use of the person or entity to whom it is addressed (the “Client”) and for the purposes outlined in the agreement between Englobe and the Client (the “Agreement”). The content of this report, including all data, analyses, and recommendations, is confidential and proprietary to Englobe and/or the Client.

Ownership and Use

All intellectual property rights in this report remain the exclusive property of Englobe. Provided that all fees owed to Englobe under the Agreement have been paid in full, the Client is granted a limited, non-transferable license to use the report solely for its intended purpose, in accordance with the Agreement. Any use must consider the report’s purpose, scope, limitations, and the state of scientific knowledge at the time of preparation.

The report contains confidential information proprietary to Englobe. The reproduction, distribution, or adaptation of the report, in whole or in part, is strictly prohibited without the prior written consent of Englobe. The report must be read and considered in its entirety. Extracts or partial use are not permitted without prior written authorization.

Limitation of Liability

This report has been prepared in accordance with the standard of care, skill, and diligence generally exercised by professional engineers providing similar services under comparable circumstances in the same locality at the time the services were performed. No other warranties, express or implied, are made, including but not limited to warranties regarding the completeness, accuracy, or suitability of the information contained in this report. Englobe expressly disclaims any responsibility or liability for:

- Use of this report beyond the scope of the Agreement;
- Use of the report or any portion thereof by third parties without prior written authorization from Englobe; or
- Unauthorized reproduction, distribution, or adaptation of the report.

Appendix A

MASW Report



eNGLOBE



FRONTWAVE
G E O P H Y S I C S

**SHEAR WAVE VELOCITY TESTING
FOR SEISMIC SITE CLASSIFICATION
THE STERLING HALL SCHOOL
99 CARTWRIGHT AVENUE, TORONTO, ONTARIO**

Submitted to:

Englobe Corp.
20 Carlson Court
Etobicoke, Ontario M9W 7K6

Attention:

Mr. Rattan Singh, M.Eng., P.Eng.

Email: rattan.singh@englobecorp.com

File No. F-26484

February 25, 2026
Revision 1

Frontwave Geophysics Inc.
Brampton, ON
(647) 514-4724
www.frontwave.ca

TABLE OF CONTENTS

1	INTRODUCTION	1
2	INVESTIGATION METHODOLOGY	1
3	RESULTS	4
4	CLOSURE	8

LIST OF FIGURES

Figure 1.	Survey location plan.....	2
Figure 2.	The procedure of MASW data processing using the SeisImager SW software package	3
Figure 3.	Example shot record and MASW dispersion images.....	5
Figure 4.	Shear wave velocity profile from MASW sounding.....	6

LIST OF TABLES

Table 1.	Shear wave velocities from MASW sounding.....	7
Table 2.	V_{s30} values from MASW sounding.....	7

1 INTRODUCTION

Frontwave Geophysics Inc. was retained by Englobe Corp. to carry out a geophysical investigation for the proposed addition to the Sterling Hall School located at 99 Cartwright Avenue in Toronto, Ontario.

The objective of the survey was to determine site designation for seismic site response based on average shear wave velocity value measured in the upper 30 m (V_{s30}). The multi-channel analysis of surface waves (MASW) method was used to obtain shear wave velocity profile.

The fieldwork was conducted on February 21, 2026. The location of the MASW survey line is shown in Figure 1.

This report describes the basic principles of MASW, survey design, interpretation method, and presents the results of the investigation in the chart and table format.

2 INVESTIGATION METHODOLOGY

Overview

The Multi-channel Analysis of Surface Waves (MASW) is a seismic method widely applied to produce shear wave velocity (V_s) profiles. It is based on the dispersive nature of Rayleigh or Love surface waves in layered media. Surface waves with longer wavelengths propagate deeper in the subsurface, hence, their phase velocity is more influenced by the elastic properties of deeper layers. The velocity of surface waves depends mainly on the shear wave velocity of the medium. The distribution of surface waves phase velocities as a function of wavelength (or frequency) can be visualized as a dispersion curve. The inverse problem is then solved by modelling the experimental data with a theoretical dispersion curve; the model parameters are typically limited to layer thickness and shear wave velocity with an assumption of horizontally layered strata. As a result of the inversion, a shear wave velocity depth profile is obtained. Figure 2 illustrates the overall procedure of the MASW method.

