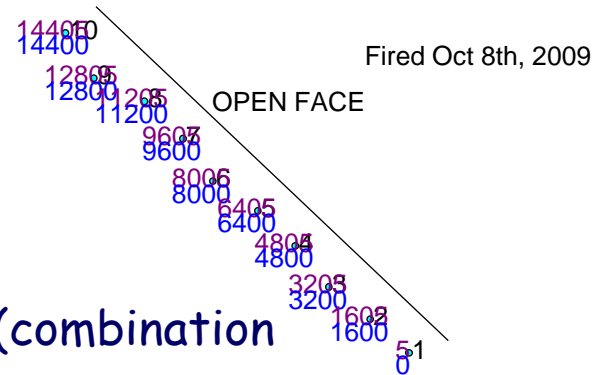
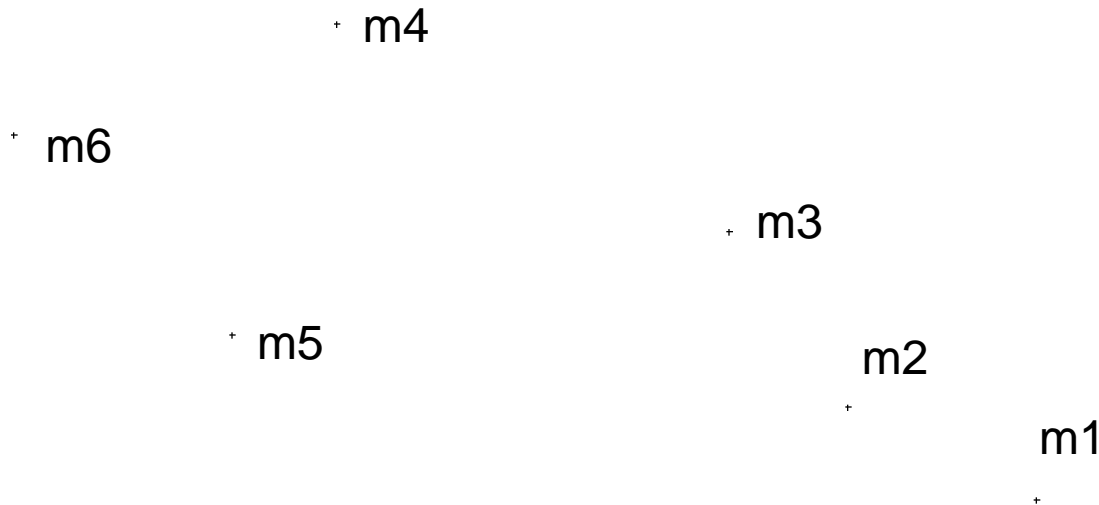


Key steps of using the MSW to make vibration predictions

To use MSW model effectively, a good set of signature hole vibration data is required. It is recommended that 45 data points - combination of monitors with signature holes. Accurate input data is required to get reliable prediction.

With good information from the analysis of signature hole blast vibration, in most case the MSW slightly over predicts the vibration measurement from production blasts. Such a feature makes the MSW model to be reliable to make a conservative prediction or blast design recommendation without calibration.

Reliable prediction from the MSW model requires good input parameters from analysis of signature hole blast vibration. Such input parameters are: ground sonic velocity, its standard deviation, parameters of the best-fit and 97.5% upper bound fit of the charge weight scaling laws, burden and spacing of blast pattern, etc.



Signature hole vibration monitoring setup

It is recommended that over 30 data points (combination of monitors with signature holes).

Good input data is required to get reliable prediction



A technique is used in North America to use Channel#4 of a seismograph to record detonation time of a signature hole charge, the first three channels Record vibration. So $V_p = 98.55 \text{ m}/32.8 \text{ ms} = 3005 \text{ m/s}$.

You may use other reliable ways to obtain the site p-wave velocity.

Get scaled distance for each monitor from a signature blast hole

2. Click "MSD"

1. Click the monitor

HoleID

Details | Results | Monte Carlo model | Airblast model | **MSD**

Station name: 1

Layer: Vibration monitors

Location:

X: 451848.00 (ft)

Y: 1119270.00 (ft)

Z: 4599.00 (ft)

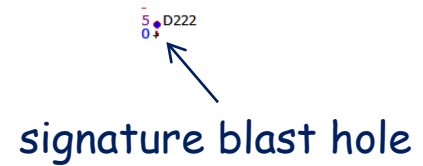
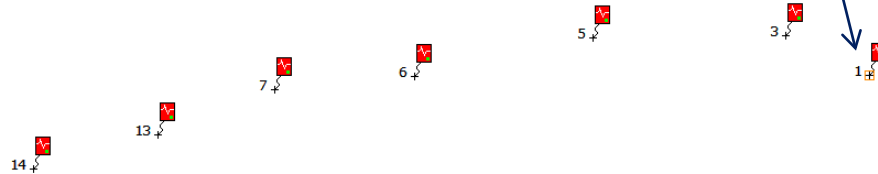
Limits:

VPPV limit (mm/s): 0.00

Airblast (dBI): 0.0

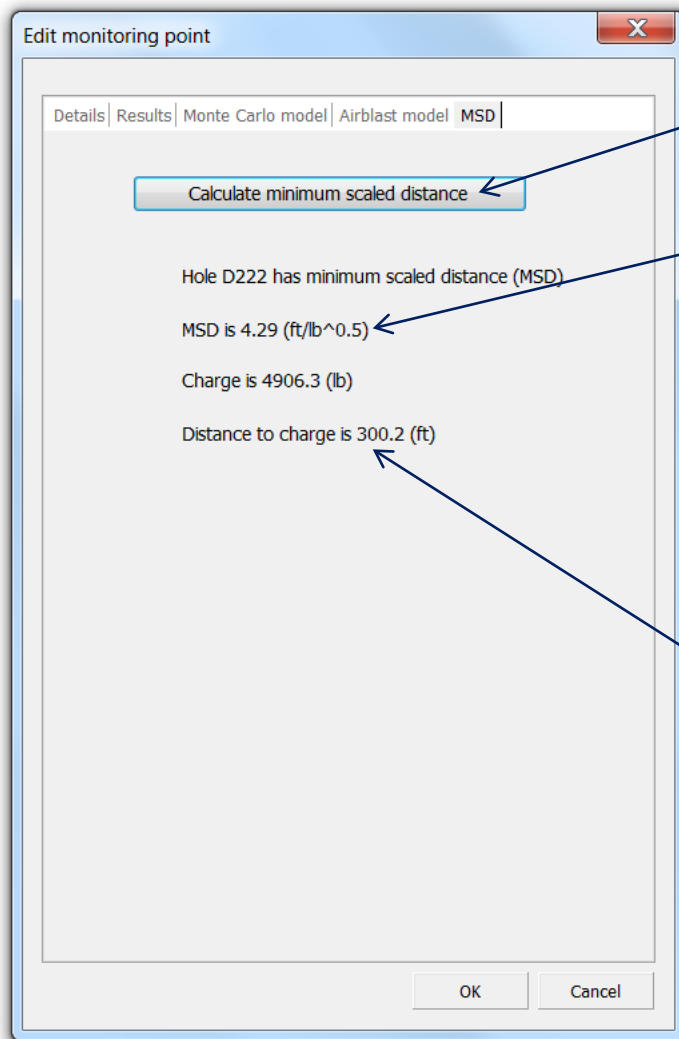
Notes:

OK Cancel



x

Get scaled distance for each monitor from a signature blast hole



click

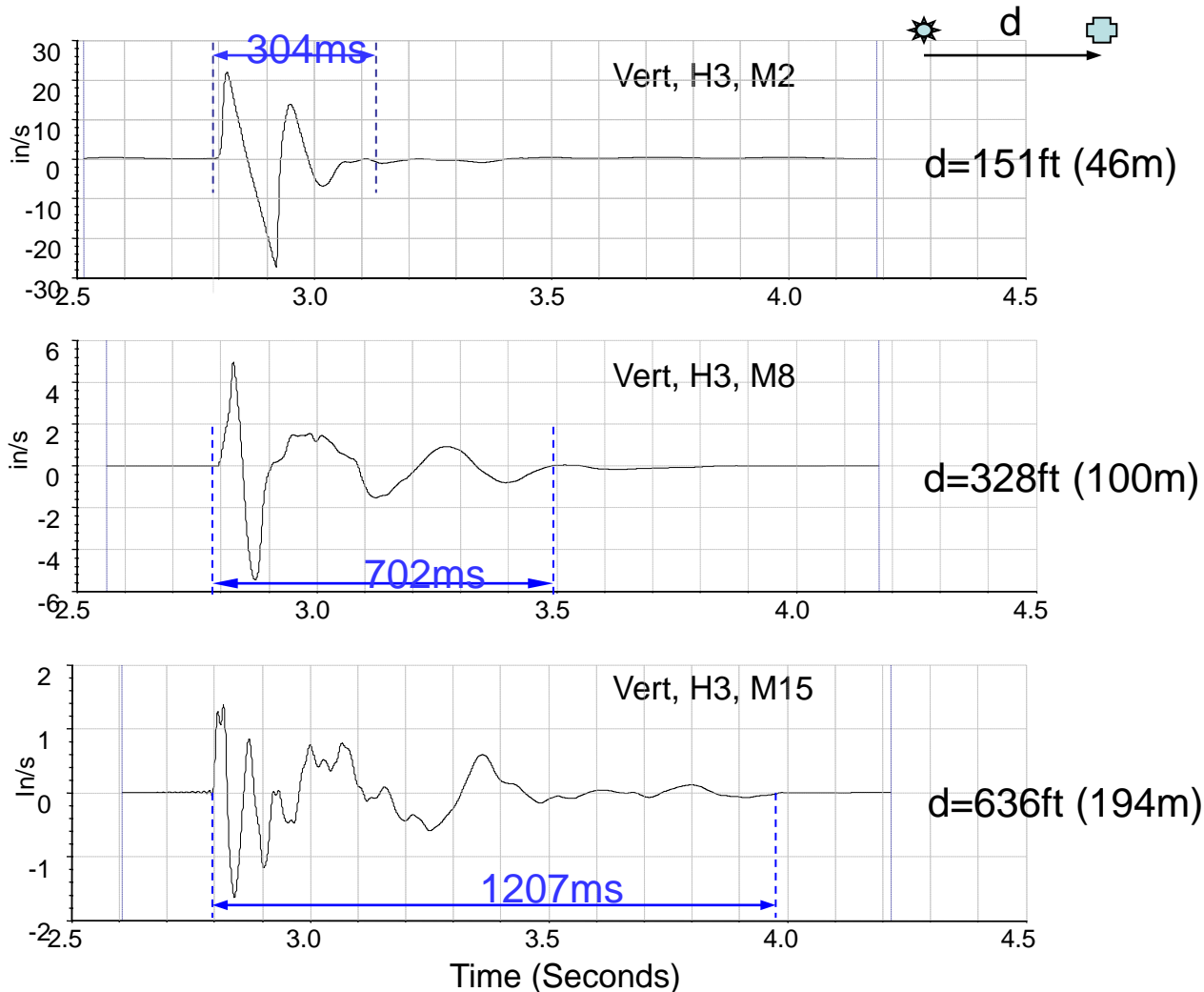
This is the scaled distance = $d/w^{0.5}$



