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June 25, 2025

File: 103013.005_Rev0

Village of Southern Victoria
1131 West Riverside Drive
Perth-Andover, NB
E7H 5G5

Attention: Dan Dionne (Dan@vilsv.ca)

**Re: Multi-channel Analysis of Surface Waves (MASW) Investigation - Village of Southern Victoria Municipal Complex**

## INTRODUCTION

A Multichannel Analysis of Surface Waves (MASW) investigation was carried out for the proposed location of the Village of Southern Victoria Municipal Complex, located in Perth-Andover, New Brunswick (Figure 1 – Site Plan). The investigation was completed to provide a Site Designation ($X_v$) in terms of $V_{s30}$, where V is the $V_{s30}$ value calculated from in-situ measurements from the MASW survey, and where the $V_{s30}$ is the time-averaged shear wave velocity for the upper 30 metres of the site.

Fieldwork for the investigation was completed on May 29, 2025, by GEMTEC Consulting Engineers and Scientists Limited (GEMTEC). Fieldwork included a single MASW survey line to characterize and assess the shear wave velocities in the near surface soils and rock at the site. At the time of the investigation the general air temperature was approximately 25 degrees Celsius, and the ground surface was dry. During field work, weather conditions were sunny with light winds and no precipitation.

Investigation results using MASW methods, provide a time-averaged shear wave velocity for the upper 30 metres of the site ($V_{s30}$) and when used in conjunction with the 2020 National Building Code of Canada (2020 NBC), the averaged velocity from the MASW survey provides a Site Designation value for structural design considerations.

Survey methodology, procedures, data processing, and results are described in the following sections.

## BASIC PRINCIPLES OF MASW SURVEYING

Unlike typical intrusive investigations, the MASW method characterizes the dispersive nature of Rayleigh-type surface waves to evaluate material properties in the near subsurface (Figure 2).

Normally, surface waves are considered noise in seismic reflection or refraction investigations but during MASW surveys, these waves help characterize the elastic properties of the near subsurface.

During an MASW investigation, the dispersion of the surface waves (assuming a heterogeneous medium) is related to the different phase velocities of the individual frequency components of the wave. Dispersion curves from seismic records are identified using the fundamental mode of the Rayleigh wave after plotting phase velocity versus frequency. The dispersion curve characteristics are utilized in an inversion routine to fit the data to a model using an iterative process to produce a shear wave velocity profile as a function of depth.

## DATA ACQUISITION

The MASW investigation was completed across the proposed site, which at the time of the investigation, consisted of a grassy field (Figure 1). The investigation required one survey line oriented approximately north to south across the site. The line orientation attempted to cross the footprint of the proposed Municipal Complex while avoiding the few trees and maintaining a relatively flat elevation. MASW surveying utilized a 24-channel survey layout consisting of twenty-four 4.5 hertz vertical geophones, a 24-channel geophone cable, a 24-channel geometrics geode, a high-impact polyethylene plate, and a 9-kilogram sledgehammer that functioned as the main seismic source (during active surveying). Geophones were placed firmly into the ground surface using soil penetrating spikes and were positioned at 3 metre intervals for an overall survey line length of 69 metres. During active surveying, six shot locations were occupied and included both forward and reverse shot locations at distances ranging from 3 to 28 metres from end geophones.

Passive data records were also collected as part of the MASW investigation to collect low-frequency ambient noise to supplement active surveying results and provide more information at depth/lower frequencies. Passive results were combined with active data to provide the final composite record and Site Designation results.

Tables 1 and 2, outline the parameters used during both active and passive surveying.

### Table 1 Acquisition Parameters for Active Surveying

| Acquisition Parameters | Description |
|---|---|
| Geophones | 4.5 Hertz geophones (24 total) |
| Geophone Interval | 3 metres |
| Survey Line Length | 69 metres |
| Shot Records | 6 shot records at 3 - 28 metres from end geophones |
| Source | 9-kilogram sledgehammer and 30 x 30 x 7.5-centimetre impact plate |

**Table 2 Acquisition Parameters for Passive Surveying.**

| Acquisition Parameters | Description |
|---|---|
| Geophones | 4.5 Hertz geophones (24 total) |
| Geophone Interval | 3 metres |
| Shot Records | 20 shot records (no stacking) |
| Source | Ambient noise from cultural sources |

## MASW DATA PROCESSING

### Data Processing Procedure

MASW shot records were processed by GEMTEC using the SeisimagerSW™ software package (V 6.0.2.1). Initial processing included the conversion of shot records from the time domain to the frequency domain using a Fast Fourier Transform (FFT). The converted data for each of the active shot records were then displayed as phase velocity vs. frequency plots to show fundamental mode dispersion curves (Figure 3). The dispersion curves were used to pick the fundamental mode for each of the shot locations/records.

