BLAST-INDUCED VIBRATION DATA EVALUATION PROGRAM

Created By:
U.S. Department of Interior
Office of Surface Mining Reclamation and Enforcement (OSMRE)
Appalachian Region
Technical Support Division
Three Parkway Center
Pittsburgh, Pennsylvania 15220

Overview

The Blast-Induced Vibration Data Evaluation Program (BIVDEP) statistically evaluates ground vibration and air overpressure (i.e. airblast) data collected from a series of monitored blast events at a surface mine. The statistical evaluation allows the user to approximate peak particle velocity (PPV) and peak airblast (AB) for future blast events using square root and cube root scaling techniques respectively. The evaluation results can also be used to develop a modified scaled-distance factor at a surface mine or within a region. The BIVDEP is a comprehensive update to a previously released blasting tool called "OSMRE Regression Analysis for Ground Vibrations and Airblast".

The BIVDEP evaluates blast event monitoring data with many different corresponding charge-weights per delay (CW) by normalizing the distance from the blast (D). In other words, distance and charge-weight per delay are combined to form a single number, which can then be plotted or used in calculations. The most common way of combining distance and charge-weight per delay is to divide the distance by the square root (for ground vibration) or the cube root (for airblast) of the maximum charge-weight per delay. The resulting number is referred to as the square root scaled distance (SD_2) and the cube root scaled distance (SD_3).

The BIVDEP works as an easy to use Microsoft Excel spreadsheet. The only data necessary to perform an evaluation is the D, CW, PPV, and AB for a monitored blast event. As the user enters the required input data for each monitored blast event, the BIVDEP plots the PPV and AB against the corresponding SD_2 and SD_3 on a log-log graph, respectively. The BIVDEP generates a best-fit line for both graphs using a least squares regression analysis, which will allow the user to approximate the PPV and AB for future blast events. An upper bound line is also generated for both graphs using a confidence interval of at least ninety-five (95) percent. Up to two-hundred and twenty (220) monitored blast events (i.e. a data set) can be evaluated.

The methods and techniques used is the BIVDEP are based largely on the discussion presented in the *International Society of Explosives Engineers (ISEE), Blaster's Handbook, 18th Edition, Chapter 26 - Vibration, Pages 551 through 630*. This reference is a valuable resource in understanding how the BIVDEP reduces, evaluates, and presents the blast-induced monitoring data. BIVDEP users are encouraged to review the discussion in Chapter 26 prior to using the BIVDEP.

BIVDEP Instructions

1. The BIVDEP and supporting document can be downloaded from the OSMRE Appalachian Region blasting website (ARblast: http://www.osmre.gov/resources/blasting/arblast.shtm). Go to the ARblast website and scroll down to the resource table called "Excel Tools". Click the link for the BIVDEP to download. BIVDEP users are encouraged to check the ARblast website periodically for any updated versions of the BIVDEP.

2. The user should read the supporting instructions and review the example provided in Attachment A prior to using the BIVDEP. Refer to the table in the following section for guidance on the required input data fields.

3. Open the BIVDEP spreadsheet and immediately save the file as a different name. Start by clicking on the File tab in the upper left, select the save-as option, and then enter the new file name. The file should be named in reference to the mine site or permit number.

4. Select the "Input_Data" worksheet tab at the lower left of the spreadsheet to begin using the BIVDEP. Be aware, an artificial data set (i.e. 184 monitored blast events) has been entered for illustration and example purposes only.

5. Blue font in the "Input_Data" worksheet identifies required data entry by the user. Black font identifies the BIVDEP template text and should not be edited. Refer to the table in the following section for guidance on the required input data fields.

6. The red font in the "Input_Data" worksheet identifies data cells that contain a calculation or rule and therefore, cannot be edited. The red font data cells are password protected from all editing.

7. The artificial data is only intended as an example of data entry. **The user must delete all of the artificial data prior to using the BIVDEP**. Simply highlight the artificial example data (i.e. the blue font) and delete.

8. Select the "Input_Data" worksheet tab at the lower left of the spreadsheet and enter the following in rows 1 and 2 of Page 1: Review Agency, Blaster, Surface Mine, Permit No., Review Date, and Reviewed by. The user only needs to enter this information once. This information is very useful and will print automatically on each graph and input data summary sheets.

9. The user may enter the date and the seismograph unit location for each monitored blast events. These data fields are optional but, are recommended for consistency and completeness.

10. Enter the D and CW for each blast-induced vibration event. The square root and cube root scaled distances will calculate automatically.

11. Continue entering the corresponding PPV and AB for the blast-induced vibration event. The statistical evaluation is performed and the graphs are generated automatically.

12. **Caution:** The user must adhere to the following instruction in order for the BIVDEP to function correctly. Because of the statistical tools used in the BIVDEP, there can be no gaps in the data field entry and the data rows must be consecutive. The user must not skip or delete data rows or cells. In other words and for example, if the user has 184 blast records to be entered, the user must input 184 D's, CW's, PPV's, and AB's each in 184 data rows consecutively. This is a requirement for the spreadsheet to function correctly. Failure to do so will result in errors and invalid results. Refer to the example provided in Attachment A for an illustration of proper data entry.

13. **Important Guidance:** For blast logs or seismograph records indicating the unit did not trigger to record the PPV and or the AB, the user may choose to eliminate the blast record from the BIVDEP data set or may choose to enter the trigger threshold settings for the unit (e.g. PPV = 0.05 inch/sec, AB = 120 db). To avoid biasing the BIVDEP results, the data set should not contain a large percentage of records (less than 5%) where the unit did not trigger. Refer to the *ISEE Field Practice Guidelines for Blasting Seismographs, 2015* for guidance on blasting seismograph threshold settings.

14. The user must exercise close attention to detail when entering the required input data. If data entry errors are made, the BIVDEP will alert the user with errors shown in the calculation data cells (e.g. *#N/A, #VALUE!*, etc.).

15. Upon completing the required input data entry, the user may assess the evaluation results by selecting the "Ground_Vibration" and "Airblast" worksheet tabs to view each graph. It is recommended the user refer to the *ISEE, Blaster's Handbook, 18th Edition, Chapter 26 - Vibration, Pages 551 through 630*. This reference provides an in-depth background on performing statistical analysis of vibration data as well as guidance on how to interpret the BIVDEP evaluation results.

16. **Caution:** The "Ground_Vibration" and "Airblast" worksheet tabs (i.e. the graphs) are not protected and may be edited by the user. This allows the user to edit the graphs to suit their specific needs. However, critical calculations related to the Best Fit Line (i.e. A and B) and the Upper Bound Line (95% Confidence) are performed on the worksheet. The user must not edit these data cells/calculations under any circumstances.

17. **Important Guidance:** It is recommended the user enter a minimum of thirty (30) monitored blast events to ensure the evaluation are statistically valid. Generally, a large data set will provide more reliable approximations. The user is encouraged to evaluate as much reliable data that is available.

18. **Important Guidance:** To ensure reliable PPV and AB approximations, the coefficient of determination or correlation coefficient (R^2) for the blast-induced data set should be no less than 0.70. A good statistical relationship exists if the R^2 is greater than 0.70. However, this does not suggest the data set is not valid if the R^2 is less than 0.70. The lower the R^2, the greater the amount of data scatter.

19. **Important Guidance:** The user may need to edit or adjust the graph axis scales and plot objects (e.g. legend, R^2 value, titles, etc.) to suit their data set. Simply right-click on either the x or y axes and select "Format Axis" to change the axis scale bounds (i.e. "Axis Options"). Note, because the x and y axes are logarithmic scales, the axis bounds must start and end with a power of ten (i.e. 10, 100, 1000, etc.). Once the axes are established, the user may click on the plot objects and drag them to an appropriate location as necessary.

20. The user is must enter the required data input in imperial units (e.g. feet, pounds, inch/second, decibels). However, the results of the BIVDEP evaluation are provided in both imperial and metric units. The user may select either unit based on their needs. Just select the appropriate Ground Vibration and Airblast worksheet tabs.

21. Printing of the BIVDEP evaluation results can be done in whole or individually. Refer to Attachment D for a BIVDEP printed workbook example. In the print window, select either in the settings dropdown menu:

    a. Entire workbook to print all the tables and graphs accordingly or;
    b. Active sheet to print the sheet being viewed.

Required BIVDEP Input Data Summary

The BIVDEP requires the following data fields to be entered in the specified format and units. The numeric data fields are formatted in BIVDEP to show the appropriate decimal places. Guidance on data input is provided in the data field description below. Only the D, CW, PPV, and AB data fields are required for the BIVDEP to function properly. The remaining data fields are optional but, are highly recommended for completeness and consistency.

Data Field	Units	Description
Review Agency	Name or ID	Name of the agency or firm conducting the blast log evaluation.
Review Date	MM/DD/YY	Date of the blast log evaluation.
Reviewed By	Name	Name of the individual(s) conducting the evaluation.
Surface Mine	Name	Name of the surface mine related to the permit number.
Permit Number	Number	Permit number assigned by regulatory authority to the surface mine.
Blaster	Name	Blasting company as reported on the blast log.
Blast Date	MM/DD/YY	Date of the blast as reported on the blast log.
Distance From Blast	Feet	Provide the distance to the nearest protected structure as reported on the blast log.
Charge Weight Per Delay (CW)	Number	The charge weight is the maximum weight of explosives detonated within an 8-millisecond delay period.
Peak Particle Velocity (PPV) Reported	Inch per Second (in/sec)	The PPV is the absolute highest zero to peak value measured from a seismograph time-history waveform. Provide the maximum PPV as reported from the blasting seismograph record. If monitoring was conducted but, the unit did not trigger, the user may choose to eliminate the blast record from the BIVDEP data set or may choose to enter the trigger threshold settings for the unit (e.g. PPV = 0.05 inch/second. To avoid biasing the BIVDEP results, the data set should not contain a large percentage of records where the unit did not trigger (less than 5%). Refer to the ISEE Field Practice Guidelines for Blasting Seismographs, 2015 for guidance on blasting seismograph threshold settings.

Data Field	Units	Description
Airblast (AB) Reported	Decibels (dB)	Seismic monitoring of a blast event typically includes a measurement of air vibrations (i.e. air overpressure). Air overpressure or AB is the additional pressure generated from a blast above the normal atmospheric pressure. AB is measured as a pressure and reported in units of decibels. Provide the airblast as reported from the blasting seismograph record. If monitoring was conducted but, the unit did not trigger, the user may choose to eliminate the blast record from the BIVDEP data set or may choose to enter the trigger threshold settings for the unit (e.g. AB = 120 db). To avoid biasing the BIVDEP results, the data set should not contain a large percentage of records where the unit did not trigger (less than 5%). Refer to the ISEE Field Practice Guidelines for Blasting Seismographs, 2015 for guidance on blasting seismograph threshold settings.
Square Root Scaled Distance (SD_2)	Feet per Square Root of Charge-Weight ($ft/lbs^{(1/2)}$)	SD_2 is defined as the distance from the blast site to the seismograph location (D), divided by the square root of the maximum weight of explosives detonated within an 8-millisecond delay period (CW). The equation for square root scaled distance is commonly represented several ways. $SD_2 = D / \sqrt{CW}$ $SD_2 = D / CW^{0.5}$ $SD_2 = D / CW^{(½)}$ Where the following units apply: SD_2 is in feet per the square root of pounds ($ft/lb^{½}$); D is in feet (ft); and CW is in square root of charge-weight ($lb^{½}$). Note: An SD_2 value of fifty-five (55 $ft/lb^{½}$) for distances between 301 to 1,000 feet provides a high level of confidence that damage to structures will not occur.