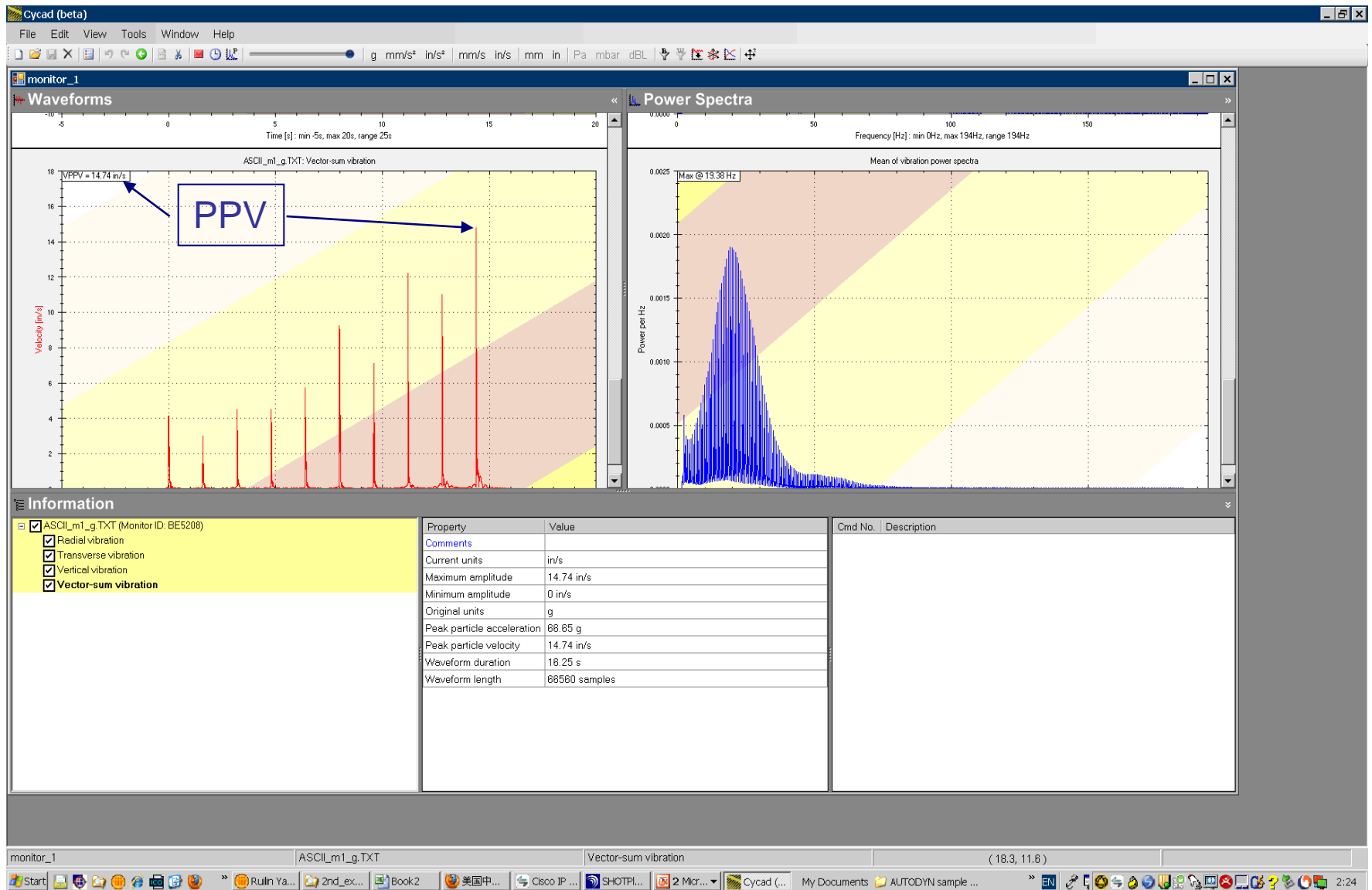
This is the distance from the charge center to the monitor.

Generate a ShotPlus file for each signature hole to get S_d , D , and W to build a table

Why MSW?



Try to get a seed at every 5m increment from the signature hole to monitor. For each seed wave file, the file name should contain 'd'. For example, h4_m1_seed_d21m.TXT. This means the seed wave from Hole#4 is recorded with Monitor#1 at the distance of 21m from the charge center to the monitor.



This is a Cycad screen dump for the vector sum of PPV from 10 signature hole at a monitoring station. From this screen, the PPV from each signature hole at the monitoring station can be obtained by zooming to each peak.

A table for signature hole vibration information should be built as below (but at least 30 rows of data), using the units corresponding to the measurement.

Monitor #	hole	d (m)	w(kg)	SD (m/kg ^{0.5})	PPV (in/s)
1	1	70.16	175	5.3	14.6
.					
.					
.					

Information in this table is used for exporting seed waveforms from Cycad since we know the distance associated with each seed waveform that we collected. When you prepare seed waveforms, you can save the seed waveform file with a file name containing monitor name, hole name, and distance, for example, m1_h1_d70m.txt

Secondly, this table is also used to build a input file for the regression of the signature hole charge weight scaling law.

Cycad (beta)

File Edit View Tools Window Help

g mm/s² in/s² mm/s in/s mm in Pa mbar dBL

monitor_1

forms

ASCII_m1_g.TXT: Radial vibration

PV = 4.028 in/s

Velocity [in/s]

Time [s]: min -0.0583s, max 0.191s, range 0.249s

Power Spectra

Power spectral density: Radial vibration

Max @ 20 Hz

Power per Hz

Frequency [Hz]: min 0Hz, max 194Hz, range 194Hz

Information

ASCII_m1_g.TXT (Monitor ID: BE5208)

- Radial vibration
- Transverse vibration
- Vertical vibration
- Vector-sum vibration

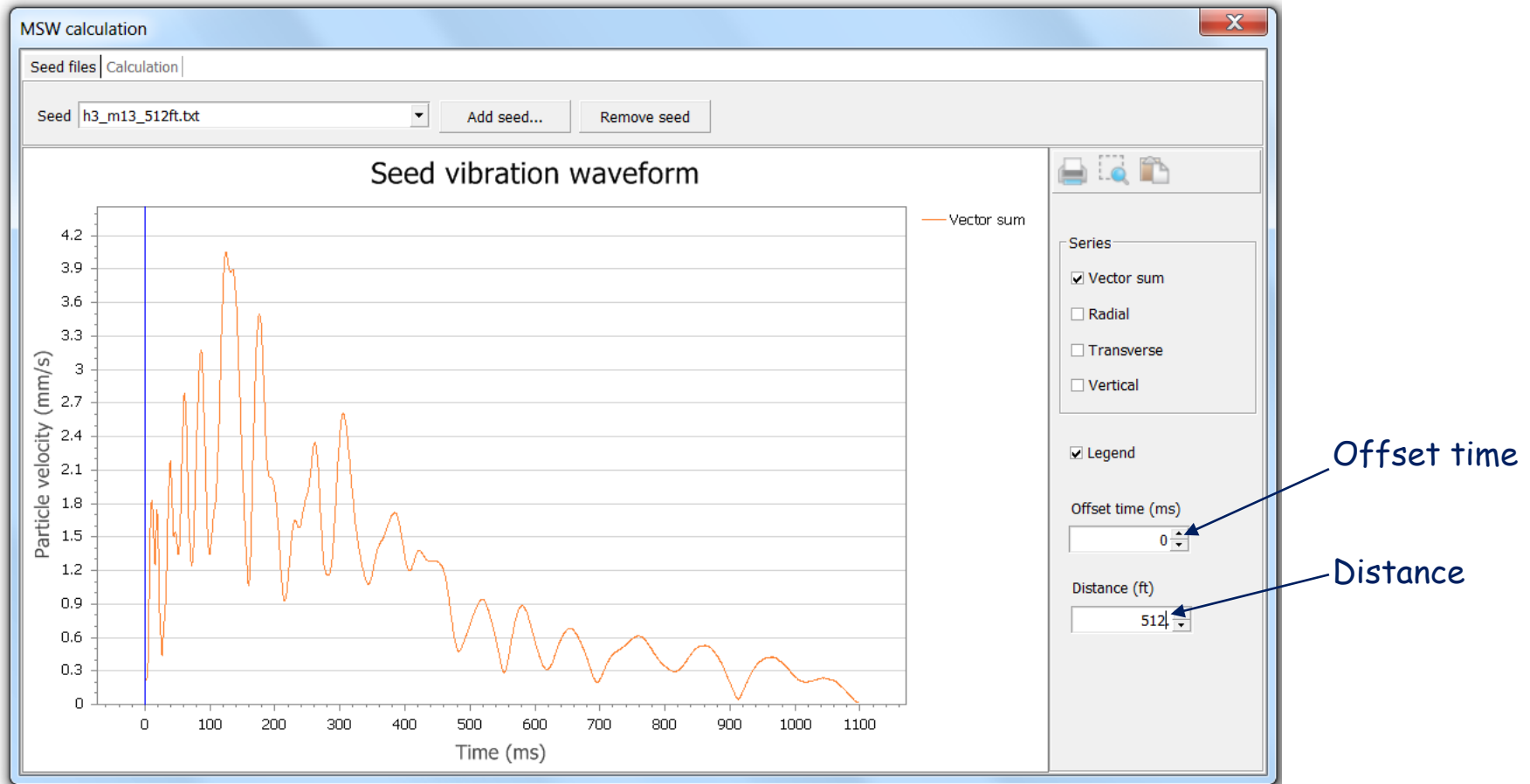
Property	Value
Channel ID	Long
Comments	
Current units	in/s
Maximum amplitude	5.358 in/s
Minimum amplitude	-10.83 in/s
Original units	g
Peak particle acceleration	36.38 g
Peak particle velocity	10.63 in/s
Waveform duration	16.25 s
Waveform length	86560 samples

Cmd No.	Description

monitor_1 ASCII_m1_g.TXT Radial vibration

Start Logout Sc... Book2 美国中文... Cisco IP C... SHOTPlus-... site_inf.ppt Cycad (be... My Documents AUTODYN sample ... 4:13

Use Cycad to export seed waveforms - zoomed in and three components of particle velocity can be exported. Save the file in the work-directory and the file name contains Hole#, Monitor#, and "d", as described in previous slide.



This window is for preparing the seeds.

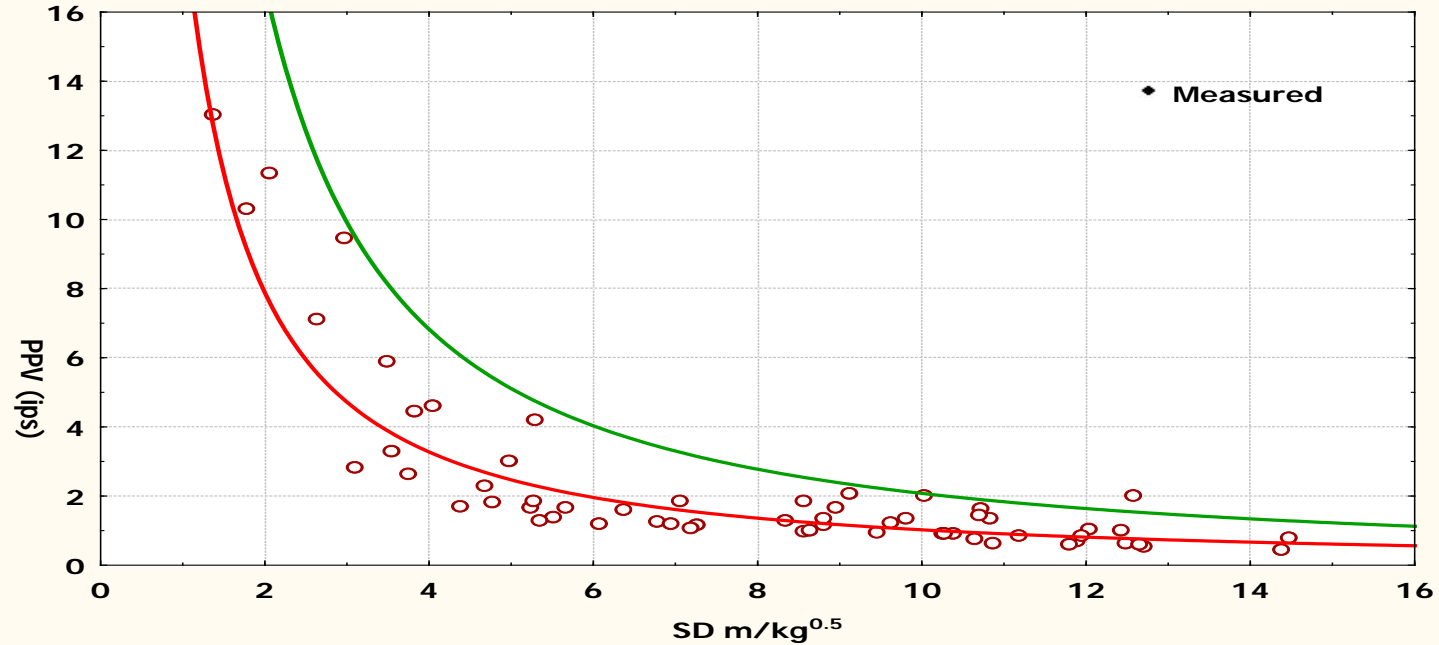
'offset time' - put an offset time, a correct offset time is indicated by the vertical blue line at the offset of the seed wave starting point.