The next processing step included the compilation and smoothing of picked data into a composite record for input into an inversion routine. Inverting the data utilized a Least Squares Method (LSM) to fit the data to a model over five iterations of the inversion. The initial models were also constructed using twelve horizontally layered units to define the upper 30 metres of soil and rock.

### Passive Data Records – Ambient Noise

A total of twenty passive data records were collected during survey procedures, which attempt to utilize the long offset and low frequency ambient seismic noise typically generated by cultural sources (e.g., vehicular traffic, industrial activities, construction etc.) from surrounding areas. The vehicular traffic and construction activities in various directions around the survey were a significant source of passive data and results were favourable because of these conditions.

## DISCUSSION

### MASW Survey Results

The $V_{s30}$ profile generated from the MASW survey for this investigation is attached to this letter in Figure 4. The figure displays the composite $V_{s30}$ profile generated from all active and passive shot records and includes max and min profiles, which were constructed using the individual (active) shot records recorded along the survey line. The time-averaged $V_{s30}$ value from the composite profile functions to provide the Site Designation value for the overall investigation. As per Sentence 4.1.8.4.(2b) of the 2020 NBC, the $V_{s30}$ value for the composite seismic profile resulted in a value of 1558 meters per second, and a **Site Designations of $X_{1558}$**.

## Discussion of Results

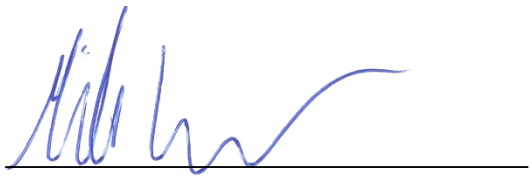
MASW results are indirect measurements and $V_{s30}$ values are time-averaged shear wave velocities for the upper 30 metres of the site. When $V_{s30}$ values are used in conjunction with the 2020 NBC, results must also consider any exceptions as noted in Table 4.1.8.4.-A of the code.

GEMTEC's opinion on the applicable Site Designation is based on the data obtained at the time of surveying, as indicated in this document. For best results, MASW surveying requires relatively homogenous and horizontal strata, and avoiding velocity reversals (i.e., asphalt and / or frost over overburden) across the entirety of the survey line.

In completing this investigation, the Geological Survey of Canada Open File 7078, Shear Wave Velocity Measurement Guidelines for Canadian Seismic Site Characterization in Soil and Rock (2012) was used as a guide and consulted throughout the duration of the project.

## CLOSURE

GEMTEC trusts this report provides sufficient information for your present purposes. If you have any questions concerning this report, please do not hesitate to contact the below.



Mike West, M.Sc., P.Geo., P.Eng.

MW/pb

Enclosures
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Attachments:
Figure 1 – Site Plan
Figure 2 – Surface Wave Illustration
Figure 3 – Phase Velocity vs Frequency Plot Showing Fundamental Mode
Figure 4 – MASW Vertical Seismic Profiles




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MASW SURVEY LINE

Scale
0 10 20 30 40 50
m

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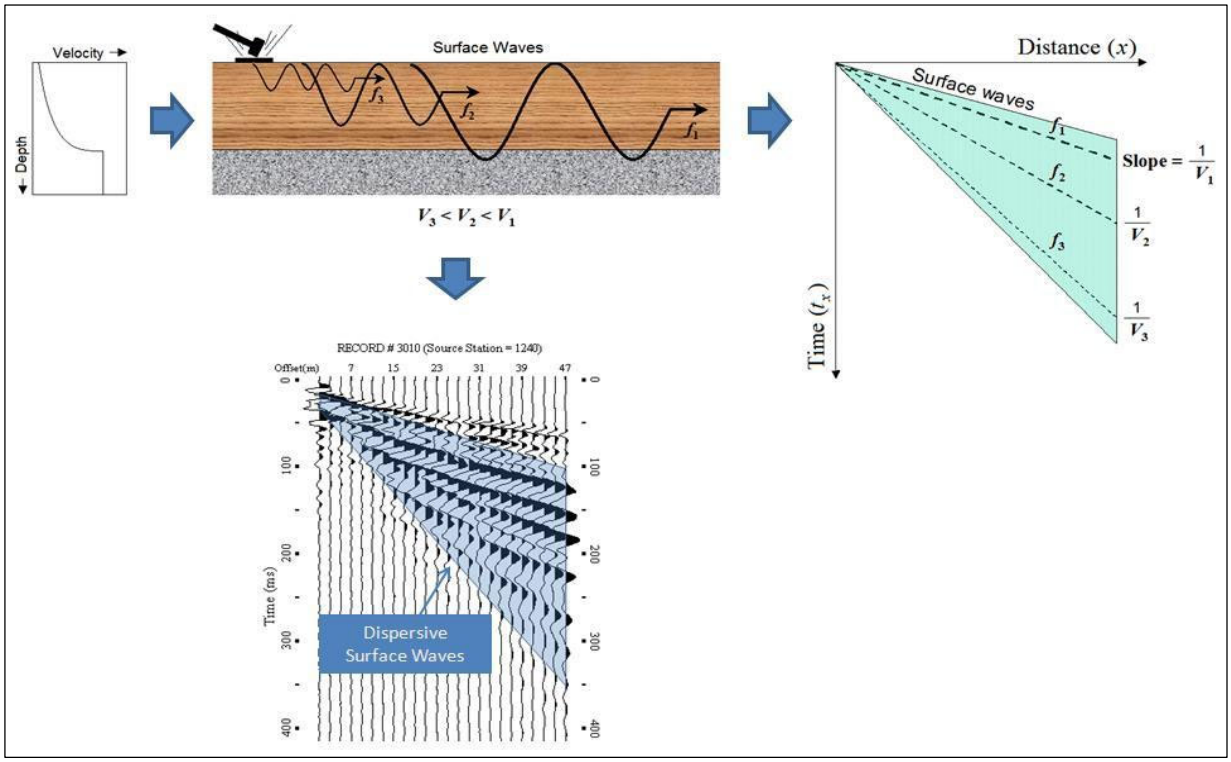
New Municipal Multiplex
Perth-Andover, NB