Two approaches different in data acquisition and processing can be implemented. The active method involves using artificial sources (e.g., sledgehammer, drop weight) to generate seismic energy, whereas the passive method utilizes energy generated by natural sources (wind, waves, microseismicity) and human activities (mostly vehicle traffic). The energy that can be generated with easily accessible active sources such as sledgehammers is typically concentrated within a relatively high frequency range, and the maximum depth of penetration for active surveys is limited to approximately 15-30 m, depending on the mass of the source and geology of the site. Ambient vibrations registered with the passive acquisition are usually of lower frequency and provide better resolution at greater depths. When survey logistics allow, the active and passive source methods are combined for obtaining well-resolved dispersion images over a wide frequency range, thus increasing the depth of investigation while retaining high resolution at shallow depths.



Legend



Location of MASW survey line
(69 m geophone spread)

Image: Google Earth 2021

Date: 2026-02-25

File No: F-26484



Title: Survey location plan

Location: 99 Cartwright Ave
Toronto, ON

Figure:
1

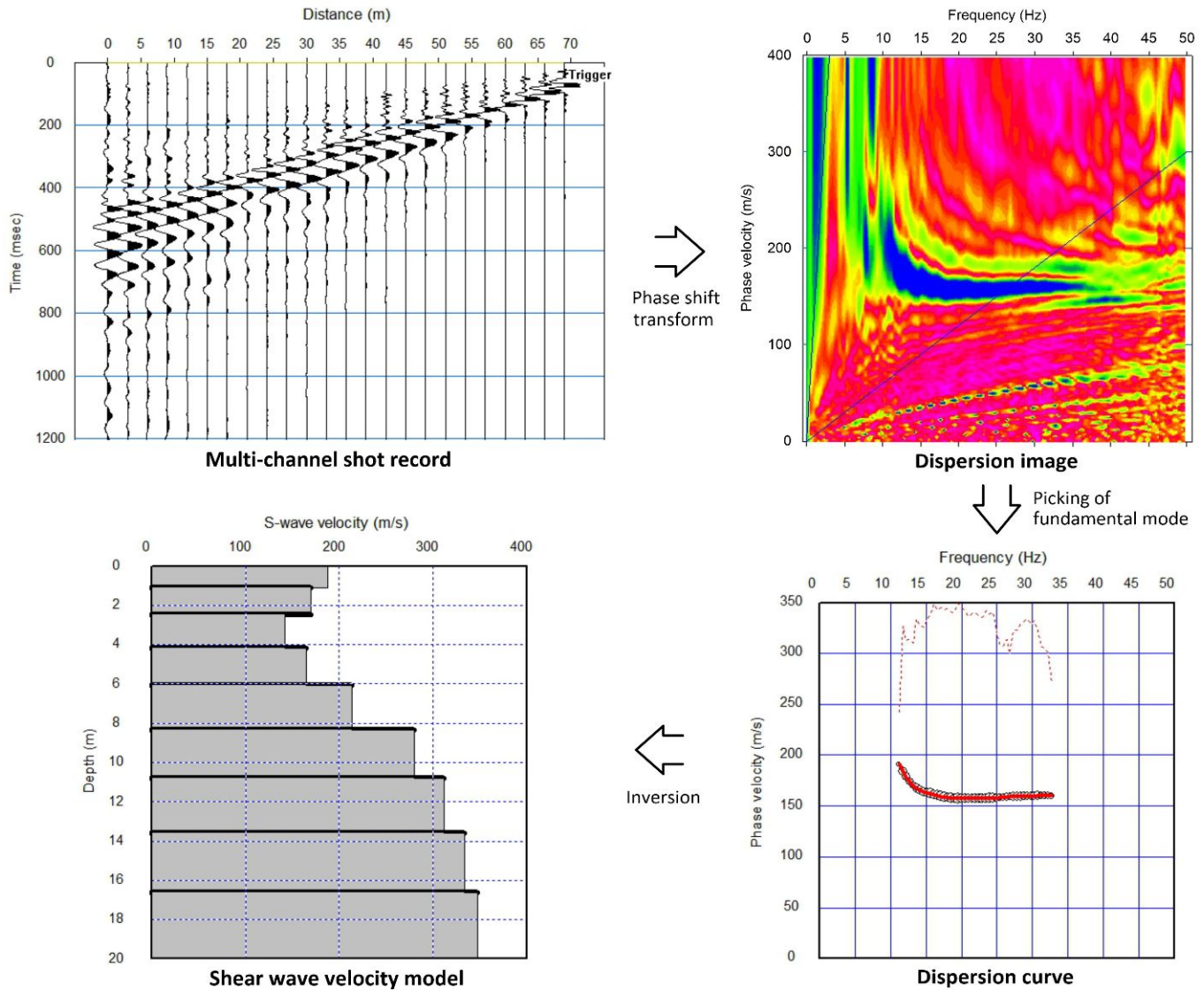


Figure 2 The procedure of MASW data processing using the SeisImager SW software package.

Survey Design

The acquisition layout consisted of 24 receivers in a linear array (spread), connected with a multicore cable to a DAQLink 4 seismograph. 4.5 Hz natural frequency vertical geophones were used for this survey. To optimize sampling of different wavelengths, two sets of measurements were conducted with spread lengths of 23 m and 69 m (1 m and 3 m spacing between geophones, respectively). Data collected with longer spreads provide a greater depth of investigation, whereas data collected with shorter geophone spacings ensure better resolution in the uppermost few meters of the subsurface.

An 8-kg sledgehammer was used as an energy source for active acquisition. Shots were executed at three to five locations per spread: two shots close to the ends of the spread and one to three