'distance' - refer to 'd' in Slide#4 in this document. The 'd' should be contained in the seed file name (as discussed in Slide-5 and -7).

Signature Hole PPV versus SD - Milton Quarry West South Side

$$\text{Best fit: PPV} = 18.97SD^{-1.266}$$

$$97\% \text{ Upper bound: PPV} = 41.23SD^{-1.297}$$

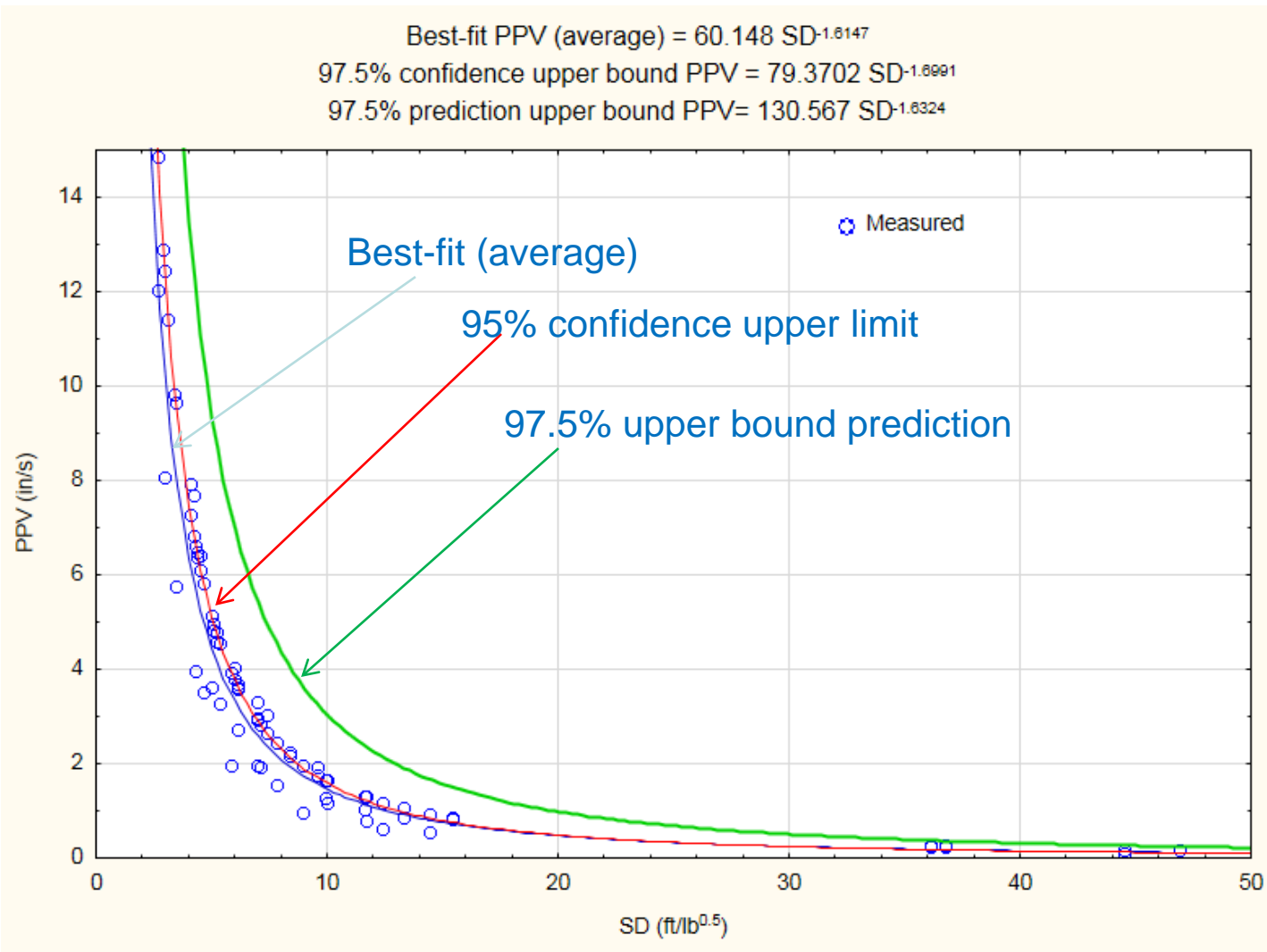


The units in the signature hole PPV-SD determines the unit selection for running the MSW.

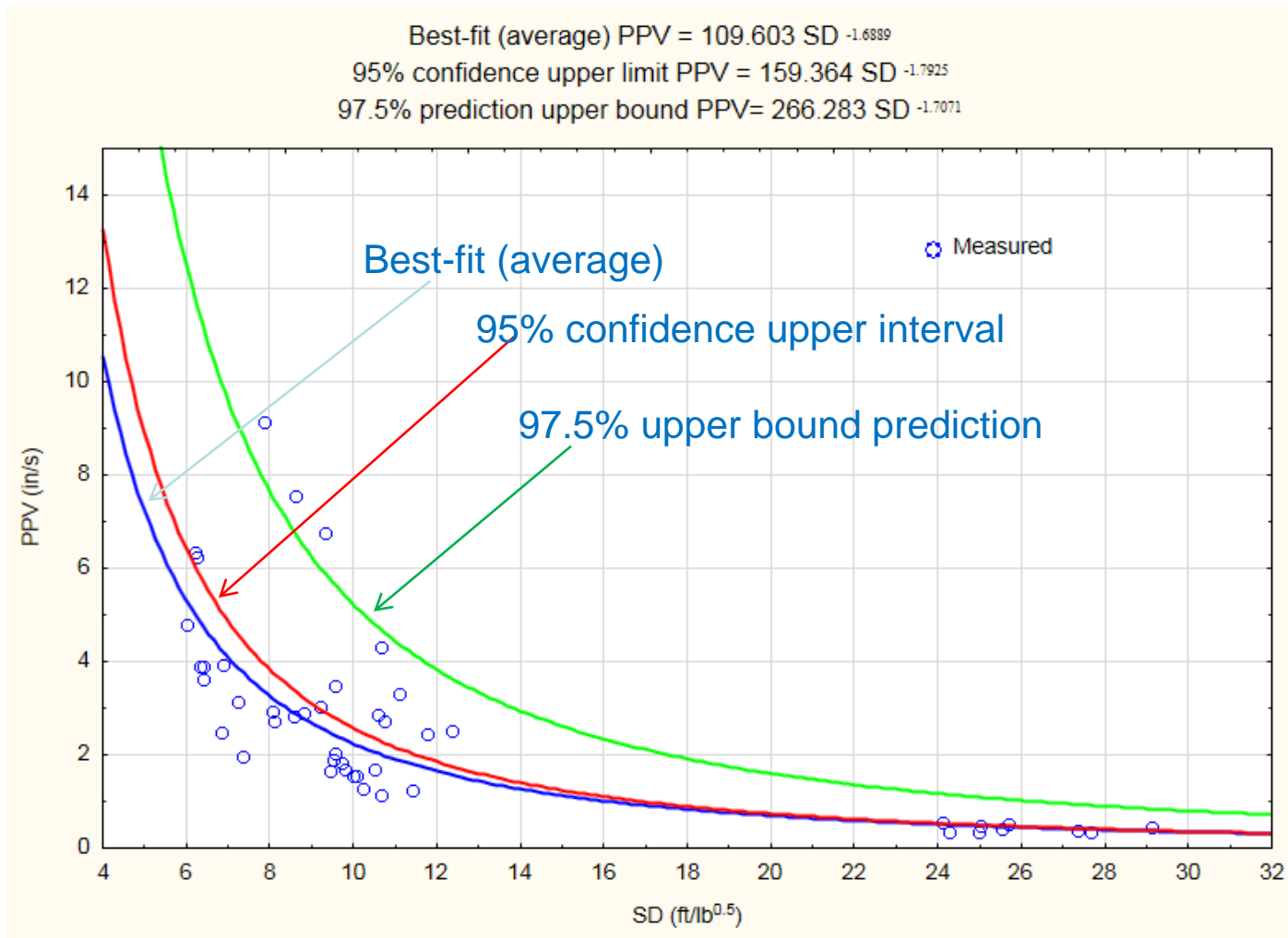
You need to have a statistical regression software to do the regression obtaining the above equations from the data in the table (shown in Slide 7).

Please note: $PPV_{97.5\% \text{ Upper}}$ is the upper bound of the 95% prediction interval. It is not the upper bound of the 95% confidence interval. The prediction interval is different from the confidence interval. It is very important to know that the MSW needs the upper bound of the 95.5% prediction interval.

The regression parameters for the best-fit and 97% upper bound are input to run MSW model. (refer to the previous slides)



MSW requires the regression of the best-fit and the 97.5% upper bound prediction for PPV statistical modeling. The 95% confidence upper limit can not be used for PPV statistical modeling.



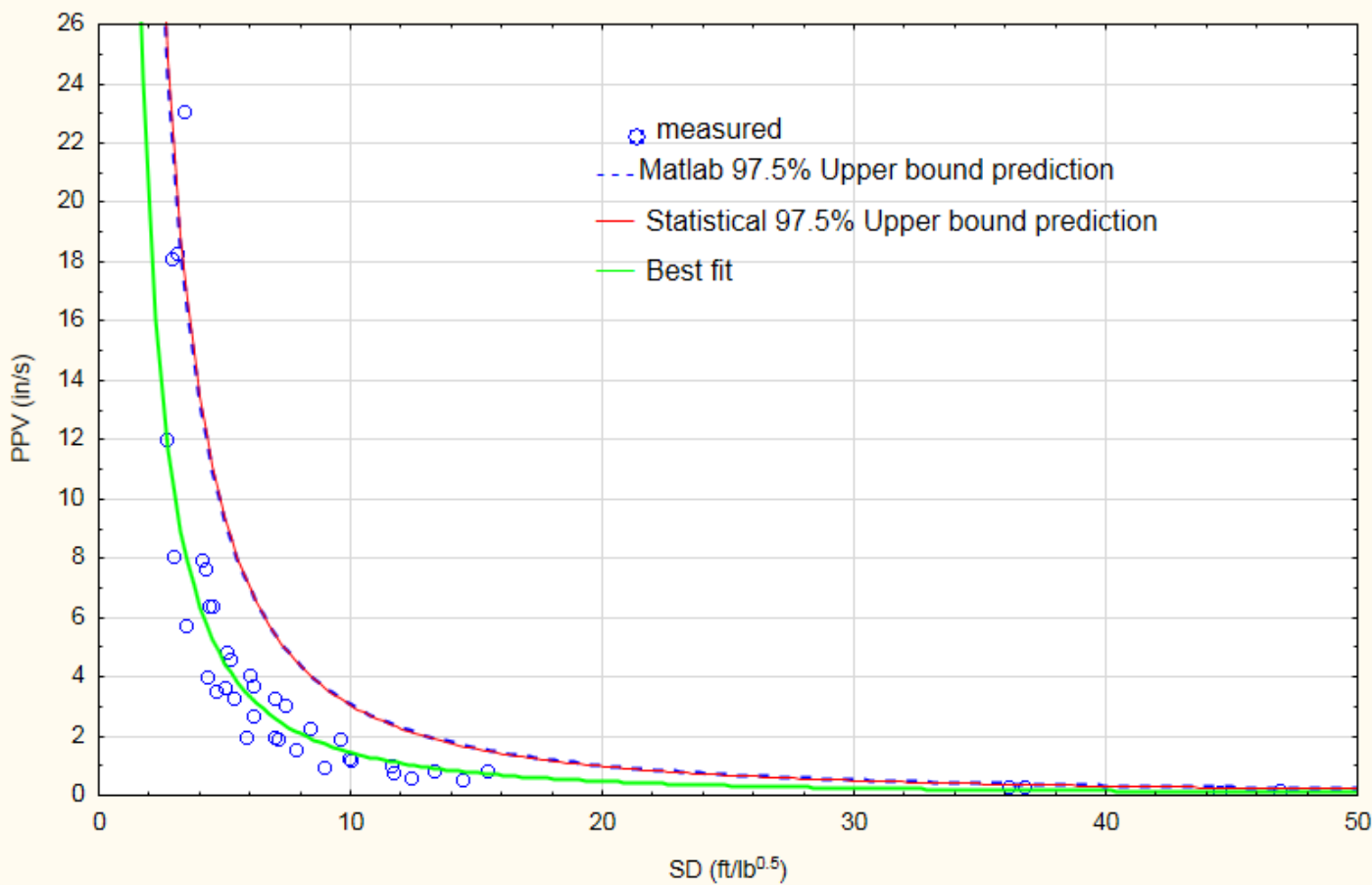
The 97.5% upper bound prediction for PPV means 97.5% of the measurement would be below this line along the scaled distance.