Data Field	Units	Description
Cube Root Scaled Distance (SD_3)	Feet per Cube Root of Charge-Weight ($ft/lbs^{(1/3)}$)	SD_3 is defined as the distance from the blast site to the seismograph location (D), divided by the cube root of the maximum weight of explosives detonated within an 8-millisecond delay period (CW). The equation for cube root scaled distance is commonly represented several ways. $SD_3 = D / \sqrt[3]{CW}$ $SD_3 = D / CW^{0.33}$ $SD_3 = D / CW^{(1/3)}$ Where the following units apply: SD_3 is in feet per the cube root of pounds ($ft/lb^{1/3}$); D is in feet (ft); and CW is in cube root of pounds ($lb^{1/3}$).

Technical Issues and Troubleshooting

Contact the individuals listed below for technical assistance. If the spreadsheet doesn't appear to be functioning properly, the spreadsheet may have been unintentionally edited or changed. In this case, simply go to the ARblast website and download a new BIVDEP spreadsheet template. Also, BIVDEP users may send any recommendations for improvement to the individuals listed below.

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Attachment A: BIVDEP Example

BIVDEP Printed Workbook Example

The following pages illustrate: 1) an example of BIVDEP data entry for a faux surface coal mine; and 2) the corresponding BIVDEP results for the faux surface coal mine.

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:		OSMRE				Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19		
Blaster:		Top Flight Blasting				Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.		
Blast Event Details and Measurements as Reported							Ground Vibration Analysis				Airblast Analysis			
Blast Record	Blast Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	AB	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB	
	mm/dd/yy		ft	lbs	in/sec	dB	$ft/lbs^{(1/2)}$	$ft/lbs^{(1/2)}$	in/sec	lbs/in^2	$ft/lbs^{(1/3)}$	$ft/lbs^{(1/3)}$	lbs/in^2	
1	04/15/01	Seis 15 A	50	426.5	5.08	139.0	2.42	0.38	0.71	0.0258	6.64	0.822	-1.588	
2	04/15/01	Seis 15	359	426.5	4.48	130.0	17.38	1.24	0.65	0.0092	47.69	1.678	-2.038	
3	04/15/01	Seis 16	680	426.5	1.80	126.0	32.93	1.52	0.26	0.0058	90.34	1.956	-2.238	
4	04/15/01	Seis 17	995	426.5	0.69	122.0	48.18	1.68	-0.16	0.0037	132.19	2.121	-2.438	
5	04/15/01	Seis 18	1,214	426.5	0.38	119.0	58.78	1.77	-0.42	0.0026	161.28	2.208	-2.588	
6	04/15/01	Seis 19	2,904	426.5	0.05	112.0	140.62	2.15	-1.30	0.0012	385.80	2.586	-2.938	
7	04/15/01	Seis 21	3,274	426.5	0.03	109.0	158.53	2.20	-1.52	0.0008	434.95	2.638	-3.088	
8	07/20/01	Seis 1A	50	360.0	6.96	135.0	2.64	0.42	0.84	0.0163	7.03	0.847	-1.788	
9	07/20/01	Seis 2A	324	360.0	1.60	125.0	17.08	1.23	0.20	0.0052	45.55	1.658	-2.288	
10	07/20/01	Seis 3	711	360.0	0.43	121.0	37.47	1.57	-0.37	0.0033	99.95	2.000	-2.488	
11	07/20/01	Seis 4	1,108	360.0	0.27	117.0	58.40	1.77	-0.57	0.0021	155.75	2.192	-2.688	
12	07/20/01	Seis 5A	1,295	360.0	0.24	116.0	68.25	1.83	-0.62	0.0018	182.04	2.260	-2.738	
13	07/20/01	Seis 5	1,690	360.0	0.20	112.0	89.07	1.95	-0.70	0.0012	237.57	2.376	-2.938	
14	07/20/01	Seis 6	2,218	360.0	0.09	109.0	116.90	2.07	-1.05	0.0008	311.79	2.494	-3.088	
15	07/20/01	Seis 15	582	360.0	0.95	132.0	30.67	1.49	-0.02	0.0115	81.81	1.913	-1.938	
16	07/20/01	Seis 16	960	360.0	0.45	125.0	50.60	1.70	-0.35	0.0052	134.95	2.130	-2.288	
17	07/20/01	Seis 17	1,214	360.0	0.26	122.0	63.98	1.81	-0.59	0.0037	170.65	2.232	-2.438	
18	07/20/01	Seis 18	1,426	360.0	0.28	118.0	75.16	1.88	-0.55	0.0023	200.46	2.302	-2.638	
19	07/20/01	Seis 19	3,432	360.0	0.06	112.0	180.88	2.26	-1.22	0.0012	482.44	2.683	-2.938	
20	07/21/01	Seis 2	396	361.5	0.94	130.0	20.83	1.32	-0.03	0.0092	55.59	1.745	-2.038	
21	07/21/01	Seis 3	792	361.5	0.33	125.0	41.66	1.62	-0.48	0.0052	111.18	2.046	-2.288	
22	07/21/01	Seis 4	1,267	361.5	0.49	124.0	66.64	1.82	-0.31	0.0046	177.86	2.250	-2.338	
23	07/21/01	Seis 5 A	1,595	361.5	0.18	123.0	83.89	1.92	-0.74	0.0041	223.90	2.350	-2.388	
24	07/21/01	Seis 5	1,900	361.5	0.15	120.0	99.93	2.00	-0.82	0.0029	266.72	2.426	-2.538	
25	07/21/01	Seis 15	634	361.5	1.02	122.0	33.35	1.52	0.01	0.0037	89.00	1.949	-2.438	
26	07/21/01	Seis 16	844	361.5	0.51	122.0	44.39	1.65	-0.29	0.0037	118.48	2.074	-2.438	
27	07/21/01	Seis 2*	528	361.5	0.76	125.0	27.77	1.44	-0.12	0.0052	74.12	1.870	-2.288	
28	07/21/01	Seis 3*	786	361.5	0.36	122.0	41.34	1.62	-0.44	0.0037	110.34	2.043	-2.438	
29	07/21/01	Seis 4*	1,372	361.5	0.49	120.0	72.16	1.86	-0.31	0.0029	192.60	2.285	-2.538	
30	07/21/01	Seis 5 A*	1,900	361.5	0.22	121.0	99.93	2.00	-0.66	0.0033	266.72	2.426	-2.488	
31	07/21/01	Seis 5*	1,848	361.5	0.25	114.0	97.20	1.99	-0.60	0.0015	259.42	2.414	-2.838	
32	07/21/01	Seis 15*	264	361.5	4.00	128.0	13.89	1.14	0.60	0.0073	37.06	1.569	-2.138	
33	07/21/01	Seis 16*	528	361.5	0.56	122.0	27.77	1.44	-0.25	0.0037	74.12	1.870	-2.438	
34	07/21/01	Seis 17*	878	361.5	0.46	117.0	46.18	1.66	-0.34	0.0021	123.25	2.091	-2.688	
35	07/21/01	Seis 18*	1,407	361.5	0.22	117.0	74.00	1.87	-0.66	0.0021	197.51	2.296	-2.688	
36	07/21/01	Seis 19*	3,125	361.5	0.10	109.0	164.36	2.22	-1.00	0.0008	438.68	2.642	-3.088	
37	07/27/00	Seis 1	90	375.5	2.08	139.0	4.64	0.67	0.32	0.0258	12.47	1.096	-1.588	
38	07/27/00	Seis 2	300	375.5	1.64	130.0	15.48	1.19	0.21	0.0092	41.58	1.619	-2.038	
39	07/27/00	Seis 3	700	375.5	0.41	123.0	36.12	1.56	-0.39	0.0041	97.03	1.987	-2.388	
40	07/27/00	Seis 4	1,230	375.5	0.16	119.0	63.47	1.80	-0.80	0.0026	170.49	2.232	-2.588	
41	07/27/00	Seis 5	2,200	375.5	0.06	116.0	113.53	2.06	-1.22	0.0018	304.94	2.484	-2.738	
42	07/27/00	Seis 6	2,600	375.5	0.05	116.0	134.17	2.13	-1.30	0.0018	360.39	2.557	-2.738	
43	07/31/00	Seis 1A	93	350.0	1.96	138.0	4.97	0.70	0.29	0.0230	13.20	1.120	-1.638	
44	07/31/00	Seis 1	294	350.0	1.28	130.0	15.71	1.20	0.11	0.0092	41.72	1.620	-2.038	
45	07/31/00	Seis 2	504	350.0	0.50	124.0	26.94	1.43	-0.30	0.0046	71.52	1.854	-2.338	