shots within the spread. A total of 8 shot records was collected. The record length was set to 1500 ms with a 0.05 ms sampling interval.

For passive acquisition, a linear 24-channel array with 3 m spacing between geophones was used. Ambient wavefield was recorded for 10 minutes with a sampling interval of 2 ms.

Interpretation

A dispersion curve is obtained from each field record by converting the shot gather into a dispersion image and then identifying and picking the fundamental mode. A shear wave velocity profile is obtained through inversion of the dispersion curve by modelling the subsurface as a horizontally layered medium with the model parameters limited to the number of layers, their thickness and shear-wave velocity.

SeisImager SW software package was used for processing, picking and inversion of the MASW data.

Some variability among the dispersion curves and resulting models obtained from different shot records is always observed due to lateral velocity variations, near and far field effects, different signal-to-noise ratio, etc. Combining independent inversion results from multiple shot records improves the estimation of the actual shear wave velocity and provides an assessment of uncertainty. The results of the interpretation are presented in the form of the average shear wave velocity profile; the observed variability of the MASW data is reported as upper and lower bound velocity profiles.

Accuracy of the results

The accuracy of MASW generally depends on the complexity of the subsurface and specific site conditions (noise levels, topography, etc.). Lateral velocity variations and steeper bedrock topography increase the dispersion uncertainty. The presence of high velocity contrast layers such as bedrock will require the use of a-priori information to optimize model parameters for more accurate results. Hence, if the a-priori information is not available (e.g. when the data are overly noisy to carry out refraction analysis), the accuracy decreases.

The uncertainty of the resulting S-wave velocity depth profile is evaluated using the upper and lower bound velocity profiles. Typically, the error margin of average V_{s30} value determined from MASW is within $\pm 10\%$.