The 95% confidence upper limit means the 95% confidence that the best-fit line is below it and above the 95% low limit line.

Best-fit PPV = 60.15 SD^{-1.6147}

Matlab 97.5% upper bound prediction PPV = 123.1 SD^{-1.603}

Statistica 97.5% upper bound prediction PPV = 130.567 SD^{-1.6324}



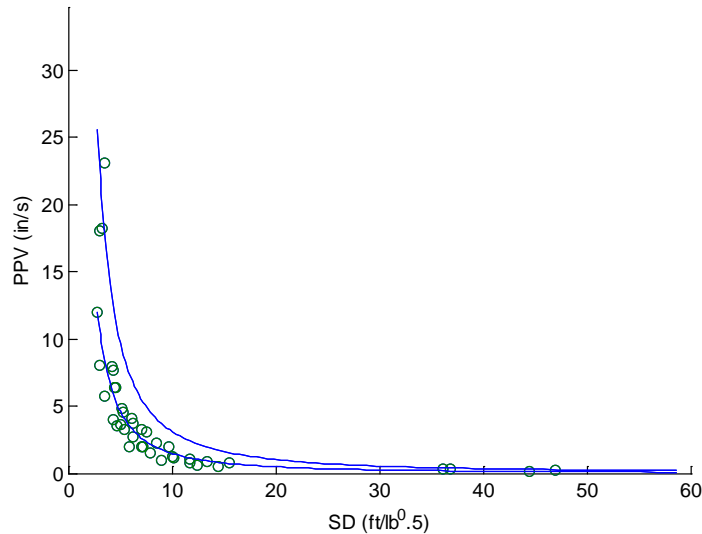
A regression program has been developed to conduct the regression to obtain the best-fit and the 97.5% upper bound prediction curve, as following equations.

$$PPV_{best-fit} = \alpha_1 \left(\frac{d}{\sqrt{w}} \right)^{-\beta_1}$$

$$PPV_{97.5\% - Upper} = \alpha_2 \left(\frac{d}{\sqrt{w}} \right)^{-\beta_2}$$

A program is developed recently (ppv_sd_regression). It can read an input file of the excel format as shown and output graphs of the best-fit and the 97.5% upper bound prediction curves. The equations are shown in the graphs.

Best fit: $PPV = 60.148 SD^{1.6147}$
 97.5% Upper Bound: $PPV = 123.0997 SD^{1.5975}$



	A	B
1	SD (ft/lb^0.5)	PPV (in/s)
2	4.29	3.98
3	4.62	3.52
4	4.98	3.64
5	5.84	1.96
6	6.94	1.96
7	7.8	1.54
8	8.93	0.96
9	12.38	0.63
10	14.41	0.54
11	44.48	0.12
12	4.06	7.94
13	4.5	6.43
14	5.09	4.84
15	6.16	3.69
16	7.4	3.05
17	8.37	2.25
18	9.6	1.94
19	13.29	0.85
20	15.42	0.82
21	46.92	0.19
22	2.92	18.1
23	3.13	18.28
24	3.41	23.1
25	4.22	7.68
26	5.2	4.59
27	5.98	4.05
28	6.97	3.3
29	9.94	1.28
30	11.63	1.05
31	36.77	0.28
32	2.69	12.04
33	2.98	8.07

MSW calculation

Seed files Calculation

Monitor point 1

Help..

Calculate

Calculate All Export

Close all

Seed selection

By distance
 Random

Seed units:
in/s

Scaling units:
ft/lb^{.5}

Output sample size (ms)
0.5

Load settings..
Save settings...

Working folder

Number of simulations 35

p-wave velocity 3005.0 (ft/s)

p-wave std error 30.0 (ft/s)

Scaling law A 60.15 (ft/lb^{.5})

Scaling law B 1.61

Scaling law exponent 0.80

Scaling law A 97.5% upper bound 123.10

Scaling law B 97.5% upper bound 1.60

Scaling law exp. 97.5% upper bound 0.80

Screening width 35.00 (ft)

Screening parameter 0.5

'p-wave velocity' - measured in the field.

'p-wave standard error' - p-wave velocity standard error.

'Charge wt-scaling law A' from the best-fit, Slide 9 in this document.

'Charge wt-scaling law B' from the best-fit, Slide 9 in this document.

'Weight scaling exponent' from the best-fit, B/2.

'Scaling law A 97.5% upper bound', Slide 9 in this document.

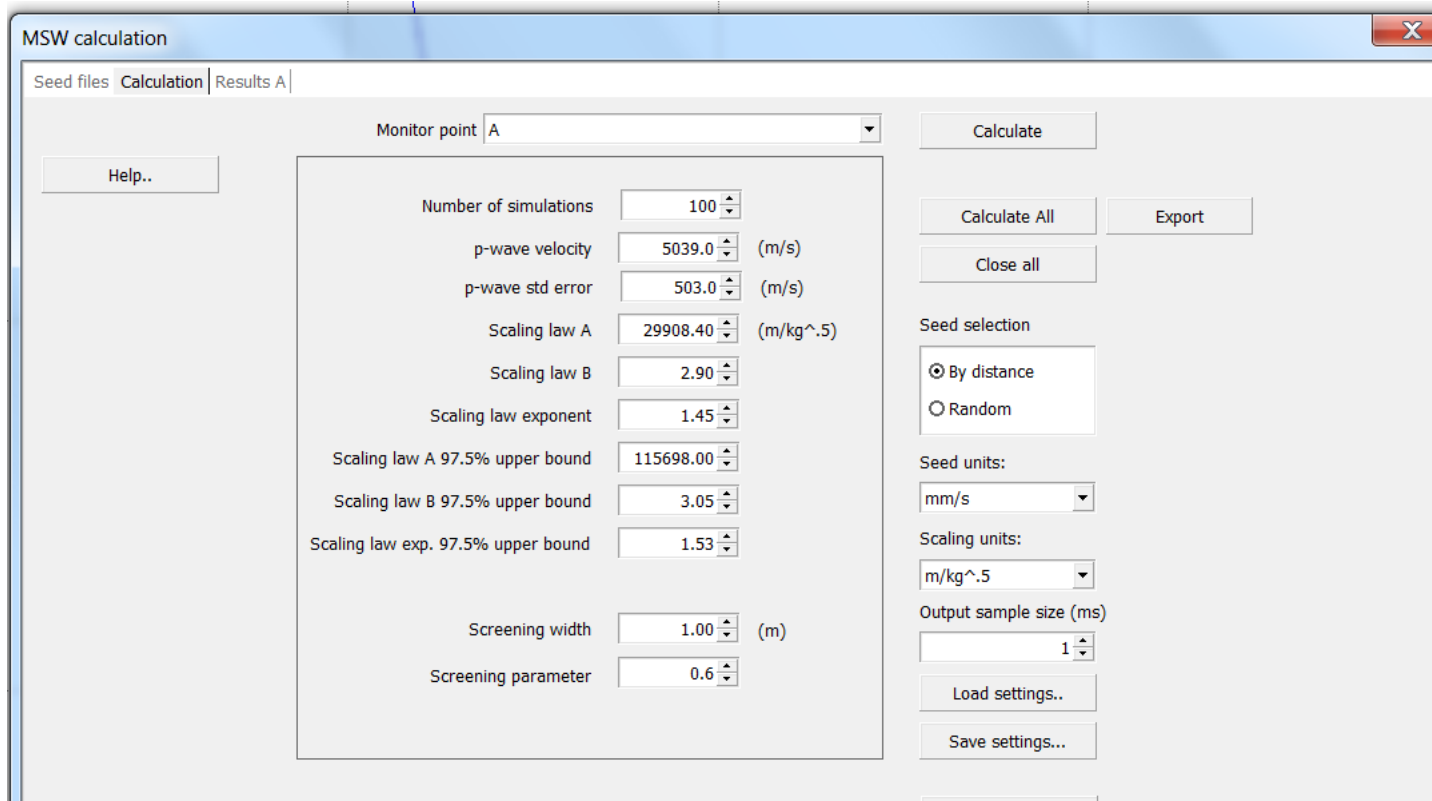
'Scaling law B 97.5% upper bound', Slide 9 in this document.

'Weight scaling exponent' from the 97.5% upper bound fit, B/2.

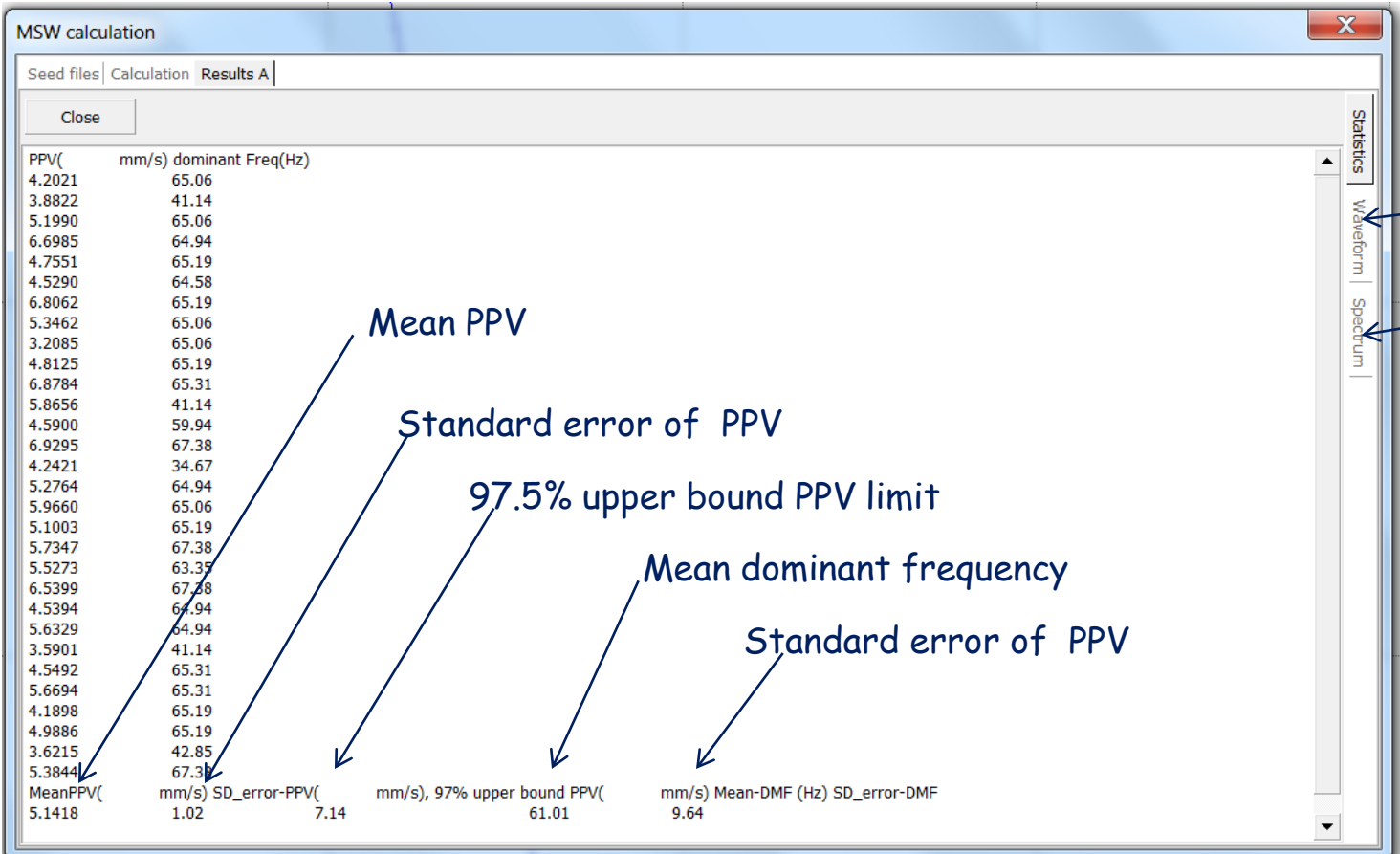
'Design spacing' - $(b+s)/2$, b- burden, s- spacing.