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Blaster:	Top Flight Blasting					Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
Blast Event Details and Measurements as Reported							**Ground Vibration Analysis**				**Airblast Analysis**		
Blast Record	Blast Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	AB	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		ft	lbs	in/sec	dB	$ft/lbs^{(1/2)}$	$ft/lbs^{(1/2)}$	in/sec	lbs/in^2	$ft/lbs^{(1/3)}$	$ft/lbs^{(1/3)}$	lbs/in^2
46	07/31/00	Seis 3	904	350.0	0.32	121.0	48.32	1.68	-0.49	0.0033	128.28	2.108	-2.488
47	07/31/00	Seis 4	1,434	350.0	0.16	125.0	76.65	1.88	-0.80	0.0052	203.48	2.309	-2.288
48	07/31/00	Seis 5 A	2,404	350.0	0.09	116.0	128.50	2.11	-1.05	0.0018	341.12	2.533	-2.738
49	07/31/00	Seis 5	2,804	350.0	0.04	112.0	149.88	2.18	-1.40	0.0012	397.88	2.600	-2.938
50	08/03/01	Seis 2	264	365.0	1.05	130.0	13.82	1.14	0.02	0.0092	36.94	1.568	-2.038
51	08/03/01	Seis 3	710	365.0	0.41	123.0	37.16	1.57	-0.39	0.0041	99.35	1.997	-2.388
52	08/03/01	Seis 4	1,056	365.0	0.28	120.0	55.27	1.74	-0.55	0.0029	147.76	2.170	-2.538
53	08/03/01	Seis 5 A	1,690	365.0	0.16	114.0	88.46	1.95	-0.80	0.0015	236.48	2.374	-2.838
54	08/03/01	Seis 6	3,220	365.0	0.05	112.0	168.54	2.23	-1.30	0.0012	450.57	2.654	-2.938
55	08/03/01	Seis 15	710	365.0	0.74	128.0	37.16	1.57	-0.13	0.0073	99.35	1.997	-2.138
56	08/03/01	Seis 16	824	365.0	0.22	122.0	43.13	1.63	-0.66	0.0037	115.30	2.062	-2.438
57	08/03/01	Seis 17	1,214	365.0	0.14	117.0	63.54	1.80	-0.85	0.0021	169.87	2.230	-2.688
58	08/03/01	Seis 18	1,436	365.0	0.31	114.0	75.16	1.88	-0.51	0.0015	200.94	2.303	-2.838
59	08/03/01	Seis 19	3,220	365.0	0.05	109.0	168.54	2.23	-1.30	0.0008	450.57	2.654	-3.088
60	08/03/00	Seis 1 A	100	414.0	4.20	137.0	4.91	0.69	0.62	0.0205	13.42	1.128	-1.688
61	08/03/00	Seis 1	563	414.0	0.79	123.0	27.67	1.44	-0.10	0.0041	75.54	1.878	-2.388
62	08/03/00	Seis 2	620	414.0	0.65	119.0	30.47	1.48	-0.19	0.0026	83.19	1.920	-2.588
63	08/03/00	Seis 3	857	414.0	0.45	117.0	42.12	1.62	-0.35	0.0021	114.99	2.061	-2.688
64	08/03/00	Seis 4	1,387	414.0	0.16	119.0	68.17	1.83	-0.80	0.0026	186.10	2.270	-2.588
65	08/03/00	Seis 5 A	2,150	414.0	0.15	116.0	105.67	2.02	-0.82	0.0018	288.47	2.460	-2.738
66	08/03/00	Seis 5	2,250	414.0	0.11	109.0	110.58	2.04	-0.96	0.0008	301.89	2.480	-3.088
67	08/03/00	Seis 6	2,750	414.0	0.10	109.0	135.16	2.13	-1.00	0.0008	368.98	2.567	-3.088
68	08/04/00	Seis 1	183	285.5	1.84	134.0	10.83	1.03	0.26	0.0145	27.79	1.444	-1.838
69	08/04/00	Seis 1A	100	285.5	4.20	140.0	5.92	0.77	0.62	0.0290	15.19	1.181	-1.538
70	08/04/00	Seis 2	383	285.5	1.28	128.0	22.67	1.36	0.11	0.0073	58.17	1.765	-2.138
71	08/04/00	Seis 3	530	285.5	0.46	122.0	31.37	1.50	-0.34	0.0037	80.49	1.906	-2.438
72	08/04/00	Seis 4	1,313	285.5	0.16	119.0	77.71	1.89	-0.80	0.0026	199.40	2.300	-2.588
73	08/04/00	Seis 5 A	2,183	285.5	0.11	117.0	129.20	2.11	-0.96	0.0021	331.53	2.521	-2.688
74	08/04/00	Seis 5	2,883	285.5	0.06	114.0	170.62	2.23	-1.22	0.0015	437.83	2.641	-2.838
75	08/04/00	Seis 6	2,783	285.5	0.03	114.0	164.71	2.22	-1.52	0.0015	422.65	2.626	-2.838
76	08/08/00	Seis 7 A	100	308.0	3.96	136.0	5.70	0.76	0.60	0.0183	14.81	1.170	-1.738
77	08/08/00	Seis 7	378	308.0	3.12	123.0	21.54	1.33	0.49	0.0041	55.97	1.748	-2.388
78	08/08/00	Seis 8	617	308.0	1.44	120.0	35.16	1.55	0.16	0.0029	91.36	1.961	-2.538
79	08/08/00	Seis 9	1,315	308.0	0.51	114.0	74.93	1.87	-0.29	0.0015	194.72	2.289	-2.838
80	08/08/00	Seis 10	1,906	308.0	0.41	114.0	108.60	2.04	-0.39	0.0015	282.23	2.451	-2.838
81	08/08/00	Seis 11	2,456	308.0	0.19	106.0	139.94	2.15	-0.72	0.0006	363.67	2.561	-3.238
82	08/08/00	Seis 12	3,056	308.0	0.19	106.0	174.13	2.24	-0.72	0.0006	452.52	2.656	-3.238
83	08/11/00	Seis 7 A	100	346.0	5.08	137.0	5.38	0.73	0.71	0.0205	14.24	1.154	-1.688
84	08/11/00	Seis 7	378	346.0	2.08	127.0	20.32	1.31	0.32	0.0065	53.84	1.731	-2.188
85	08/11/00	Seis 8	617	346.0	1.72	120.0	33.17	1.52	0.24	0.0029	87.89	1.944	-2.538
86	08/11/00	Seis 9	1,315	346.0	0.45	117.0	70.69	1.85	-0.35	0.0021	187.31	2.273	-2.688
87	08/11/00	Seis 10	1,906	346.0	0.41	116.0	102.47	2.01	-0.39	0.0018	271.50	2.434	-2.738
88	08/11/00	Seis 11	2,465	346.0	0.17	109.0	132.52	2.12	-0.77	0.0008	351.12	2.545	-3.088
89	08/11/00	Seis 12	3,065	346.0	0.18	106.0	164.78	2.22	-0.74	0.0006	436.59	2.640	-3.238
90	08/11/00	Seis 13	3,185	346.0	0.15	106.0	171.23	2.23	-0.82	0.0006	453.68	2.657	-3.238

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE					Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:	Top Flight Blasting					Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
Blast Event Details and Measurements as Reported							**Ground Vibration Analysis**				**Airblast Analysis**		
Blast Record	Blast Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	AB	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		ft	lbs	in/sec	dB	$ft/lbs^{(1/2)}$	$ft/lbs^{(1/2)}$	in/sec	lbs/in^2	$ft/lbs^{(1/3)}$	$ft/lbs^{(1/3)}$	lbs/in^2
91	08/16/00	Seis 7 A	100	346.5	5.08	137.0	5.37	0.73	0.71	0.0205	14.24	1.153	-1.688
92	08/16/00	Seis 7	317	346.5	3.04	127.0	17.03	1.23	0.48	0.0065	45.13	1.654	-2.188
93	08/16/00	Seis 8	556	346.5	1.80	125.0	29.87	1.48	0.26	0.0052	79.16	1.899	-2.288
94	08/16/00	Seis 9	1,254	346.5	0.51	121.0	67.37	1.83	-0.29	0.0033	178.54	2.252	-2.488
95	08/16/00	Seis 10	1,845	346.5	0.39	119.0	99.12	2.00	-0.41	0.0026	262.68	2.419	-2.588
96	08/16/00	Seis 11	2,395	346.5	0.22	112.0	128.66	2.11	-0.66	0.0012	340.99	2.533	-2.938
97	08/16/00	Seis 12	3,004	346.5	0.21	109.0	161.38	2.21	-0.68	0.0008	427.69	2.631	-3.088
98	08/16/00	Seis 13	3,849	346.5	0.09	106.0	206.77	2.32	-1.05	0.0006	548.00	2.739	-3.238
99	08/13/01	Seis 1A	50	392.0	10.24	138.0	2.53	0.40	1.01	0.0230	6.83	0.835	-1.638
100	08/13/01	Seis 2	317	392.0	1.13	128.0	16.01	1.20	0.05	0.0073	43.31	1.637	-2.138
101	08/13/01	Seis 3	686	392.0	0.48	118.0	34.65	1.54	-0.32	0.0023	93.73	1.972	-2.638
102	08/13/01	Seis 4	1,214	392.0	0.44	118.0	61.32	1.79	-0.36	0.0023	165.88	2.220	-2.638
103	08/13/01	Seis 5 A	1,795	392.0	0.18	118.0	90.66	1.96	-0.74	0.0023	245.27	2.390	-2.638
104	08/13/01	Seis 5	1,848	392.0	0.31	109.0	93.34	1.97	-0.51	0.0008	252.51	2.402	-3.088
105	08/13/01	Seis 6	2,270	392.0	0.11	106.0	114.65	2.06	-0.96	0.0006	310.17	2.492	-3.238
106	08/13/01	Seis 7	1,267	392.0	0.13	123.0	63.99	1.81	-0.89	0.0041	173.12	2.238	-2.388
107	08/13/01	Seis 8	1,320	392.0	0.32	120.0	66.67	1.82	-0.49	0.0029	180.36	2.256	-2.538
108	08/13/01	Seis 9	1,540	392.0	0.12	119.0	77.78	1.89	-0.92	0.0026	210.42	2.323	-2.588
109	08/13/01	Seis 10	1,637	392.0	0.27	117.0	82.68	1.92	-0.57	0.0021	223.68	2.350	-2.688
110	08/13/01	Seis 11	1,848	392.0	0.08	114.0	93.34	1.97	-1.10	0.0015	252.51	2.402	-2.838
111	08/18/00	Seis 15 A	109	427.5	3.20	137.0	5.27	0.72	0.51	0.0205	14.47	1.160	-1.688
112	08/18/00	Seis 15	306	427.5	1.96	130.0	14.80	1.17	0.29	0.0092	40.62	1.609	-2.038
113	08/18/00	Seis 16	623	427.5	1.07	127.0	30.13	1.48	0.03	0.0065	82.70	1.918	-2.188
114	08/18/00	Seis 17	1,082	427.5	0.41	123.0	52.33	1.72	-0.39	0.0041	143.63	2.157	-2.388
115	08/18/00	Seis 18	1,340	427.5	1.12	119.0	64.81	1.81	0.05	0.0026	177.88	2.250	-2.588
116	08/18/00	Seis 20	3,716	427.5	0.06	106.0	179.72	2.25	-1.22	0.0006	493.28	2.693	-3.238
117	08/22/00	Seis 15 A	90	293.5	2.96	138.0	5.25	0.72	0.47	0.0230	13.54	1.132	-1.638
118	08/22/00	Seis 15	183	293.5	2.64	134.0	10.68	1.03	0.42	0.0145	27.54	1.440	-1.838
119	08/22/00	Seis 16	422	293.5	1.16	126.0	24.63	1.39	0.06	0.0058	63.50	1.803	-2.238
120	08/22/00	Seis 17	842	293.5	0.51	117.0	49.15	1.69	-0.29	0.0021	126.70	2.103	-2.688
121	08/22/00	Seis 18	1,162	293.5	0.60	116.0	67.83	1.83	-0.22	0.0018	174.85	2.243	-2.738
122	08/22/00	Seis 21	3,221	293.5	0.03	106.0	188.01	2.27	-1.52	0.0006	484.68	2.685	-3.238
123	08/22/00	Seis 7 A	100	334.0	4.88	140.0	5.47	0.74	0.69	0.0290	14.41	1.159	-1.538
124	08/22/00	Seis 7	262	334.0	2.36	130.0	14.34	1.16	0.37	0.0092	37.76	1.577	-2.038
125	08/22/00	Seis 8	512	334.0	2.04	124.0	28.02	1.45	0.31	0.0046	73.79	1.868	-2.338
126	08/22/00	Seis 9	935	334.0	0.67	119.0	51.16	1.71	-0.17	0.0026	134.76	2.130	-2.588
127	08/22/00	Seis 10	1,367	334.0	0.42	119.0	74.80	1.87	-0.38	0.0026	197.02	2.295	-2.588
128	08/22/00	Seis 11	1,698	334.0	0.35	116.0	92.91	1.97	-0.46	0.0018	244.73	2.389	-2.738
129	08/22/00	Seis 12	2,060	334.0	0.17	112.0	112.72	2.05	-0.77	0.0012	296.91	2.473	-2.938
130	08/22/00	Seis 13	3,004	334.0	0.12	106.0	164.37	2.22	-0.92	0.0006	432.96	2.636	-3.238
131	08/22/00	Seis 13 A	3,706	334.0	0.05	106.0	202.78	2.31	-1.30	0.0006	534.14	2.728	-3.238
132	08/27/01	Seis 1A	50	431.0	7.92	140.0	2.41	0.38	0.90	0.0290	6.62	0.821	-1.538
133	08/27/01	Seis 2	528	431.0	0.88	128.0	25.43	1.41	-0.06	0.0073	69.90	1.844	-2.138
134	08/27/01	Seis 3	844	431.0	0.67	122.0	40.65	1.61	-0.17	0.0037	111.73	2.048	-2.438
135	08/27/01	Seis 4	1,373	431.0	0.37	118.0	66.14	1.82	-0.43	0.0023	181.77	2.260	-2.638