3 RESULTS

The collected surface wave data were of good quality; the dispersion images showed good resolution and covered a frequency range of approximately 3 to 65 Hz. Example shot record and MASW dispersion images obtained at this site are presented in Figure 3.

Seismic refraction analysis indicated that the depth to bedrock at this site was beyond the investigation depth of the refraction method (which was estimated to be approximately 23 m below the ground surface). Compressional (P) wave velocity measured in the overburden below the water table was approximately 2100 m/s.

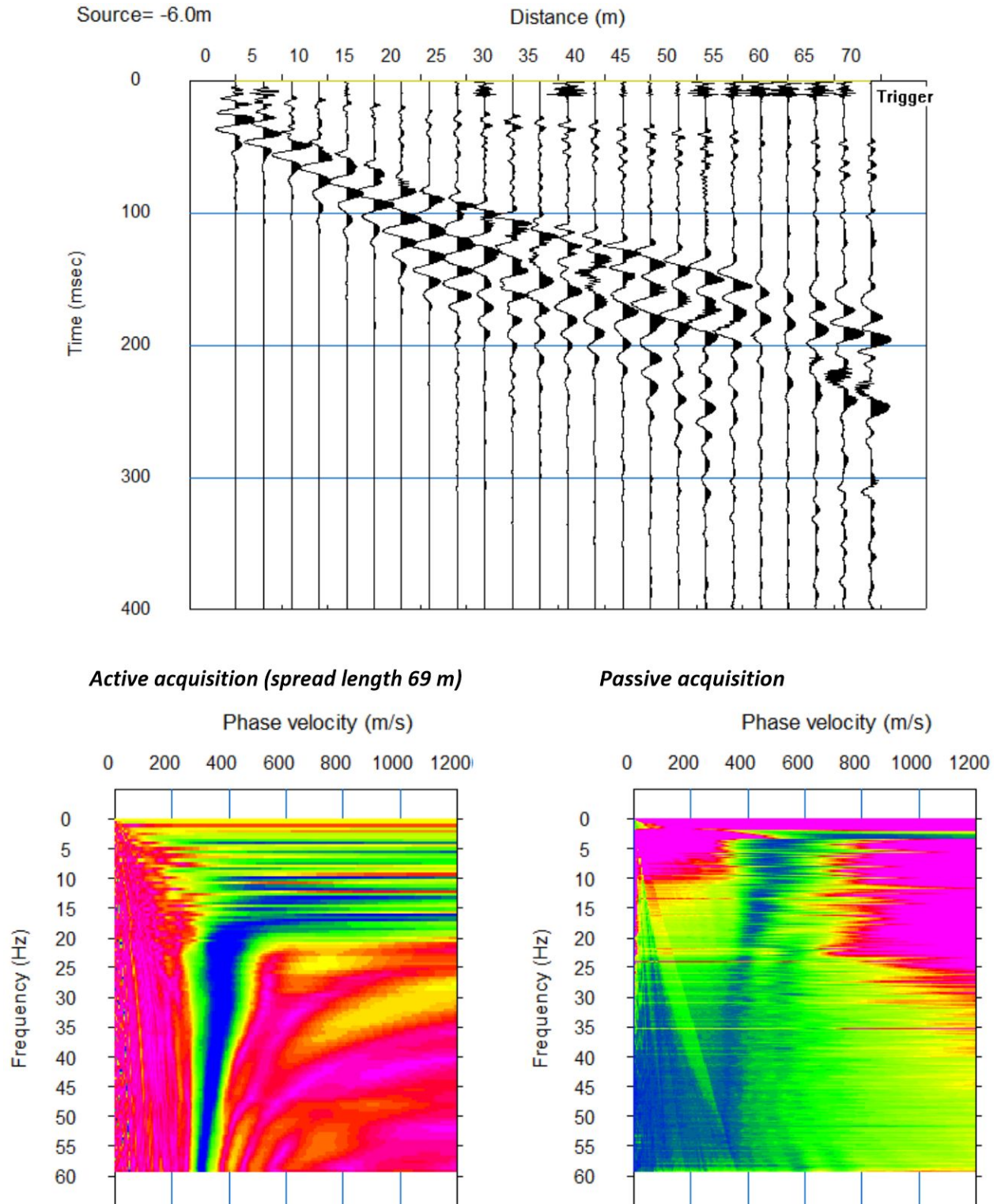


Figure 3 Example shot record (top) and MASW dispersion images (bottom).

The results of the MASW sounding are presented in Figure 4. The average shear wave velocity profile from the active shot records and passive data is plotted in the chart as a solid line. The dashed lines represent the upper and lower bound S-wave velocity profiles.