'Screening parameter' - start with 0.75, it can be in the range 0.1-0.99.

'output sample size (ms)' - the sampling time interval of the output waveform.



- 'Save settings' - save the model parameter setup settings to a directory.
- 'Load settings' - Load a previously saved model setting from a directory to the present modeling.
- 'Export' - export the modeling results.
- 'Close all' - close all results for all monitors.
- 'Calculate all' - calculate all results for all monitors.
- 'Calculate' - calculate results for selected monitor point.
- 'Help' - read help manual on how to set up MSW modeling parameters and run the model



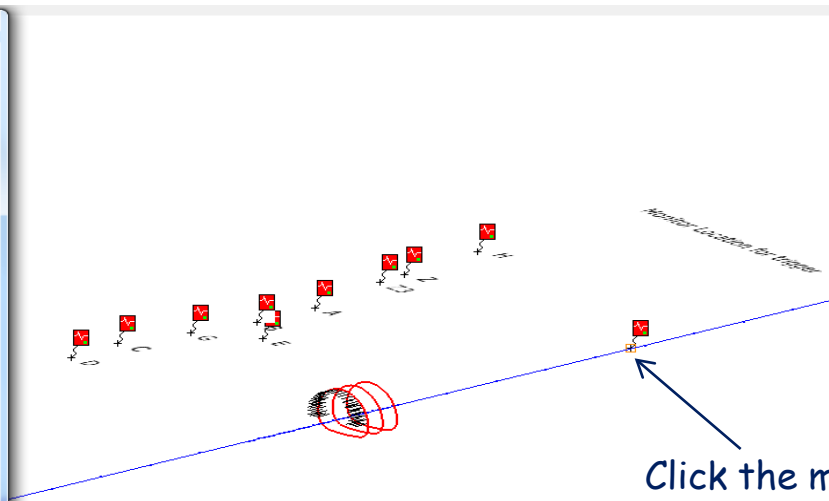
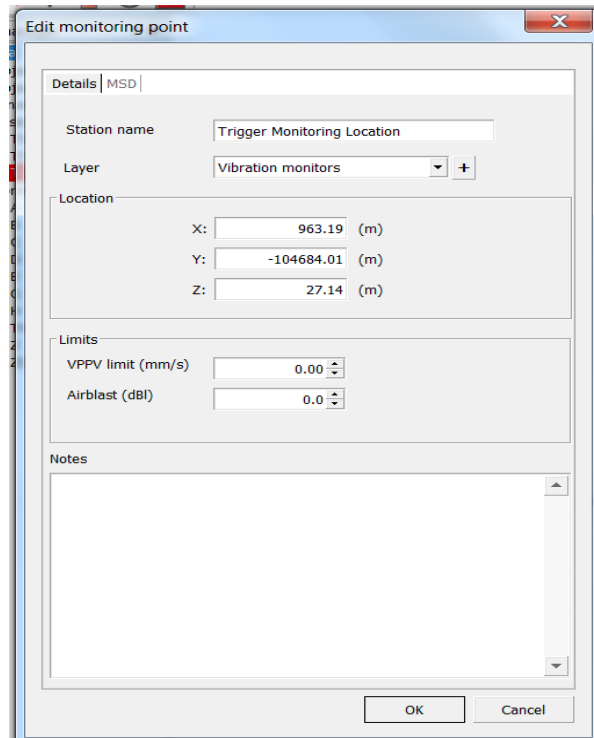
Modeled waveforms

Modeled Frequency spectrum

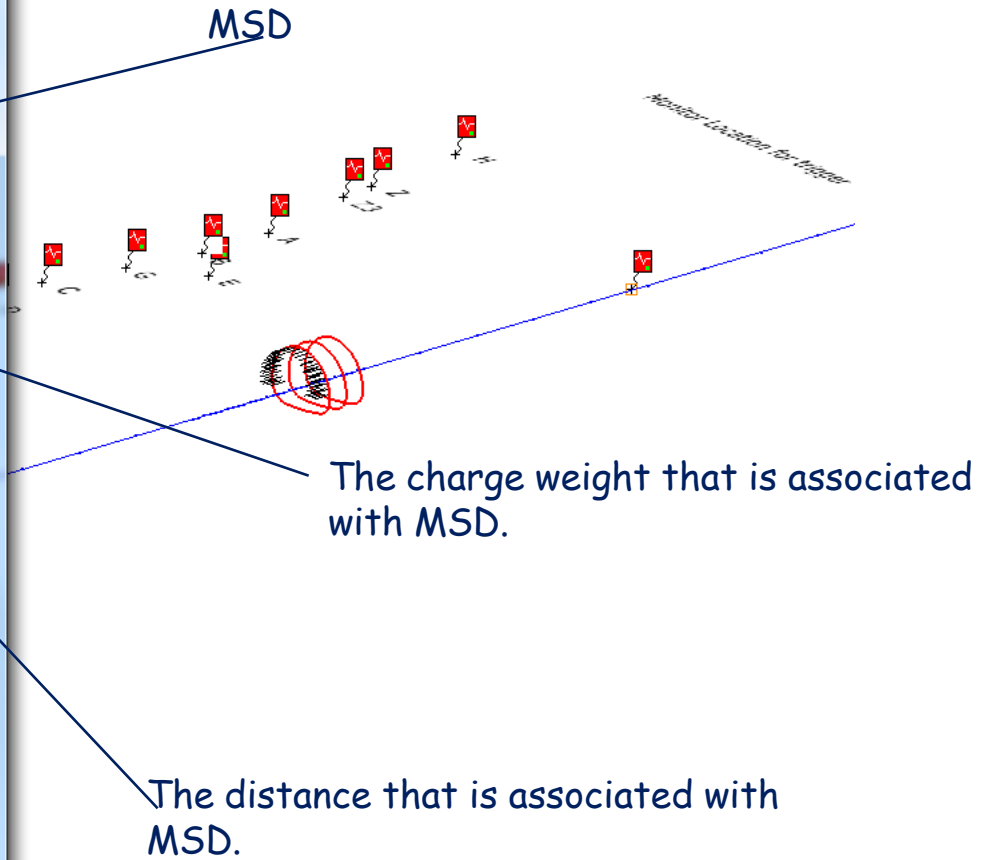
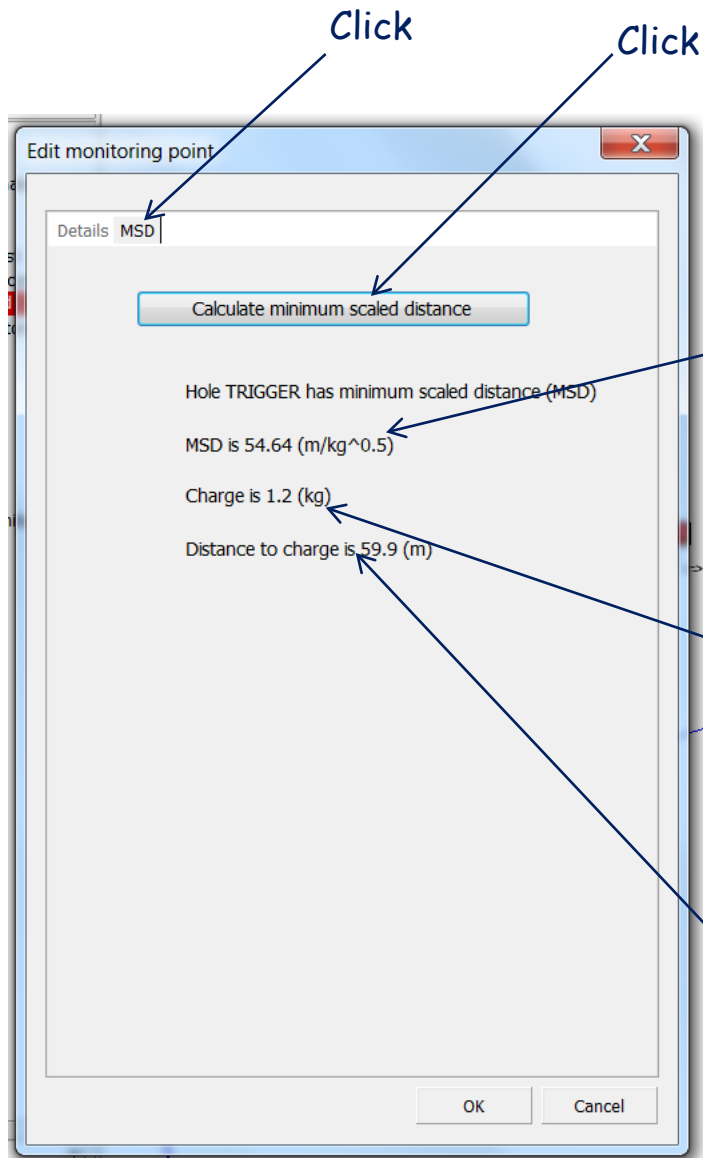
Plot Modeled (and measured) PPV versus MSD for a production blast

$$MDS = \min \left(\frac{d_1}{\sqrt{w_1}}, \frac{d_2}{\sqrt{w_2}}, \dots, \frac{d_n}{\sqrt{w_n}} \right)$$

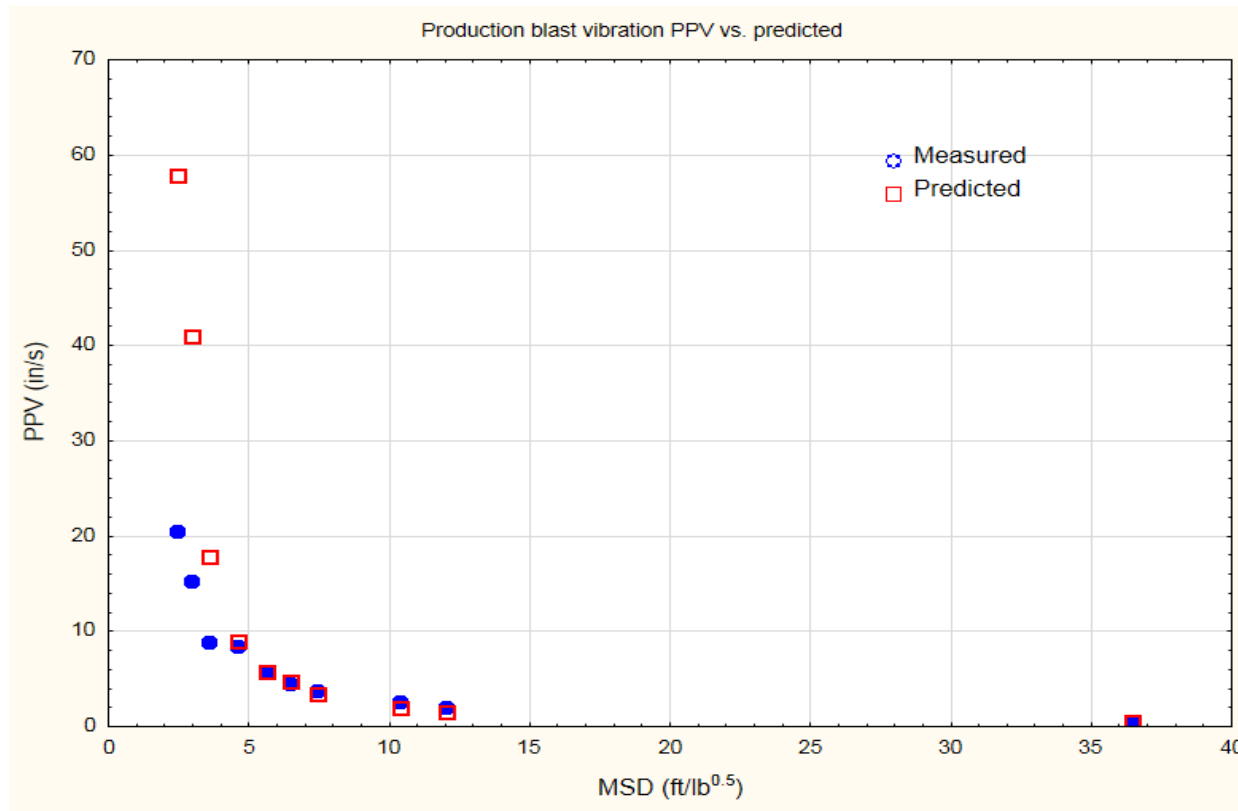
MSD is the minimum scaled distance, n is the number of blast holes in the production blast.