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE					Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:	Top Flight Blasting					Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
Blast Event Details and Measurements as Reported							**Ground Vibration Analysis**				**Airblast Analysis**		
Blast Record	Blast Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	AB	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		ft	lbs	in/sec	dB	$ft/lbs^{(1/2)}$	$ft/lbs^{(1/2)}$	in/sec	lbs/in^2	$ft/lbs^{(1/3)}$	$ft/lbs^{(1/3)}$	lbs/in^2
136	08/27/01	Seis 5 A	1,954	431.0	0.36	119.0	94.12	1.97	-0.44	0.0026	258.68	2.413	-2.588
137	08/27/01	Seis 5	2,006	431.0	0.40	116.0	96.63	1.99	-0.40	0.0018	265.57	2.424	-2.738
138	08/27/01	Seis 6	2,428	431.0	0.11	114.0	116.95	2.07	-0.96	0.0015	321.43	2.507	-2.838
139	08/27/01	Seis 7	1,267	431.0	0.13	123.0	61.03	1.79	-0.89	0.0041	167.73	2.225	-2.388
140	08/27/01	Seis 8	1,372	431.0	0.66	127.0	66.09	1.82	-0.18	0.0065	181.63	2.259	-2.188
141	08/27/01	Seis 9	1,584	431.0	0.23	117.0	76.30	1.88	-0.64	0.0021	209.70	2.322	-2.688
142	08/27/01	Seis 10	1,690	431.0	0.43	124.0	81.40	1.91	-0.37	0.0046	223.73	2.350	-2.338
143	08/27/01	Seis 11	1,954	431.0	0.25	120.0	94.12	1.97	-0.60	0.0029	258.68	2.413	-2.538
144	08/29/01	Seis 7	1,056	431.0	0.23	123.0	50.87	1.71	-0.64	0.0041	139.80	2.146	-2.388
145	08/29/01	Seis 8	1,109	431.0	0.75	118.0	53.42	1.73	-0.12	0.0023	146.82	2.167	-2.638
146	08/29/01	Seis 9	1,320	431.0	0.23	116.0	63.58	1.80	-0.64	0.0018	174.75	2.242	-2.738
147	08/29/01	Seis 10	1,584	431.0	0.21	116.0	76.30	1.88	-0.68	0.0018	209.70	2.322	-2.738
148	08/29/01	Seis 11	1,748	431.0	0.15	114.0	84.20	1.93	-0.82	0.0015	231.41	2.364	-2.838
149	08/29/01	Seis 1A	50	418.0	9.20	136.0	2.45	0.39	0.96	0.0183	6.69	0.825	-1.738
150	08/29/01	Seis 2	643	418.0	0.47	130.0	31.45	1.50	-0.33	0.0092	86.00	1.934	-2.038
151	08/29/01	Seis 3	950	418.0	0.36	124.0	46.47	1.67	-0.44	0.0046	127.06	2.104	-2.338
152	08/29/01	Seis 4	1,415	418.0	0.33	120.0	69.21	1.84	-0.48	0.0029	189.25	2.277	-2.538
153	08/29/01	Seis 5 A	2,057	418.0	0.18	118.0	100.61	2.00	-0.74	0.0023	275.11	2.440	-2.638
154	08/29/01	Seis 5	1,953	418.0	0.20	109.0	95.52	1.98	-0.70	0.0008	261.20	2.417	-3.088
155	08/29/01	Seis 6	2,428	418.0	0.08	109.0	118.76	2.07	-1.10	0.0008	324.73	2.512	-3.088
156	08/29/00	Seis 7	211	338.0	4.08	131.0	11.48	1.06	0.61	0.0103	30.29	1.481	-1.988
157	08/29/00	Seis 7 A	60	338.0	5.08	142.0	3.26	0.51	0.71	0.0365	8.61	0.935	-1.438
158	08/29/00	Seis 8	422	338.0	2.40	131.0	22.95	1.36	0.38	0.0103	60.58	1.782	-1.988
159	08/29/00	Seis 9	792	338.0	0.70	120.0	43.08	1.63	-0.15	0.0029	113.70	2.056	-2.538
160	08/29/00	Seis 10	1,267	338.0	0.45	117.0	68.92	1.84	-0.35	0.0021	181.89	2.260	-2.688
161	08/29/00	Seis 11	1,531	338.0	0.31	116.0	83.28	1.92	-0.51	0.0018	219.79	2.342	-2.738
162	08/29/00	Seis 12	2,112	338.0	0.15	109.0	114.88	2.06	-0.82	0.0008	303.19	2.482	-3.088
163	08/29/00	Seis 13	2,904	338.0	0.11	106.0	157.96	2.20	-0.96	0.0006	416.89	2.620	-3.238
164	08/29/00	Seis 14	3,643	338.0	0.08	106.0	198.15	2.30	-1.10	0.0006	522.98	2.718	-3.238
165	09/01/00	Seis 7	158	496.5	5.08	133.0	7.09	0.85	0.71	0.0130	19.95	1.300	-1.888
166	09/01/00	Seis 8	369	496.5	2.76	132.0	16.56	1.22	0.44	0.0115	46.60	1.668	-1.938
167	09/01/00	Seis 9	739	496.5	0.77	123.0	33.17	1.52	-0.11	0.0041	93.33	1.970	-2.388
168	09/01/00	Seis 10	1,215	496.5	0.45	120.0	54.53	1.74	-0.35	0.0029	153.44	2.186	-2.538
169	09/01/00	Seis 11	1,479	496.5	0.36	116.0	66.38	1.82	-0.44	0.0018	186.78	2.271	-2.738
170	09/01/00	Seis 12	2,059	496.5	0.16	112.0	92.41	1.97	-0.80	0.0012	260.03	2.415	-2.938
171	09/01/00	Seis 13	2,904	496.5	0.08	109.0	130.33	2.12	-1.10	0.0008	366.74	2.564	-3.088
172	09/21/00	Seis 15 A	100	481.5	5.04	138.0	4.56	0.66	0.70	0.0230	12.76	1.106	-1.638
173	09/21/00	Seis 15	729	481.5	0.98	126.0	33.22	1.52	-0.01	0.0058	93.01	1.969	-2.238
174	09/21/00	Seis 16	980	481.5	1.16	122.0	44.66	1.65	0.06	0.0037	125.03	2.097	-2.438
175	09/21/00	Seis 17	1,214	481.5	0.39	119.0	55.32	1.74	-0.41	0.0026	154.89	2.190	-2.588
176	09/21/00	Seis 18	1,478	481.5	0.57	117.0	67.36	1.83	-0.24	0.0021	188.57	2.275	-2.688
177	09/21/00	Seis 19	3,062	481.5	0.06	106.0	139.54	2.14	-1.22	0.0006	390.67	2.592	-3.238
178	09/21/00	Seis 21	3,332	481.5	0.03	123.0	151.85	2.18	-1.52	0.0041	425.11	2.629	-2.388
179	09/16/00	Seis 15	255	375.5	1.80	131.0	13.16	1.12	0.26	0.0103	35.35	1.548	-1.988
180	09/16/00	Seis 16	528	375.5	1.64	124.0	27.25	1.44	0.21	0.0046	73.19	1.864	-2.338

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:		OSMRE				Surface Mine:	Pittsburgh Mine					Review Date:	01/01/19	
Blaster:		Top Flight Blasting				Permit No.:	D-12345					Reviewed By:	Brian Farmer, P.E.	
Blast Event Details and Measurements as Reported							**Ground Vibration Analysis**				**Airblast Analysis**			
Blast Record	Blast Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	AB	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB	
	mm/dd/yy		ft	lbs	in/sec	dB	$ft/lbs^{(1/2)}$	$ft/lbs^{(1/2)}$	in/sec	lbs/in^2	$ft/lbs^{(1/3)}$	$ft/lbs^{(1/3)}$	lbs/in^2	
181	09/16/00	Seis 17	899	375.5	0.56	119.0	46.39	1.67	-0.25	0.0026	124.61	2.096	-2.588	
182	09/16/00	Seis 18	1,162	375.5	0.60	117.0	59.97	1.78	-0.22	0.0021	161.07	2.207	-2.688	
183	09/16/00	Seis 19	2,791	375.5	0.05	109.0	144.03	2.16	-1.30	0.0008	386.86	2.588	-3.088	
184	09/16/00	Seis 21	3,274	375.5	0.03	106.0	168.96	2.23	-1.52	0.0006	453.81	2.657	-3.238	
185							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
186							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
187							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
188							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
189							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
190							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
191							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
192							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
193							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
194							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
195							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
196							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
197							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
198							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
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200							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
201							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
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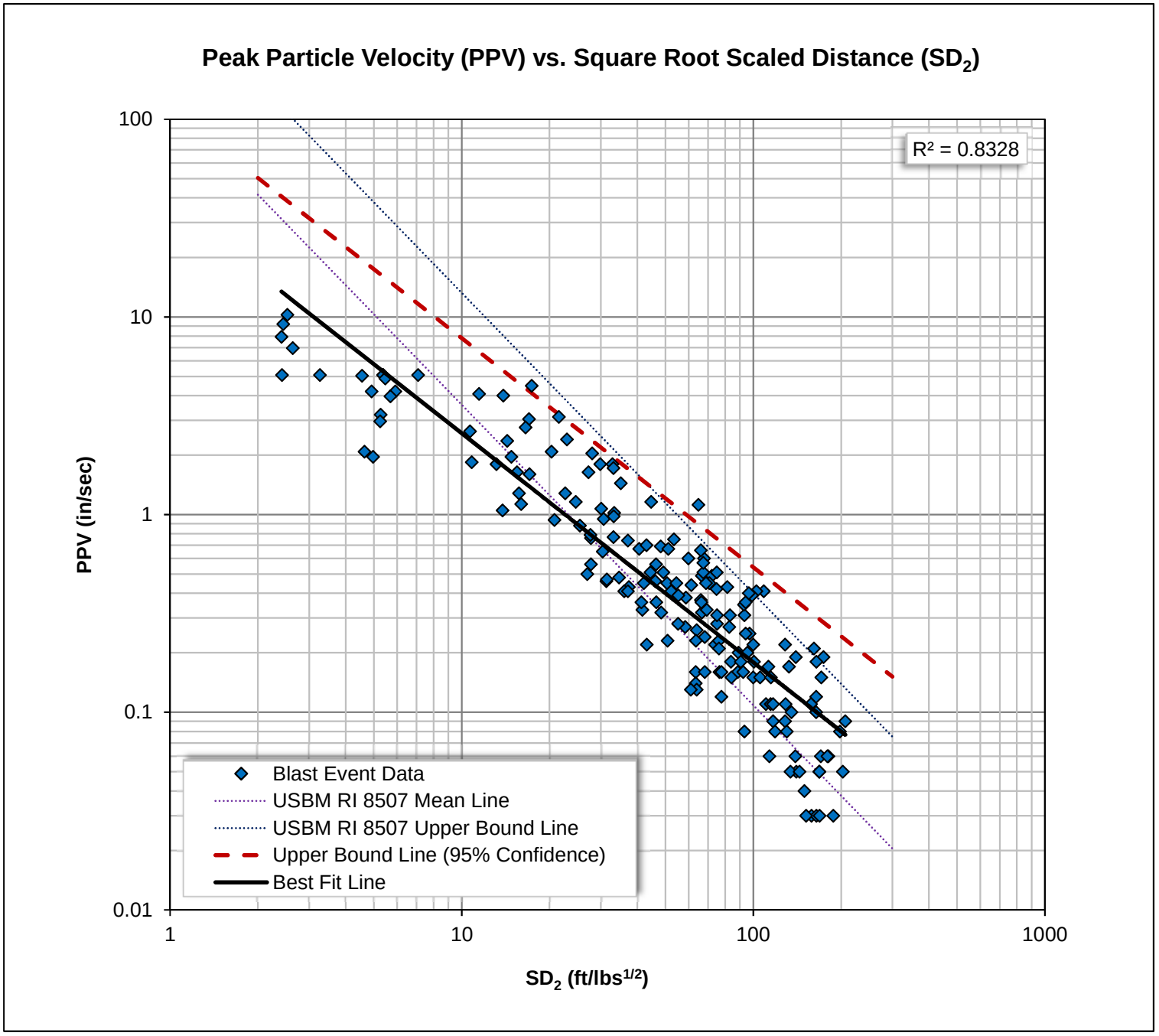
203							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
204							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
205							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
206							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
207							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
208							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
209							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
210							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
211							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
212							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
213							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
214							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
215							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
216							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
217							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
218							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
219							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	
220							#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	