MASW Survey

Figure 1

| Surface Wave Dispersive Properties and Arrival Data Records (illustrative). | FIGURE 2 |
|---|---|




www.parkseismic.com/SurfaceWaveSurvey.html

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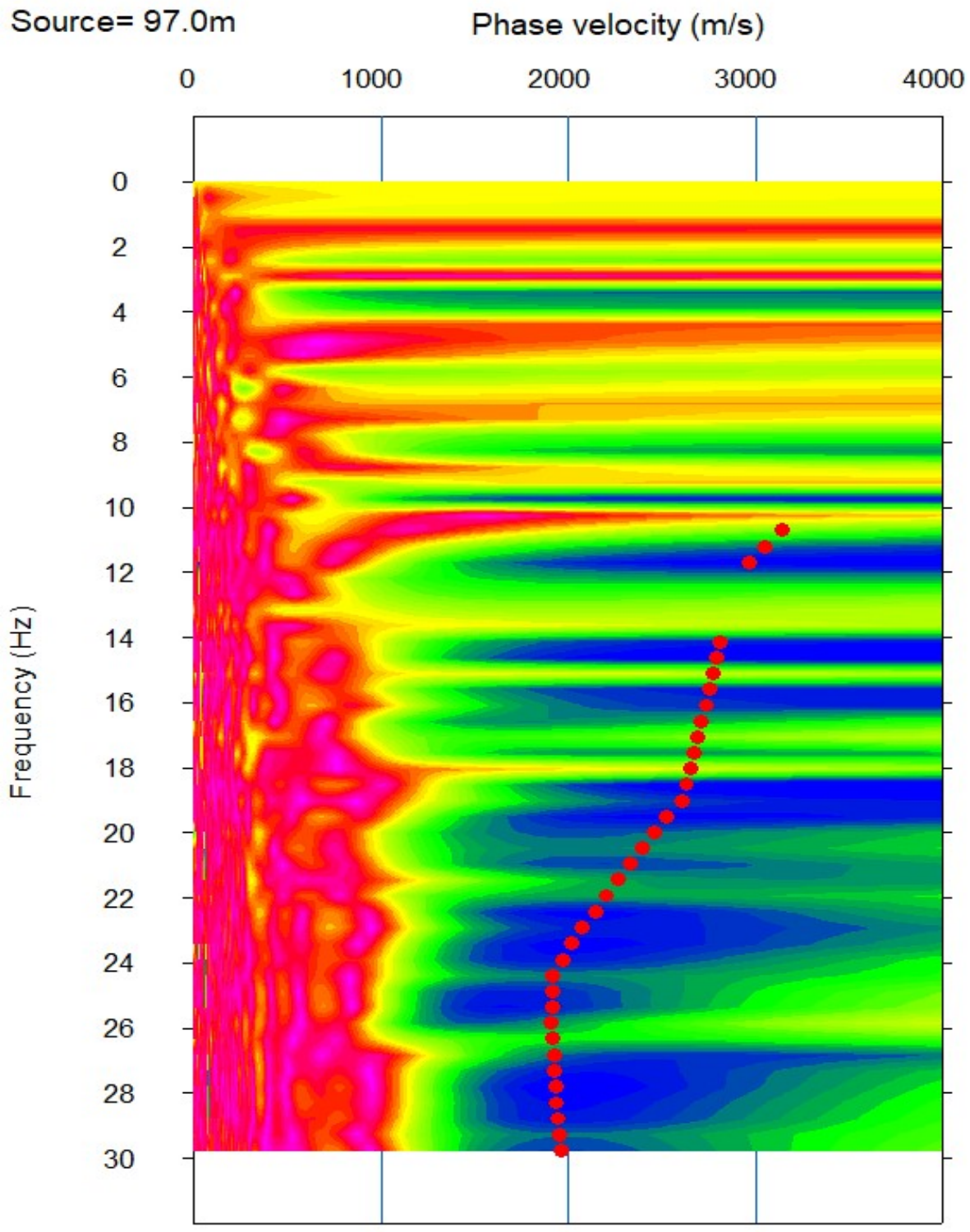
| Phase Velocity vs Frequency Plot Displaying the Dispersion Curve and Picks for an active shot location | FIGURE 3 |
|---|---|