Click the monitor
To get MSD, then the
window in the right
appears.

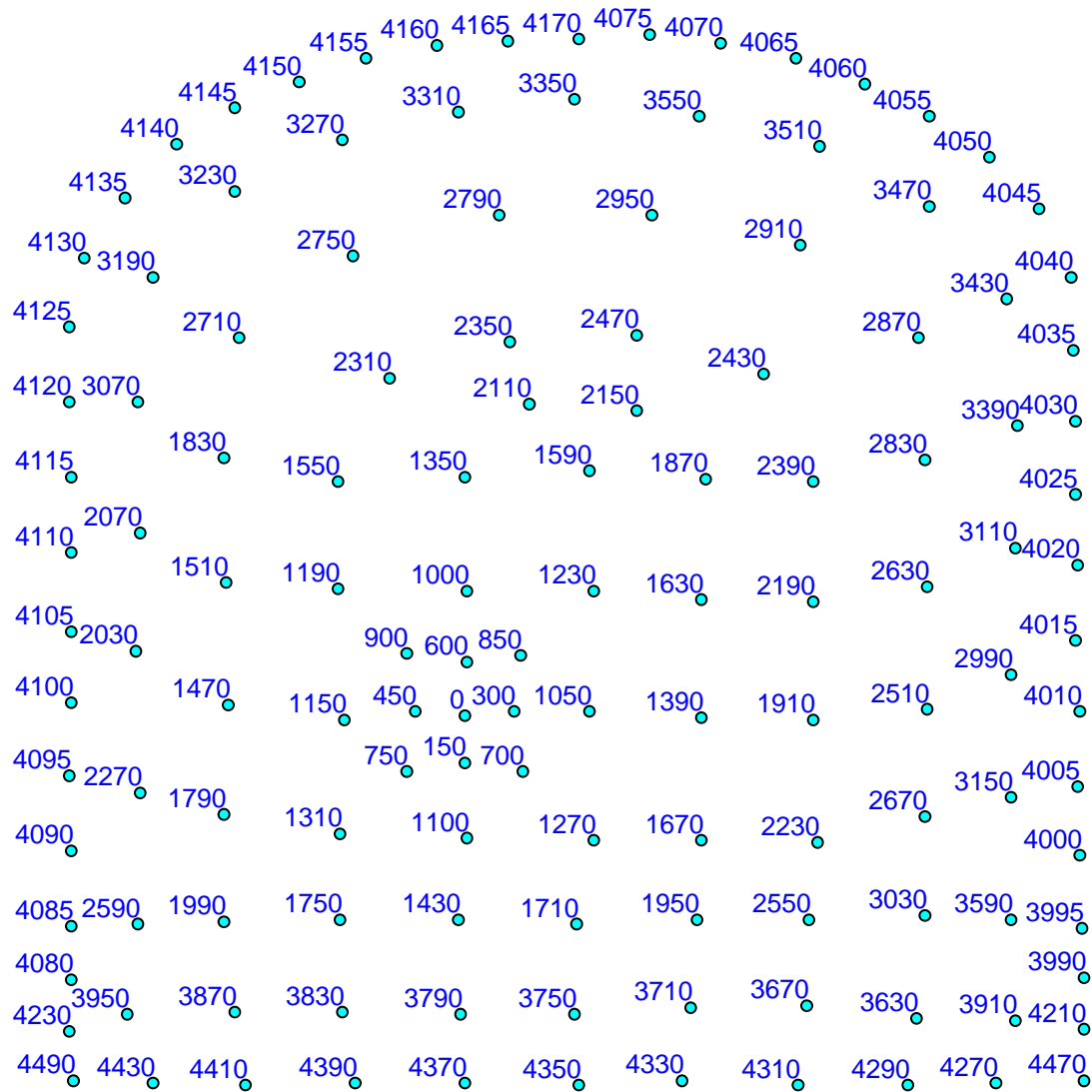


An example of modeled vs. predicted

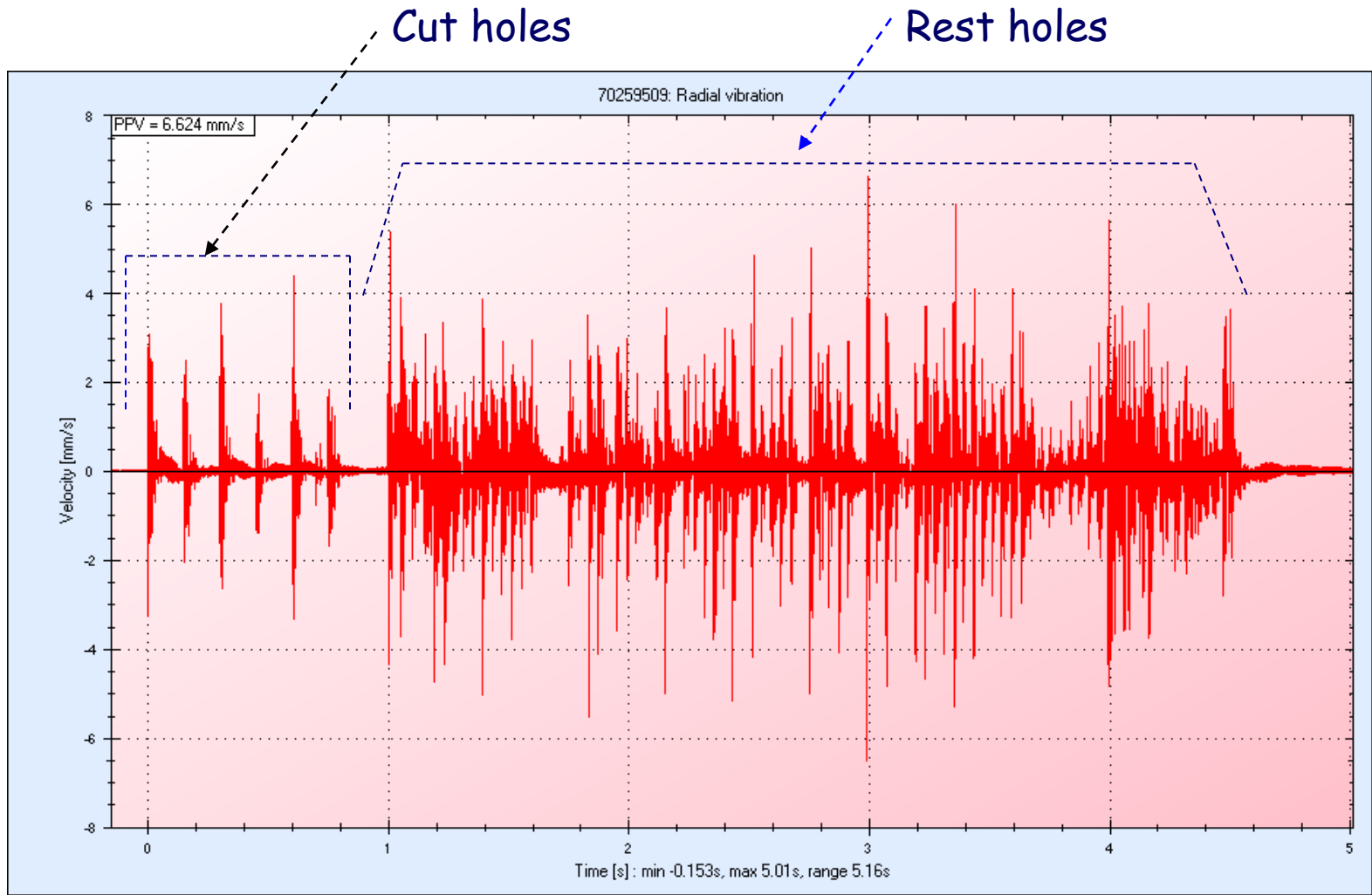


With good information from the analysis of signature hole blast vibration, in most case the MSW slightly over predicts the vibration measurement from production blasts. Such a feature makes the MSW model to be reliable to make a conservative prediction or blast design recommendation without calibration.