OSMRE Blast-Induced Vibration Data Evaluation

Mine:	Pittsburgh Mine	Review Agency:	OSMRE
Permit:	D-12345	Review Date:	01/01/19
Blaster:	Top Flight Blasting	Performed By:	Brian Farmer, P.E.

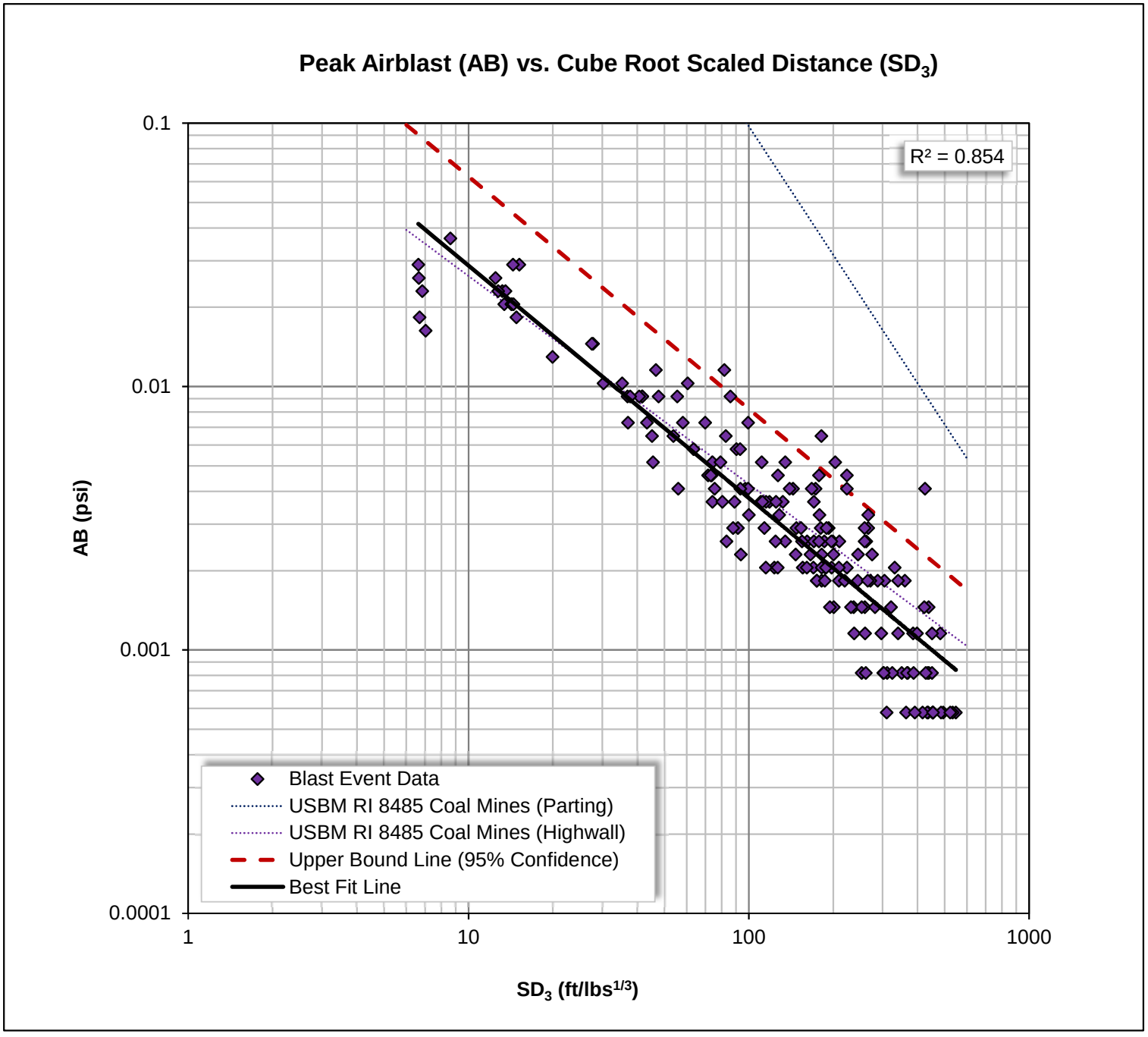


The blast event data was collected intermittently between the following dates: 07/27/00 and 08/29/01.

The Best Fit Line and Upper Bound Line (95% Confidence) may be approximated using the following equation:		
$PPV = A \times SD_2^{-B}$	where A =	**37.18** , y-intercept for Best Fit Line at SD_2 = 1.0
	or A =	**112.57** , y-intercept for Upper Bound Line (95% Confidence) at SD_2 = 1.0
	and B =	**-1.16** , slope of the Best Fit Line and Upper Bound Line

OSMRE Blast-Induced Vibration Data Evaluation

Mine:	Pittsburgh Mine	Review Agency:	OSMRE
Permit:	D-12345	Review Date:	01/01/19
Blaster:	Top Flight Blasting	Performed By:	Brian Farmer, P.E.



The blast event data was collected intermittently between the following dates: 07/27/00 and 08/29/01.

The Best Fit Line and Upper Bound Line (95% Confidence) may be approximated using the following equation:		
$AB = A \times SD_3^{-B}$	where A =	**0.220** , y-intercept for Best Fit Line at SD_3 = 1.0
	or A =	**0.479** , y-intercept for Upper Bound Line (95% Confidence) at SD_3 = 1.0
	and B =	**-0.883** , slope of the Best Fit Line and Upper Bound Line

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE			Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:	Top Flight Blasting			Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
	Blast Event Details and Measurements						**Ground Vibration Analysis**			**Airblast Analysis**		
Record	Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		m	kg	mm/sec	Pa	$m/kg^{(1/2)}$	$m/kg^{(1/2)}$	mm/sec	$m/kg^{(1/3)}$	$m/kg^{(1/3)}$	Pa
1	04/15/01	Seis 15 A	15.2	193.46	129.03	178.20	1.10	0.04	2.11	2.64	0.421	2.251
2	04/15/01	Seis 15	109.4	193.46	113.79	63.23	7.87	0.90	2.06	18.92	1.277	1.801
3	04/15/01	Seis 16	207.3	193.46	45.72	39.89	14.90	1.17	1.66	35.84	1.554	1.601
4	04/15/01	Seis 17	303.3	193.46	17.53	25.17	21.80	1.34	1.24	52.44	1.720	1.401
5	04/15/01	Seis 18	370.0	193.46	9.65	17.82	26.60	1.42	0.98	63.98	1.806	1.251
6	04/15/01	Seis 19	885.1	193.46	1.27	7.96	63.64	1.80	0.10	153.04	2.185	0.901
7	04/15/01	Seis 21	997.9	193.46	0.76	5.64	71.75	1.86	-0.12	172.54	2.237	0.751
8	07/20/01	Seis 1A	15.2	163.29	176.78	112.44	1.19	0.08	2.25	2.79	0.445	2.051
9	07/20/01	Seis 2A	98.8	163.29	40.64	35.56	7.73	0.89	1.61	18.07	1.257	1.551
10	07/20/01	Seis 3	216.7	163.29	10.92	22.43	16.96	1.23	1.04	39.65	1.598	1.351
11	07/20/01	Seis 4	337.7	163.29	6.86	14.16	26.43	1.42	0.84	61.79	1.791	1.151
12	07/20/01	Seis 5A	394.7	163.29	6.10	12.62	30.89	1.49	0.79	72.22	1.859	1.101
13	07/20/01	Seis 5	515.1	163.29	5.08	7.96	40.31	1.61	0.71	94.24	1.974	0.901
14	07/20/01	Seis 6	676.0	163.29	2.29	5.64	52.90	1.72	0.36	123.69	2.092	0.751
15	07/20/01	Seis 15	177.4	163.29	24.13	79.60	13.88	1.14	1.38	32.46	1.511	1.901
16	07/20/01	Seis 16	292.6	163.29	11.43	35.56	22.90	1.36	1.06	53.53	1.729	1.551
17	07/20/01	Seis 17	370.0	163.29	6.60	25.17	28.96	1.46	0.82	67.70	1.831	1.401
18	07/20/01	Seis 18	434.6	163.29	7.11	15.88	34.01	1.53	0.85	79.52	1.900	1.201
19	07/20/01	Seis 19	1,046.1	163.29	1.52	7.96	81.86	1.91	0.18	191.38	2.282	0.901
20	07/21/01	Seis 2	120.7	163.97	23.88	63.23	9.43	0.97	1.38	22.05	1.343	1.801
21	07/21/01	Seis 3	241.4	163.97	8.38	35.56	18.85	1.28	0.92	44.10	1.644	1.551
22	07/21/01	Seis 4	386.2	163.97	12.45	31.69	30.16	1.48	1.10	70.56	1.849	1.501
23	07/21/01	Seis 5 A	486.2	163.97	4.57	28.24	37.97	1.58	0.66	88.82	1.949	1.451
24	07/21/01	Seis 5	579.1	163.97	3.81	19.99	45.23	1.66	0.58	105.81	2.025	1.301
25	07/21/01	Seis 15	193.2	163.97	25.91	25.17	15.09	1.18	1.41	35.31	1.548	1.401
26	07/21/01	Seis 16	257.3	163.97	12.95	25.17	20.09	1.30	1.11	47.00	1.672	1.401
27	07/21/01	Seis 2*	160.9	163.97	19.30	35.56	12.57	1.10	1.29	29.40	1.468	1.551
28	07/21/01	Seis 3*	239.6	163.97	9.14	25.17	18.71	1.27	0.96	43.77	1.641	1.401
29	07/21/01	Seis 4*	418.2	163.97	12.45	19.99	32.66	1.51	1.10	76.40	1.883	1.301
30	07/21/01	Seis 5 A*	579.1	163.97	5.59	22.43	45.23	1.66	0.75	105.81	2.025	1.351
31	07/21/01	Seis 5*	563.3	163.97	6.35	10.02	43.99	1.64	0.80	102.91	2.012	1.001
32	07/21/01	Seis 15*	80.5	163.97	101.60	50.22	6.28	0.80	2.01	14.70	1.167	1.701
33	07/21/01	Seis 16*	160.9	163.97	14.22	25.17	12.57	1.10	1.15	29.40	1.468	1.401
34	07/21/01	Seis 17*	267.6	163.97	11.68	14.16	20.90	1.32	1.07	48.89	1.689	1.151
35	07/21/01	Seis 18*	428.9	163.97	5.59	14.16	33.49	1.52	0.75	78.35	1.894	1.151
36	07/21/01	Seis 19*	952.5	163.97	2.54	5.64	74.38	1.87	0.40	174.02	2.241	0.751
37	07/27/00	Seis 1	27.4	170.32	52.83	178.20	2.10	0.32	1.72	4.95	0.694	2.251
38	07/27/00	Seis 2	91.4	170.32	41.66	63.23	7.01	0.85	1.62	16.50	1.217	1.801
39	07/27/00	Seis 3	213.4	170.32	10.41	28.24	16.35	1.21	1.02	38.49	1.585	1.451
40	07/27/00	Seis 4	374.9	170.32	4.06	17.82	28.73	1.46	0.61	67.63	1.830	1.251
41	07/27/00	Seis 5	670.6	170.32	1.52	12.62	51.38	1.71	0.18	120.97	2.083	1.101
42	07/27/00	Seis 6	792.5	170.32	1.27	12.62	60.72	1.78	0.10	142.97	2.155	1.101
43	07/31/00	Seis 1A	28.3	158.76	49.78	158.82	2.25	0.35	1.70	5.24	0.719	2.201
44	07/31/00	Seis 1	89.6	158.76	32.51	63.23	7.11	0.85	1.51	16.55	1.219	1.801
45	07/31/00	Seis 2	153.6	158.76	12.70	31.69	12.19	1.09	1.10	28.37	1.453	1.501