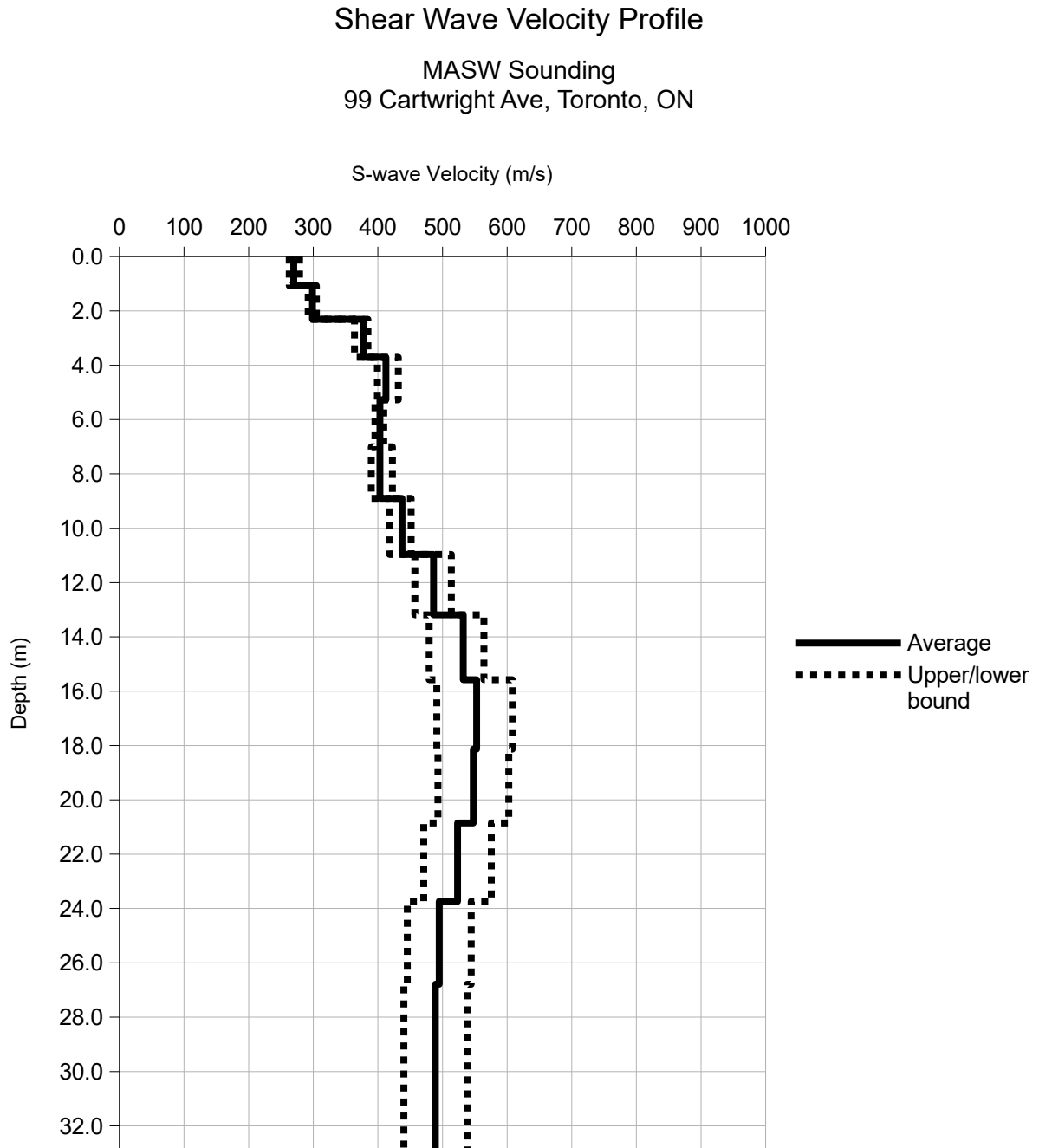


Figure 4 Shear wave velocity profile from MASW sounding.

The tabulated shear wave velocity model is presented in Table 1.

Table 1 *Shear wave velocities from MASW sounding.*

Depth Interval (m)		S-wave Velocity (m/s)
From	To	
0.0	1.1	270
1.1	2.3	299
2.3	3.7	377
3.7	5.3	412
5.3	7.0	403
7.0	8.9	403
8.9	11.0	437
11.0	13.2	486
13.2	15.6	532
15.6	18.1	553
18.1	20.9	548
20.9	23.7	523
23.7	26.8	495
26.8	33.0	489

The average shear wave velocity within the upper 30 meters (V_{s30}) is defined as the travel-time weighted average velocity from surface to a depth of 30 m and calculated using the following formula:

$$V_{s30} = 30 / \sum (d/V_s),$$

where d is the thickness of any layer and V_s is the layer S-wave velocity. In other words, V_{s30} is calculated as 30 m divided by the sum of the S-wave travel times for each layer within the topmost 30 m.

At the request of the client, the site designation was also determined from V_s values averaged over depth interval of 3 to 33 m to take into account the proposed depth of building foundations below the existing grade.

The calculated V_{s30} values are presented in Table 2.

Table 2 *V_{s30} values from MASW sounding.*

Depth Range (m)	Minimum V_{s30} (m/s)	Average V_{s30} (m/s)	Maximum V_{s30} (m/s)	NBC 2020 Site Designation
0 to 30	422	453	481	X₄₅₃
3 to 33	443	481	515	X₄₈₁