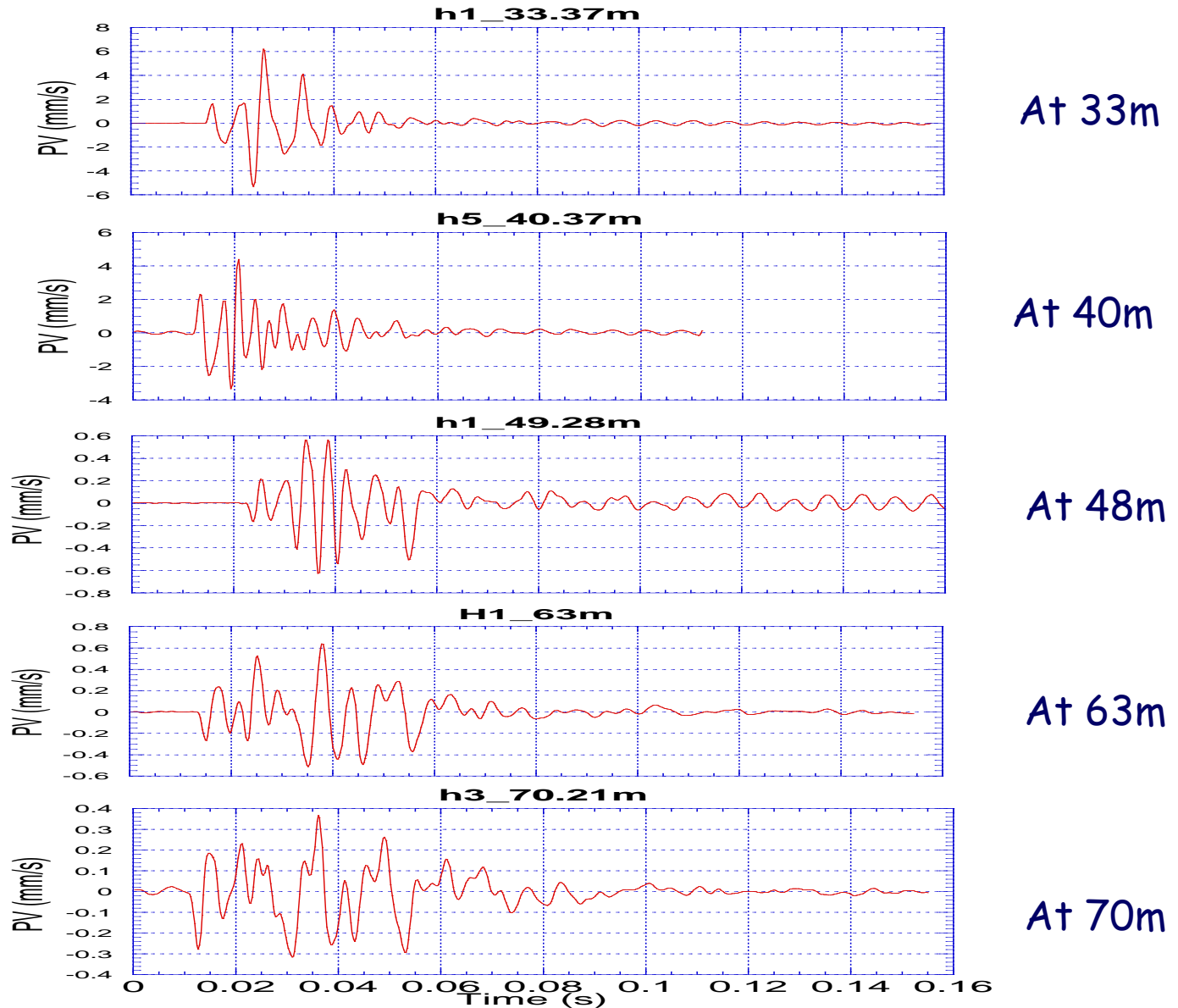
NSW model applied in tunnel blasts



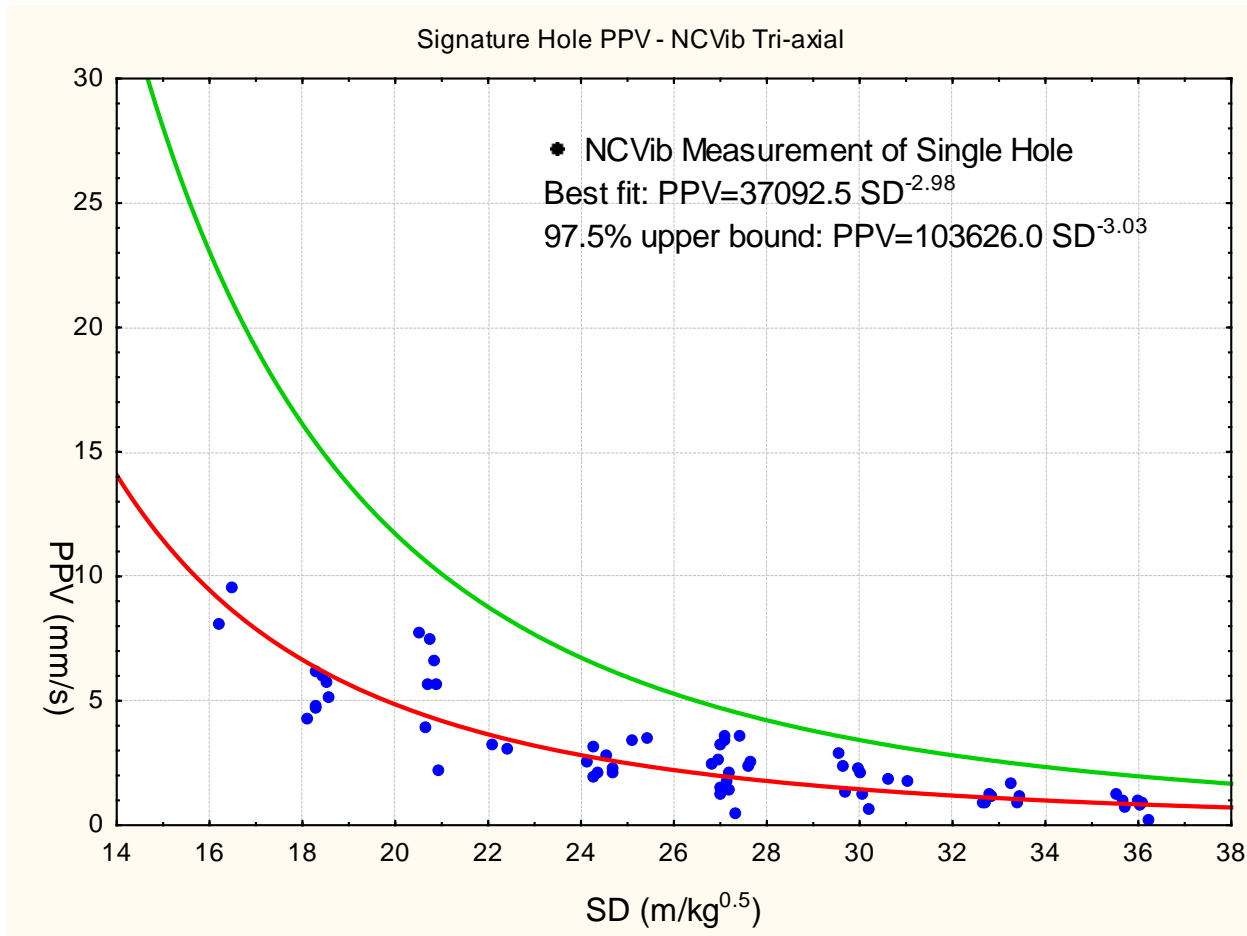
Blast holes and timing in a complete blast round



Vibration trace from a complete blast round

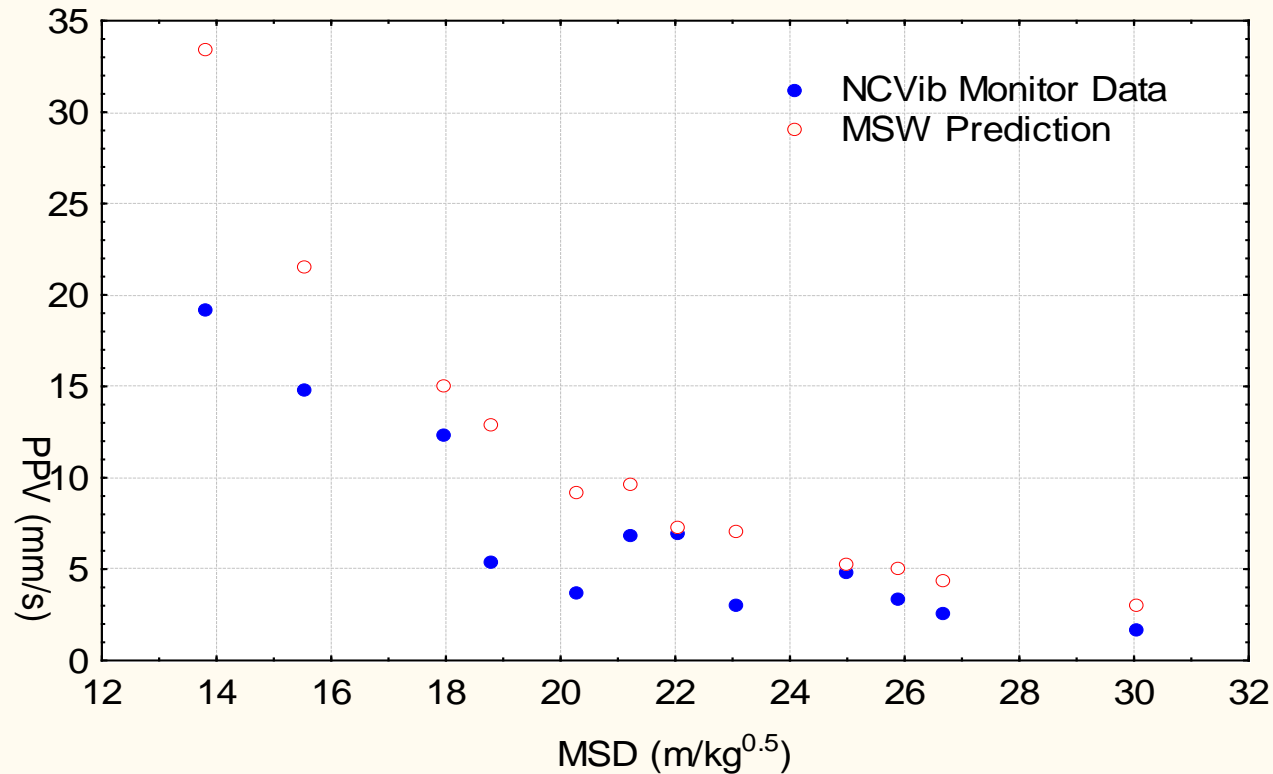


Waveform changes at different distance from a signature hole, even in such hard granite of Stockholm.



64 signature hole waveforms were collected with NCVib monitors from three production blasts. The parameters from the signature hole vibration are used without alteration as input to the MSW model for Predictions of production blasts.

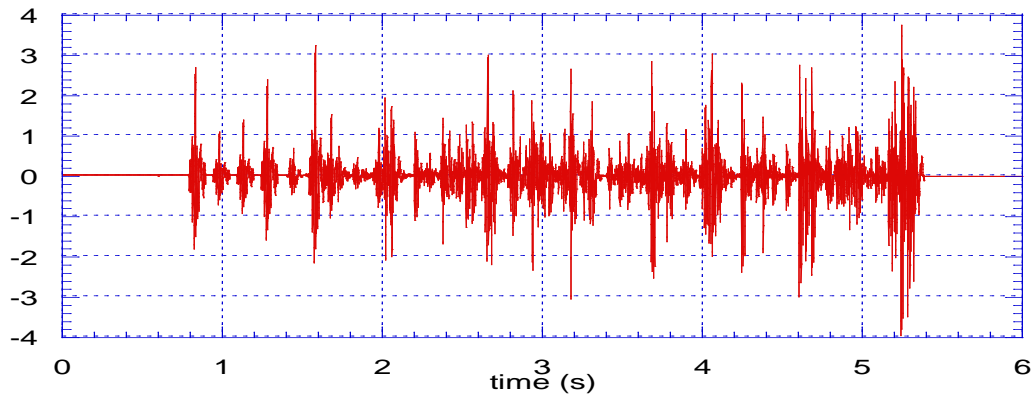
Comparison Between Model and Measurement
for Three Production Blasts



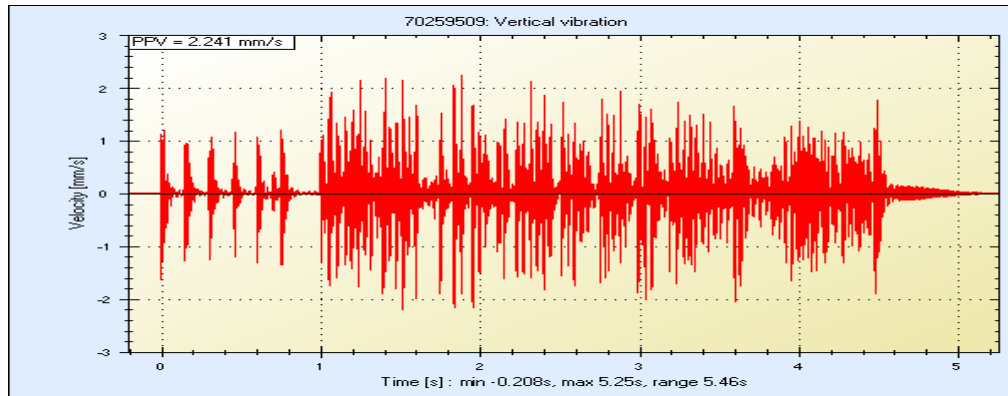
With the parameters from the signature hole blasts, the MSW prediction of the average PPV's from 100 runs compared with the measured PPV from three blasts with NCVib monitors.

A further refinement of the MSW screening algorithm is under the way to improve the MSW tunnel and underground blast vibration modeling.

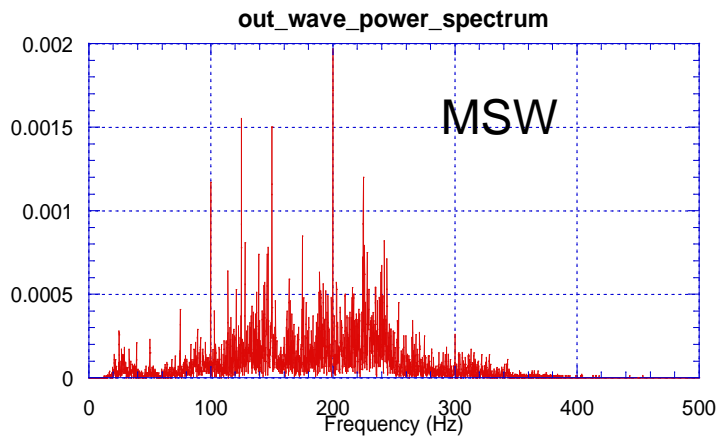
The MSW model can be used in tunnel vibration modeling reliably.