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE			Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:	Top Flight Blasting			Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
	Blast Event Details and Measurements						**Ground Vibration Analysis**			**Airblast Analysis**		
Record	Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		m	kg	mm/sec	Pa	$m/kg^{(1/2)}$	$m/kg^{(1/2)}$	mm/sec	$m/kg^{(1/3)}$	$m/kg^{(1/3)}$	Pa
46	07/31/00	Seis 3	275.5	158.76	8.13	22.43	21.87	1.34	0.91	50.89	1.707	1.351
47	07/31/00	Seis 4	437.1	158.76	4.06	35.56	34.69	1.54	0.61	80.72	1.907	1.551
48	07/31/00	Seis 5 A	732.7	158.76	2.29	12.62	58.15	1.76	0.36	135.32	2.131	1.101
49	07/31/00	Seis 5	854.7	158.76	1.02	7.96	67.83	1.83	0.01	157.84	2.198	0.901
50	08/03/01	Seis 2	80.5	165.56	26.67	63.23	6.25	0.80	1.43	14.65	1.166	1.801
51	08/03/01	Seis 3	216.4	165.56	10.41	28.24	16.82	1.23	1.02	39.41	1.596	1.451
52	08/03/01	Seis 4	321.9	165.56	7.11	19.99	25.01	1.40	0.85	58.62	1.768	1.301
53	08/03/01	Seis 5 A	515.1	165.56	4.06	10.02	40.03	1.60	0.61	93.81	1.972	1.001
54	08/03/01	Seis 6	981.5	165.56	1.27	7.96	76.28	1.88	0.10	178.74	2.252	0.901
55	08/03/01	Seis 15	216.4	165.56	18.80	50.22	16.82	1.23	1.27	39.41	1.596	1.701
56	08/03/01	Seis 16	251.2	165.56	5.59	25.17	19.52	1.29	0.75	45.74	1.660	1.401
57	08/03/01	Seis 17	370.0	165.56	3.56	14.16	28.76	1.46	0.55	67.39	1.829	1.151
58	08/03/01	Seis 18	437.7	165.56	7.87	10.02	34.02	1.53	0.90	79.71	1.902	1.001
59	08/03/01	Seis 19	981.5	165.56	1.27	5.64	76.28	1.88	0.10	178.74	2.252	0.751
60	08/03/00	Seis 1 A	30.5	187.79	106.68	141.55	2.22	0.35	2.03	5.32	0.726	2.151
61	08/03/00	Seis 1	171.6	187.79	20.07	28.24	12.52	1.10	1.30	29.97	1.477	1.451
62	08/03/00	Seis 2	189.0	187.79	16.51	17.82	13.79	1.14	1.22	33.00	1.519	1.251
63	08/03/00	Seis 3	261.2	187.79	11.43	14.16	19.06	1.28	1.06	45.61	1.659	1.151
64	08/03/00	Seis 4	422.8	187.79	4.06	17.82	30.85	1.49	0.61	73.82	1.868	1.251
65	08/03/00	Seis 5 A	655.3	187.79	3.81	12.62	47.82	1.68	0.58	114.44	2.059	1.101
66	08/03/00	Seis 5	685.8	187.79	2.79	5.64	50.05	1.70	0.45	119.76	2.078	0.751
67	08/03/00	Seis 6	838.2	187.79	2.54	5.64	61.17	1.79	0.40	146.37	2.165	0.751
68	08/04/00	Seis 1	55.8	129.50	46.74	100.21	4.90	0.69	1.67	11.02	1.042	2.001
69	08/04/00	Seis 1A	30.5	129.50	106.68	199.95	2.68	0.43	2.03	6.02	0.780	2.301
70	08/04/00	Seis 2	116.7	129.50	32.51	50.22	10.26	1.01	1.51	23.07	1.363	1.701
71	08/04/00	Seis 3	161.5	129.50	11.68	25.17	14.20	1.15	1.07	31.93	1.504	1.401
72	08/04/00	Seis 4	400.2	129.50	4.06	17.82	35.17	1.55	0.61	79.10	1.898	1.251
73	08/04/00	Seis 5 A	665.4	129.50	2.79	14.16	58.47	1.77	0.45	131.52	2.119	1.151
74	08/04/00	Seis 5	878.7	129.50	1.52	10.02	77.22	1.89	0.18	173.69	2.240	1.001
75	08/04/00	Seis 6	848.3	129.50	0.76	10.02	74.54	1.87	-0.12	167.66	2.224	1.001
76	08/08/00	Seis 7 A	30.5	139.71	100.58	126.16	2.58	0.41	2.00	5.87	0.769	2.101
77	08/08/00	Seis 7	115.2	139.71	79.25	28.24	9.75	0.99	1.90	22.20	1.346	1.451
78	08/08/00	Seis 8	188.1	139.71	36.58	19.99	15.91	1.20	1.56	36.24	1.559	1.301
79	08/08/00	Seis 9	400.8	139.71	12.95	10.02	33.91	1.53	1.11	77.24	1.888	1.001
80	08/08/00	Seis 10	580.9	139.71	10.41	10.02	49.15	1.69	1.02	111.96	2.049	1.001
81	08/08/00	Seis 11	748.6	139.71	4.83	3.99	63.33	1.80	0.68	144.27	2.159	0.601
82	08/08/00	Seis 12	931.5	139.71	4.83	3.99	78.81	1.90	0.68	179.51	2.254	0.601
83	08/11/00	Seis 7 A	30.5	156.94	129.03	141.55	2.43	0.39	2.11	5.65	0.752	2.151
84	08/11/00	Seis 7	115.2	156.94	52.83	44.76	9.20	0.96	1.72	21.36	1.330	1.651
85	08/11/00	Seis 8	188.1	156.94	43.69	19.99	15.01	1.18	1.64	34.86	1.542	1.301
86	08/11/00	Seis 9	400.8	156.94	11.43	14.16	31.99	1.51	1.06	74.31	1.871	1.151
87	08/11/00	Seis 10	580.9	156.94	10.41	12.62	46.37	1.67	1.02	107.70	2.032	1.101
88	08/11/00	Seis 11	751.3	156.94	4.32	5.64	59.97	1.78	0.64	139.29	2.144	0.751
89	08/11/00	Seis 12	934.2	156.94	4.57	3.99	74.57	1.87	0.66	173.19	2.239	0.601
90	08/11/00	Seis 13	970.8	156.94	3.81	3.99	77.49	1.89	0.58	179.97	2.255	0.601