The V_{s30} values obtained from the MASW sounding varied from 422 m/s to 481 m/s with an average of 453 m/s.

Based on Sentence 4.1.8.4.(2b) of the National Building Code of Canada 2020 (NBC 2020), the **Site Designation** is **X₄₅₃**.

The V_s values averaged over the depth interval of 3 to 33 m to take into consideration the expected depth of foundations varied from 443 m/s to 515 m/s with an average of 481 m/s. The respective **Site Designation** is **X₄₈₁**.

4 CLOSURE

Shear wave velocity testing involving the multi-channel analysis of surface waves (MASW) method was carried out for the proposed addition to the Sterling Hall School located at 99 Cartwright Avenue in Toronto, Ontario.

The average shear wave velocity (V_{s30}) value calculated from in situ shear wave velocity measurements was **453 m/s**. Based on Sentence 4.1.8.4.(2b) of the National Building Code of Canada 2020 (NBC 2020), the applicable **Site Designation** is **X₄₅₃**.

The average shear wave velocity value calculated for the depth interval of 3 to 33 m was **481 m/s**. If the foundations of the proposed building are constructed at a depth of 3 m below the existing ground level, the applicable **Site Designation** is **X₄₈₁**.

We hope you find this report satisfactory. Should you have any questions or require additional information, please do not hesitate to contact the undersigned.

Frontwave Geophysics Inc.



Ilia Gusakov, P.Geo.
Geophysicist
(647) 514-4724
ilia.gusakov@frontwave.ca