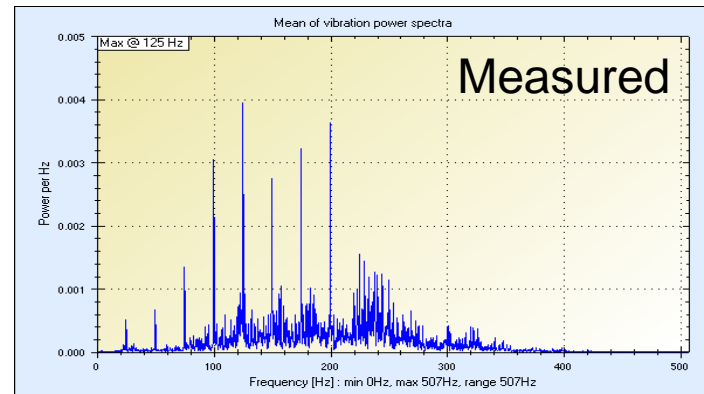
MSW



Measured

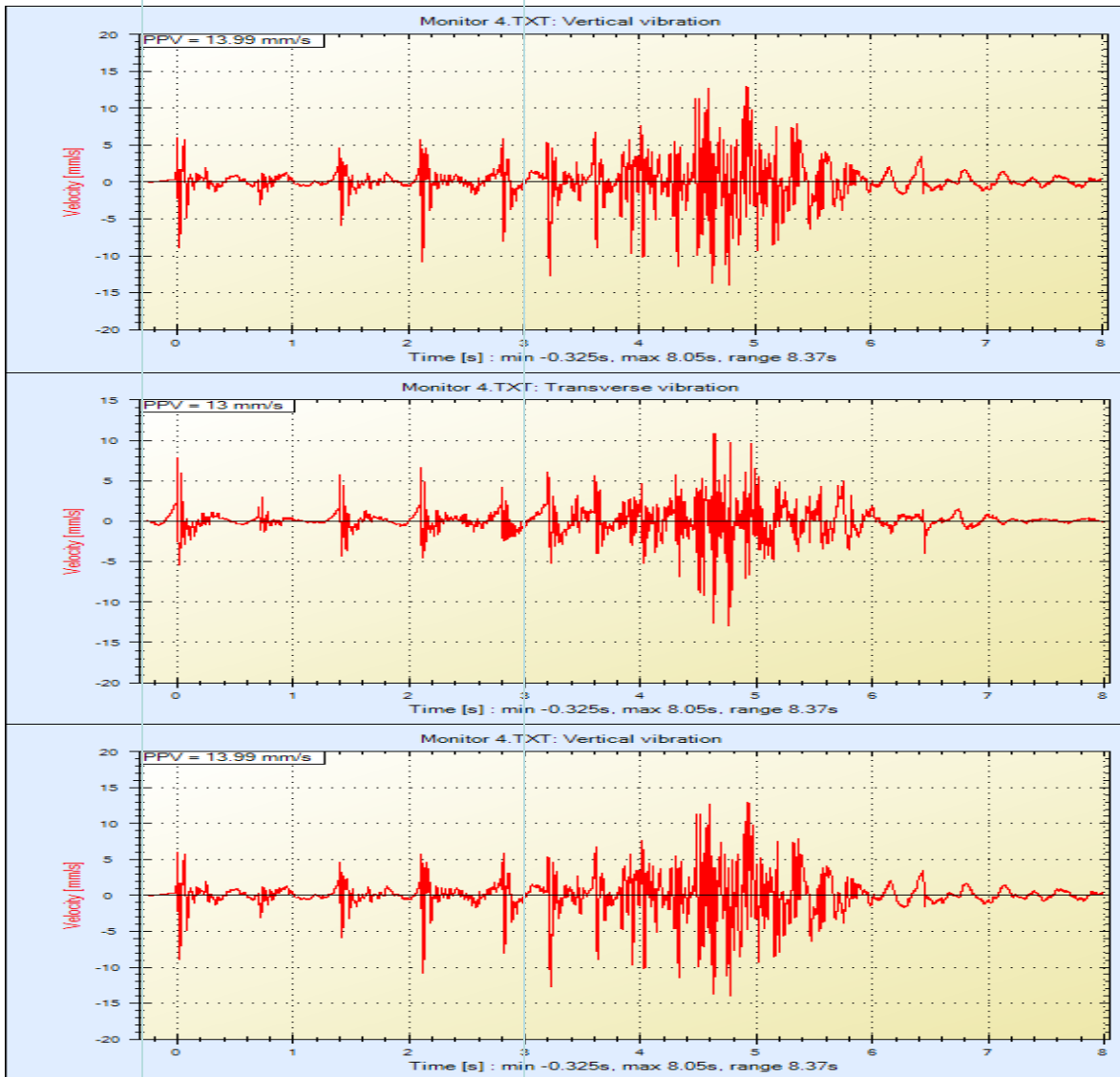


MSW



Measured

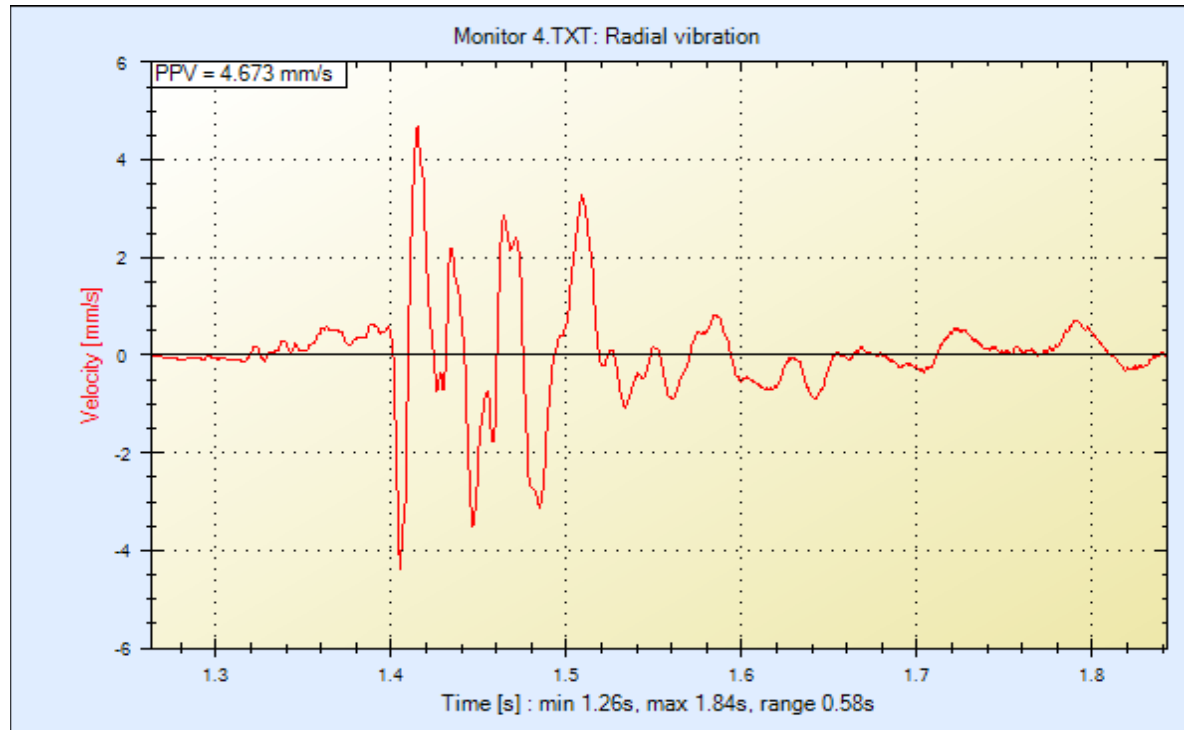
NSW model applied in underground blasts



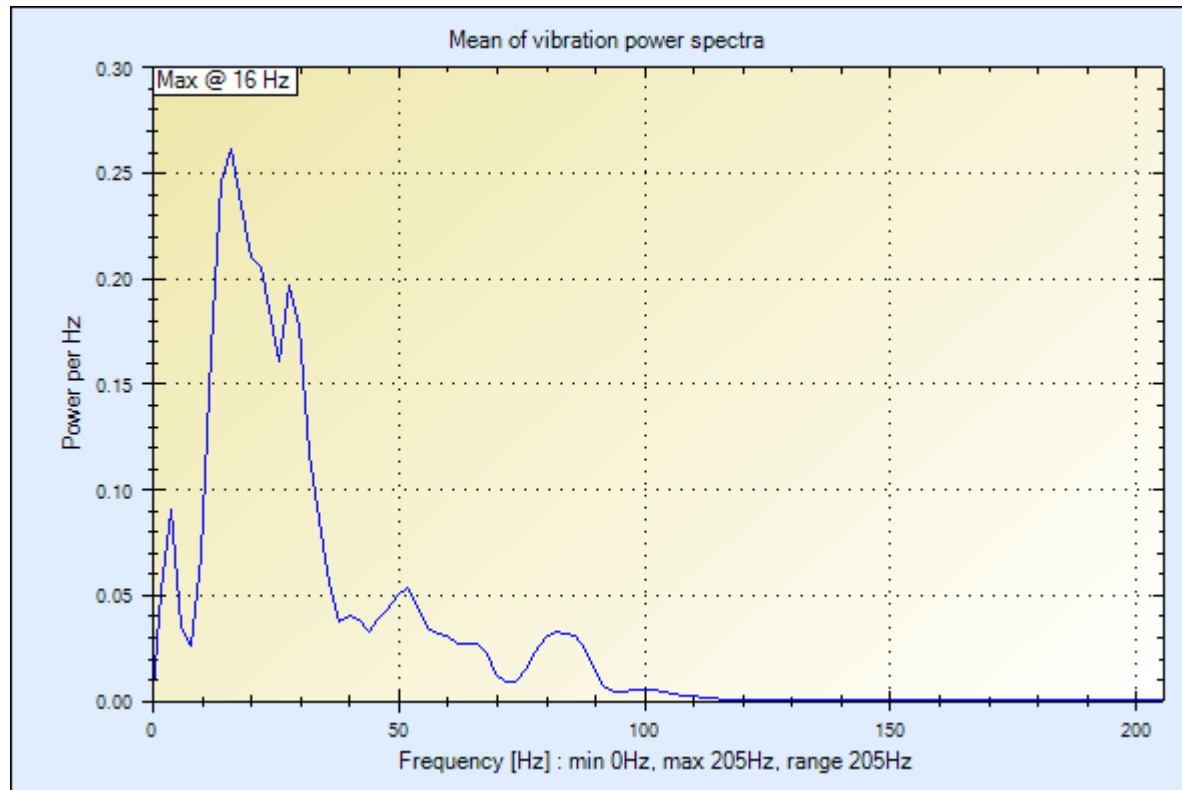
From cut hole vibration we obtain:

- 1) Multiple seed waveforms;
- 2) PPV or PPA attenuations;
- 3) Ground frequency response;
- 4) Ground sonic velocity.

← Cut holes →



A seed wave from a cut blast hole.

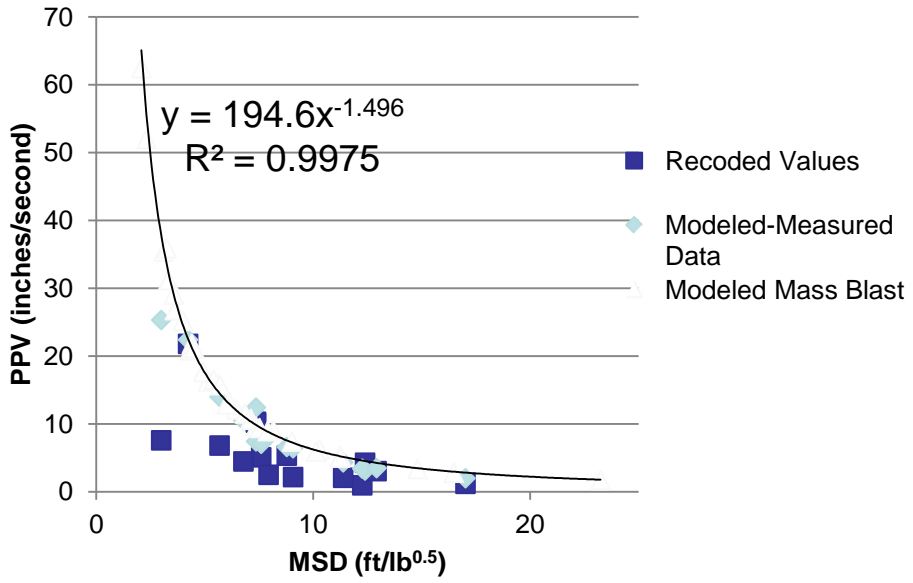


Amplitude spectrum of the vibration from a cut blast hole, Indicating the ground resonant frequency is 16 Hz and in the frequency range of 0 - 100 hz there is significant vibration energy.

MSW is used successfully in recent BBS project at Gold Strike Mine - Barrick Gold
Kameron Ray, Steve Piercey, Ruilin Yang



Goldstrike Vibration Curve



Ground sonic velocity was measured with our proprietary plug-in apparatus
 $C_p = 3580 \text{ m/s}$