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE			Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:	Top Flight Blasting			Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
	Blast Event Details and Measurements						**Ground Vibration Analysis**			**Airblast Analysis**		
Record	Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		m	kg	mm/sec	Pa	$m/kg^{(1/2)}$	$m/kg^{(1/2)}$	mm/sec	$m/kg^{(1/3)}$	$m/kg^{(1/3)}$	Pa
91	08/16/00	Seis 7 A	30.5	157.17	129.03	141.55	2.43	0.39	2.11	5.65	0.752	2.151
92	08/16/00	Seis 7	96.6	157.17	77.22	44.76	7.71	0.89	1.89	17.90	1.253	1.651
93	08/16/00	Seis 8	169.5	157.17	45.72	35.56	13.52	1.13	1.66	31.40	1.497	1.551
94	08/16/00	Seis 9	382.2	157.17	12.95	22.43	30.49	1.48	1.11	70.83	1.850	1.351
95	08/16/00	Seis 10	562.4	157.17	9.91	17.82	44.86	1.65	1.00	104.20	2.018	1.251
96	08/16/00	Seis 11	730.0	157.17	5.59	7.96	58.23	1.77	0.75	135.27	2.131	0.901
97	08/16/00	Seis 12	915.6	157.17	5.33	5.64	73.03	1.86	0.73	169.66	2.230	0.751
98	08/16/00	Seis 13	1,173.2	157.17	2.29	3.99	93.58	1.97	0.36	217.39	2.337	0.601
99	08/13/01	Seis 1A	15.2	177.81	260.10	158.82	1.14	0.06	2.42	2.71	0.433	2.201
100	08/13/01	Seis 2	96.6	177.81	28.70	50.22	7.25	0.86	1.46	17.18	1.235	1.701
101	08/13/01	Seis 3	209.1	177.81	12.19	15.88	15.68	1.20	1.09	37.18	1.570	1.201
102	08/13/01	Seis 4	370.0	177.81	11.18	15.88	27.75	1.44	1.05	65.80	1.818	1.201
103	08/13/01	Seis 5 A	547.1	177.81	4.57	15.88	41.03	1.61	0.66	97.30	1.988	1.201
104	08/13/01	Seis 5	563.3	177.81	7.87	5.64	42.24	1.63	0.90	100.17	2.001	0.751
105	08/13/01	Seis 6	691.9	177.81	2.79	3.99	51.89	1.72	0.45	123.04	2.090	0.601
106	08/13/01	Seis 7	386.2	177.81	3.30	28.24	28.96	1.46	0.52	68.68	1.837	1.451
107	08/13/01	Seis 8	402.3	177.81	8.13	19.99	30.17	1.48	0.91	71.55	1.855	1.301
108	08/13/01	Seis 9	469.4	177.81	3.05	17.82	35.20	1.55	0.48	83.47	1.922	1.251
109	08/13/01	Seis 10	499.0	177.81	6.86	14.16	37.42	1.57	0.84	88.73	1.948	1.151
110	08/13/01	Seis 11	563.3	177.81	2.03	10.02	42.24	1.63	0.31	100.17	2.001	1.001
111	08/18/00	Seis 15 A	33.2	193.91	81.28	141.55	2.39	0.38	1.91	5.74	0.759	2.151
112	08/18/00	Seis 15	93.3	193.91	49.78	63.23	6.70	0.83	1.70	16.11	1.207	1.801
113	08/18/00	Seis 16	189.9	193.91	27.18	44.76	13.64	1.13	1.43	32.81	1.516	1.651
114	08/18/00	Seis 17	329.8	193.91	10.41	28.24	23.68	1.37	1.02	56.98	1.756	1.451
115	08/18/00	Seis 18	408.4	193.91	28.45	17.82	29.33	1.47	1.45	70.56	1.849	1.251
116	08/18/00	Seis 20	1,132.6	193.91	1.52	3.99	81.34	1.91	0.18	195.68	2.292	0.601
117	08/22/00	Seis 15 A	27.4	133.13	75.18	158.82	2.38	0.38	1.88	5.37	0.730	2.201
118	08/22/00	Seis 15	55.8	133.13	67.06	100.21	4.83	0.68	1.83	10.92	1.038	2.001
119	08/22/00	Seis 16	128.6	133.13	29.46	39.89	11.15	1.05	1.47	25.19	1.401	1.601
120	08/22/00	Seis 17	256.6	133.13	12.95	14.16	22.24	1.35	1.11	50.26	1.701	1.151
121	08/22/00	Seis 18	354.2	133.13	15.24	12.62	30.70	1.49	1.18	69.36	1.841	1.101
122	08/22/00	Seis 21	981.8	133.13	0.76	3.99	85.09	1.93	-0.12	192.27	2.284	0.601
123	08/22/00	Seis 7 A	30.5	151.50	123.95	199.95	2.48	0.39	2.09	5.72	0.757	2.301
124	08/22/00	Seis 7	79.9	151.50	59.94	63.23	6.49	0.81	1.78	14.98	1.176	1.801
125	08/22/00	Seis 8	156.1	151.50	51.82	31.69	12.68	1.10	1.71	29.27	1.466	1.501
126	08/22/00	Seis 9	285.0	151.50	17.02	17.82	23.15	1.36	1.23	53.46	1.728	1.251
127	08/22/00	Seis 10	416.7	151.50	10.67	17.82	33.85	1.53	1.03	78.16	1.893	1.251
128	08/22/00	Seis 11	517.6	151.50	8.89	12.62	42.05	1.62	0.95	97.08	1.987	1.101
129	08/22/00	Seis 12	627.9	151.50	4.32	7.96	51.01	1.71	0.64	117.78	2.071	0.901
130	08/22/00	Seis 13	915.6	151.50	3.05	3.99	74.39	1.87	0.48	171.76	2.235	0.601
131	08/22/00	Seis 13 A	1,129.6	151.50	1.27	3.99	91.77	1.96	0.10	211.89	2.326	0.601
132	08/27/01	Seis 1A	15.2	195.50	201.17	199.95	1.09	0.04	2.30	2.63	0.419	2.301
133	08/27/01	Seis 2	160.9	195.50	22.35	50.22	11.51	1.06	1.35	27.73	1.443	1.701
134	08/27/01	Seis 3	257.3	195.50	17.02	25.17	18.40	1.26	1.23	44.32	1.647	1.401
135	08/27/01	Seis 4	418.5	195.50	9.40	15.88	29.93	1.48	0.97	72.11	1.858	1.201

OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:	OSMRE			Surface Mine:	Pittsburgh Mine					Review Date:	01/01/19	
Blaster:	Top Flight Blasting			Permit No.:	D-12345					Reviewed By:	Brian Farmer, P.E.	
	Blast Event Details and Measurements						**Ground Vibration Analysis**			**Airblast Analysis**		
Record	Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		m	kg	mm/sec	Pa	$m/kg^{(1/2)}$	$m/kg^{(1/2)}$	mm/sec	$m/kg^{(1/3)}$	$m/kg^{(1/3)}$	Pa
136	08/27/01	Seis 5 A	595.6	195.50	9.14	17.82	42.60	1.63	0.96	102.62	2.011	1.251
137	08/27/01	Seis 5	611.4	195.50	10.16	12.62	43.73	1.64	1.01	105.35	2.023	1.101
138	08/27/01	Seis 6	740.1	195.50	2.79	10.02	52.93	1.72	0.45	127.51	2.106	1.001
139	08/27/01	Seis 7	386.2	195.50	3.30	28.24	27.62	1.44	0.52	66.54	1.823	1.451
140	08/27/01	Seis 8	418.2	195.50	16.76	44.76	29.91	1.48	1.22	72.05	1.858	1.651
141	08/27/01	Seis 9	482.8	195.50	5.84	14.16	34.53	1.54	0.77	83.19	1.920	1.151
142	08/27/01	Seis 10	515.1	195.50	10.92	31.69	36.84	1.57	1.04	88.75	1.948	1.501
143	08/27/01	Seis 11	595.6	195.50	6.35	19.99	42.60	1.63	0.80	102.62	2.011	1.301
144	08/29/01	Seis 7	321.9	195.50	5.84	28.24	23.02	1.36	0.77	55.46	1.744	1.451
145	08/29/01	Seis 8	338.0	195.50	19.05	15.88	24.18	1.38	1.28	58.24	1.765	1.201
146	08/29/01	Seis 9	402.3	195.50	5.84	12.62	28.78	1.46	0.77	69.32	1.841	1.101
147	08/29/01	Seis 10	482.8	195.50	5.33	12.62	34.53	1.54	0.73	83.19	1.920	1.101
148	08/29/01	Seis 11	532.8	195.50	3.81	10.02	38.11	1.58	0.58	91.80	1.963	1.001
149	08/29/01	Seis 1A	15.2	189.60	233.68	126.16	1.11	0.04	2.37	2.65	0.424	2.101
150	08/29/01	Seis 2	196.0	189.60	11.94	63.23	14.23	1.15	1.08	34.11	1.533	1.801
151	08/29/01	Seis 3	289.6	189.60	9.14	31.69	21.03	1.32	0.96	50.40	1.702	1.501
152	08/29/01	Seis 4	431.3	189.60	8.38	19.99	31.32	1.50	0.92	75.07	1.875	1.301
153	08/29/01	Seis 5 A	627.0	189.60	4.57	15.88	45.53	1.66	0.66	109.14	2.038	1.201
154	08/29/01	Seis 5	595.3	189.60	5.08	5.64	43.23	1.64	0.71	103.62	2.015	0.751
155	08/29/01	Seis 6	740.1	189.60	2.03	5.64	53.75	1.73	0.31	128.82	2.110	0.751
156	08/29/00	Seis 7	64.3	153.31	103.63	70.94	5.19	0.72	2.02	12.02	1.080	1.851
157	08/29/00	Seis 7 A	18.3	153.31	129.03	251.72	1.48	0.17	2.11	3.42	0.534	2.401
158	08/29/00	Seis 8	128.6	153.31	60.96	70.94	10.39	1.02	1.79	24.03	1.381	1.851
159	08/29/00	Seis 9	241.4	153.31	17.78	19.99	19.50	1.29	1.25	45.10	1.654	1.301
160	08/29/00	Seis 10	386.2	153.31	11.43	14.16	31.19	1.49	1.06	72.15	1.858	1.151
161	08/29/00	Seis 11	466.6	153.31	7.87	12.62	37.69	1.58	0.90	87.19	1.940	1.101
162	08/29/00	Seis 12	643.7	153.31	3.81	5.64	51.99	1.72	0.58	120.28	2.080	0.751
163	08/29/00	Seis 13	885.1	153.31	2.79	3.99	71.49	1.85	0.45	165.38	2.218	0.601
164	08/29/00	Seis 14	1,110.4	153.31	2.03	3.99	89.68	1.95	0.31	207.47	2.317	0.601
165	09/01/00	Seis 7	48.2	225.21	129.03	89.31	3.21	0.51	2.11	7.92	0.898	1.951
166	09/01/00	Seis 8	112.5	225.21	70.10	79.60	7.49	0.87	1.85	18.49	1.267	1.901
167	09/01/00	Seis 9	225.2	225.21	19.56	28.24	15.01	1.18	1.29	37.02	1.568	1.451
168	09/01/00	Seis 10	370.3	225.21	11.43	19.99	24.68	1.39	1.06	60.87	1.784	1.301
169	09/01/00	Seis 11	450.8	225.21	9.14	12.62	30.04	1.48	0.96	74.09	1.870	1.101
170	09/01/00	Seis 12	627.6	225.21	4.06	7.96	41.82	1.62	0.61	103.15	2.013	0.901
171	09/01/00	Seis 13	885.1	225.21	2.03	5.64	58.98	1.77	0.31	145.48	2.163	0.751
172	09/21/00	Seis 15 A	30.5	218.40	128.02	158.82	2.06	0.31	2.11	5.06	0.704	2.201
173	09/21/00	Seis 15	222.2	218.40	24.89	39.89	15.04	1.18	1.40	36.90	1.567	1.601
174	09/21/00	Seis 16	298.7	218.40	29.46	25.17	20.21	1.31	1.47	49.60	1.695	1.401
175	09/21/00	Seis 17	370.0	218.40	9.91	17.82	25.04	1.40	1.00	61.44	1.788	1.251
176	09/21/00	Seis 18	450.5	218.40	14.48	14.16	30.48	1.48	1.16	74.81	1.874	1.151
177	09/21/00	Seis 19	933.3	218.40	1.52	3.99	63.15	1.80	0.18	154.98	2.190	0.601
178	09/21/00	Seis 21	1,015.6	218.40	0.76	28.24	68.72	1.84	-0.12	168.64	2.227	1.451
179	09/16/00	Seis 15	77.7	170.32	45.72	70.94	5.96	0.77	1.66	14.02	1.147	1.851
180	09/16/00	Seis 16	160.9	170.32	41.66	31.69	12.33	1.09	1.62	29.03	1.463	1.501