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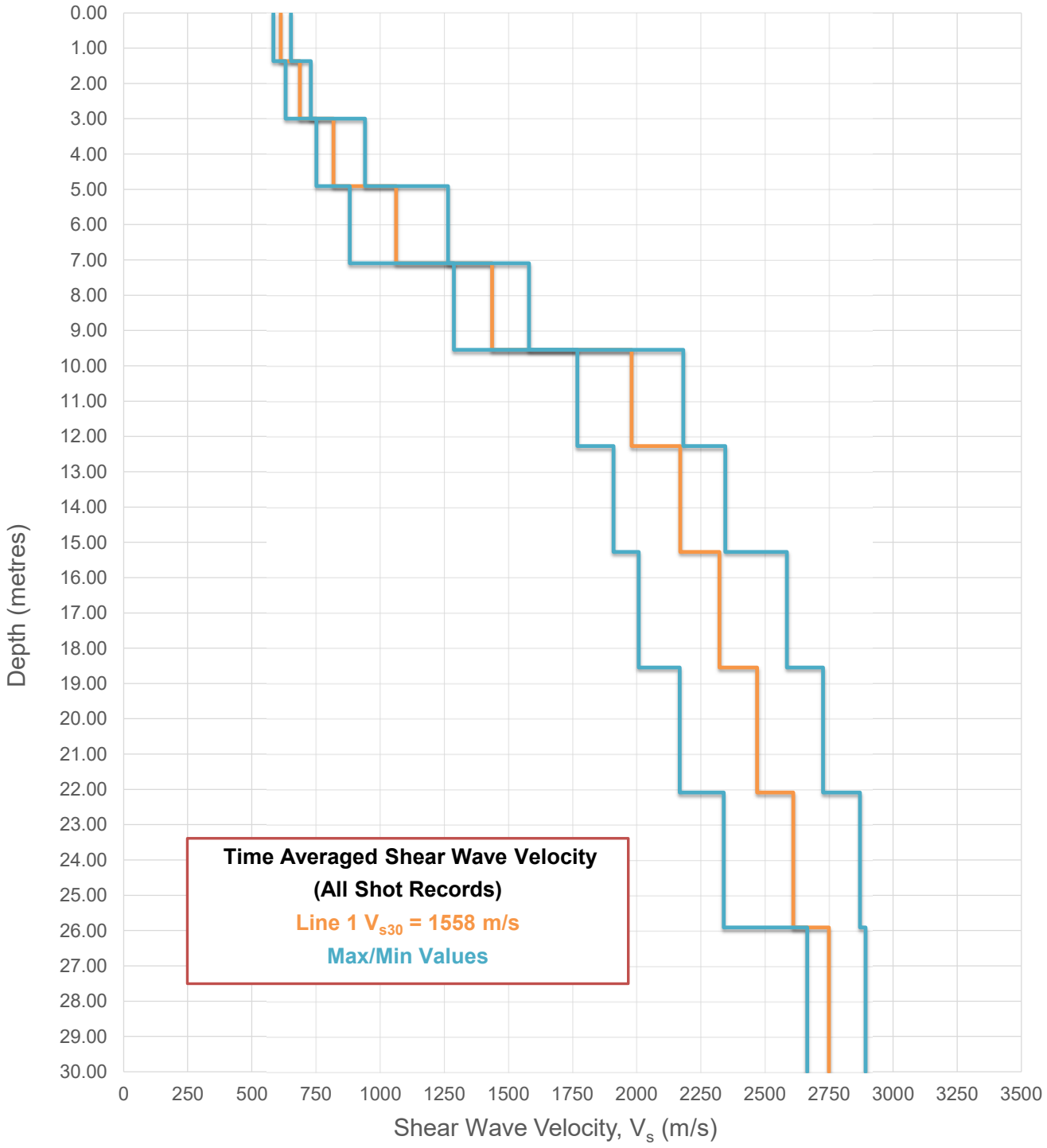
**Village of Southern Victoria Municipal Complex**
**Shear Wave Velocity ($V_s$) vs Depth**

**FIGURE 4**

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