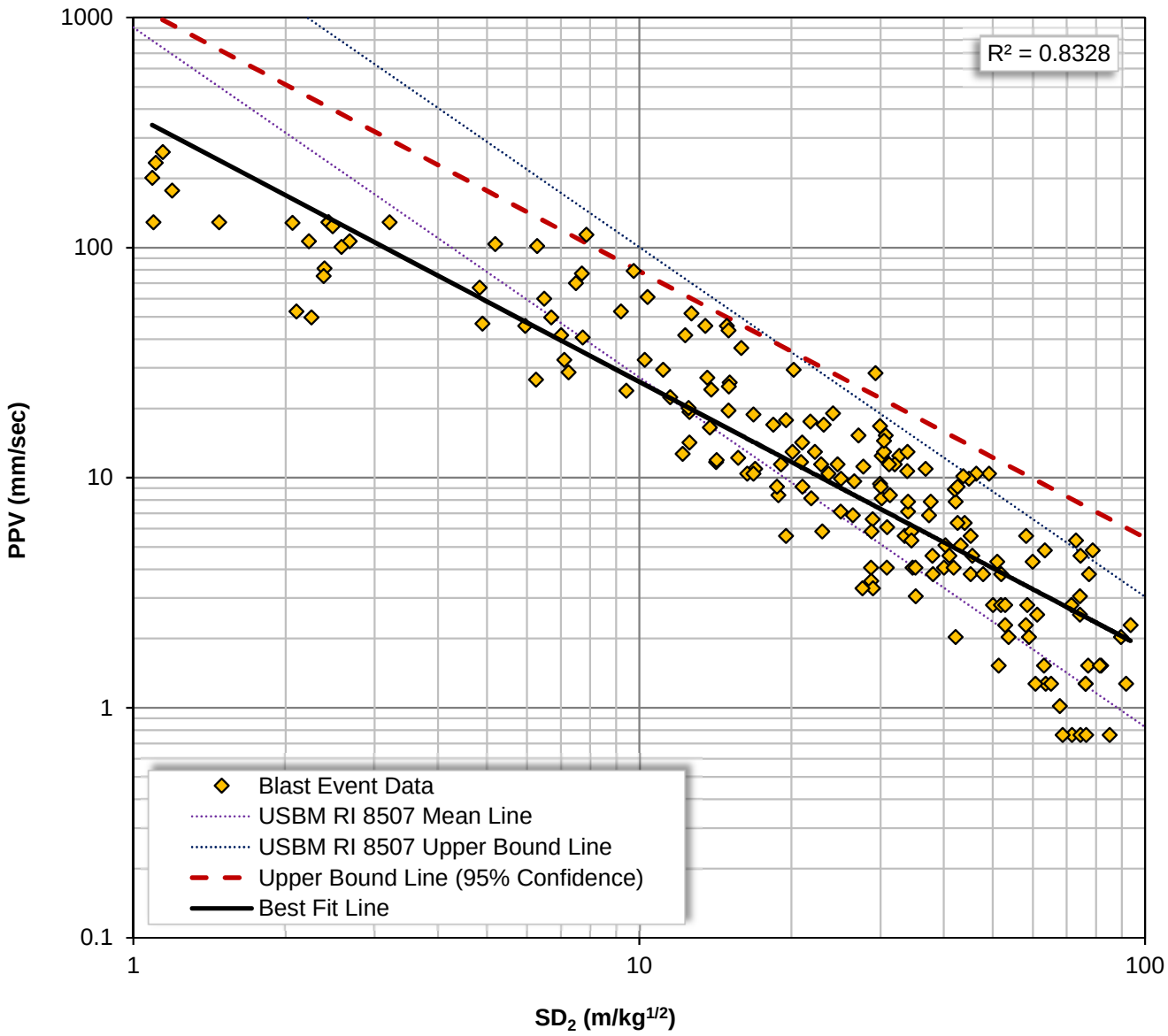
OSMRE Regression Analysis of Blast-Induced Vibration Data

Review Agency:		OSMRE			Surface Mine:	Pittsburgh Mine				Review Date:	01/01/19	
Blaster:		Top Flight Blasting			Permit No.:	D-12345				Reviewed By:	Brian Farmer, P.E.	
Blast Event Details and Measurements							**Ground Vibration Analysis**			**Airblast Analysis**		
Record	Date	Seismograph Location	Distance From Blast (D)	Charge Weight Per Delay (CW)	Peak Particle Velocity (PPV)	Airblast (AB)	Square Root Scaled Distance (SD_2)	Log SD_2	Log PPV	Cube Root Scaled Distance (SD_3)	Log SD_3	Log AB
	mm/dd/yy		m	kg	mm/sec	Pa	$m/kg^{(1/2)}$	$m/kg^{(1/2)}$	mm/sec	$m/kg^{(1/3)}$	$m/kg^{(1/3)}$	Pa
181	09/16/00	Seis 17	274.0	170.32	14.22	17.82	21.00	1.32	1.15	49.43	1.694	1.251
182	09/16/00	Seis 18	354.2	170.32	15.24	14.16	27.14	1.43	1.18	63.89	1.805	1.151
183	09/16/00	Seis 19	850.7	170.32	1.27	5.64	65.18	1.81	0.10	153.47	2.186	0.751
184	09/16/00	Seis 21	997.9	170.32	0.76	3.99	76.46	1.88	-0.12	180.03	2.255	0.601
185	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
186	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
187	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
188	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
189	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
190	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
191	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
192	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
193	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
194	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
195	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
196	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
197	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
198	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
199	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
200	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
201	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
202	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
203	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
204	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
205	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
206	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
207	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
208	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
209	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
210	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
211	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
212	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
213	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
214	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
215	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
216	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
217	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
218	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
219	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A
220	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A	#N/A

OSMRE Blast-Induced Vibration Data Evaluation

Mine:	Pittsburgh Mine	Review Agency:	OSMRE
Permit:	D-12345	Review Date:	01/01/19
Blaster:	Top Flight Blasting	Performed By:	Brian Farmer, P.E.

Peak Particle Velocity (PPV) vs. Square Root Scaled Distance (SD_2)

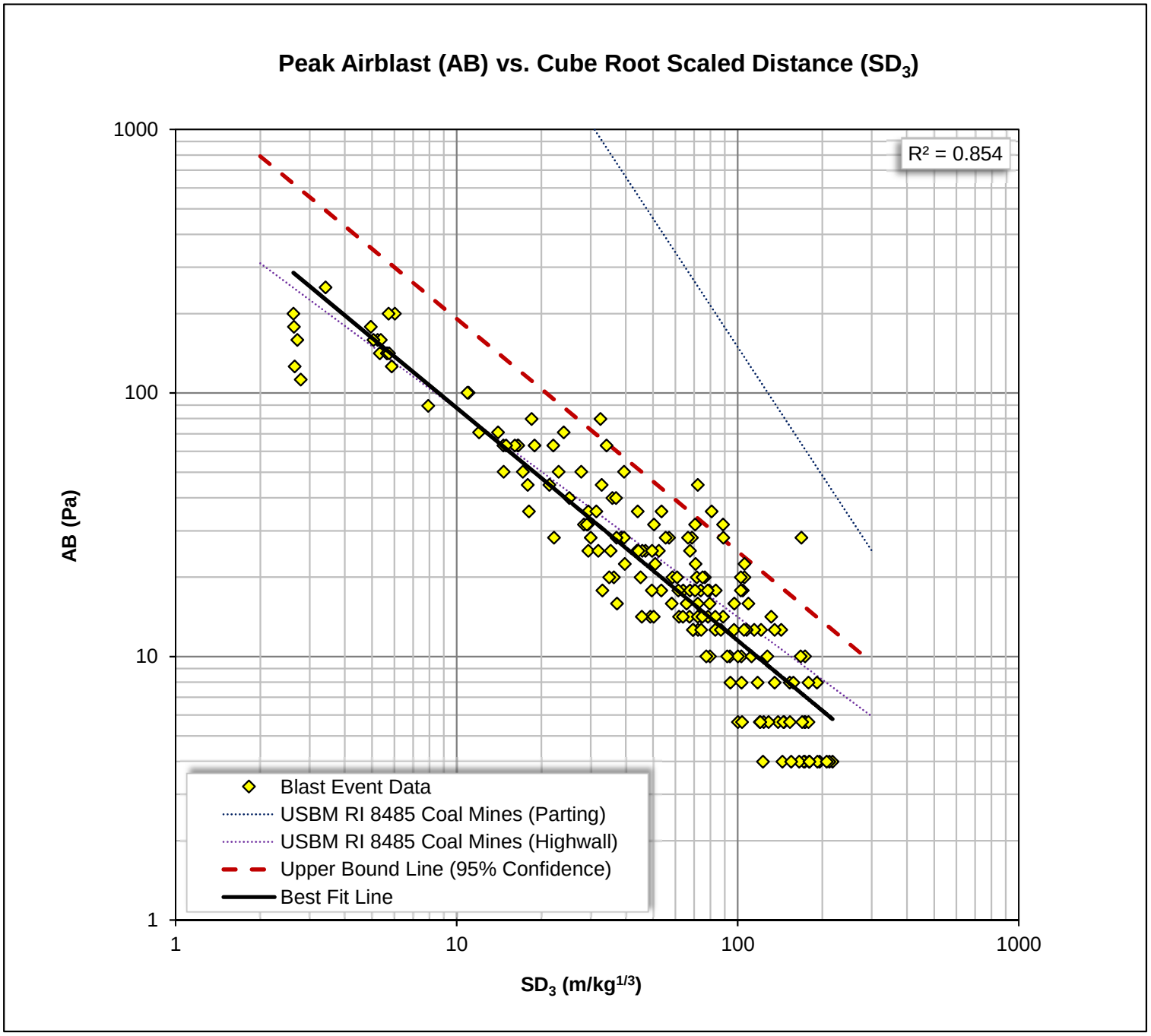


The blast event data was collected intermittently between the following dates: 07/27/00 and 08/29/01.

The Best Fit Line and Upper Bound Line (95% Confidence) may be approximated using the following equation:		
$PPV = A \times SD_2^{-B}$	where A =	**376.79** , y-intercept for Best Fit Line at SD_2 = 1.0
	or A =	**1,140.73** , y-intercept for Upper Bound Line (95% Confidence) at SD_2 = 1.0
	and B =	**-1.16** , slope of the Best Fit Line and Upper Bound Line

OSMRE Regression Analysis of Airblast Data

Mine:	Pittsburgh Mine	Review Agency:	OSMRE
Permit:	D-12345	Review Date:	01/01/19
Blaster:	Top Flight Blasting	Performed By:	Brian Farmer, P.E.



The blast event data was collected intermittently between the following dates: 07/27/00 and 08/29/01.

The Best Fit Line and Upper Bound Line (95% Confidence) may be approximated using the following equation:		
$AB = A \times SD_3^{-B}$	where A =	**669.73** , y-intercept for Best Fit Line at SD_3 = 1.0
	or A =	**1,458.97** , y-intercept for Upper Bound Line (95% Confidence) at SD_3 = 1.0
	and B =	**-0.88** , slope of the Best Fit Line and Upper Bound Line