**FINAL REPORT**

# Bat Monitoring, Fort Leonard Wood, Missouri: Sound and Seismic Effects

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## INTRODUCTION

The U.S. Army Maneuver Support Center of Excellence and U.S. Army Garrison Fort Leonard Wood (Installation) has prepared a Biological Assessment (BA) to evaluate effects of the construction and operation of a Mine Clearing Line Charge (MICLIC) range on threatened and endangered species at the Installation. A pilot monitoring plan will describe the process in which field data are to be gathered and timelines in which field data are processed and/or reported. The data collected during this pilot monitoring survey will be used to validate the noise and seismic estimations, as described in the BA, for MICLIC detonations and ensure that thresholds of sound and vibration have not been surpassed. If field data results surpass thresholds, the USFWS will be consulted and appropriate coordination will be conducted.

Dr. Kevin Mickus, geophysicist and Distinguished Professor in the Department of Geography, Geology, and Planning at Missouri State University (MSU), was the lead scientist on the pilot monitoring survey to assess the noise and sound effects during MICLIC testing. He was assisted in the field by Paul Wilkerson, an undergraduate student in geology. The seismic and sound data were collected at King Cave which is the closest of the seven caves to the MICLIC Range (Figures 1 and 2).

## METHODS

### Instrumentation

The Instantel Blastmate III-Micromate model was used to record both seismic and sound data. Seismic levels were recorded in inches per second (ips) and sound was recorded in pounds per square inch (psi). The deployed system had a three component seismic sensor to record vertical tangential and radial components of the source signal and a linear microphone to record the air blast. The equipment was housed in a metal cylinder that was connected to a 12-volt battery which was charged by a solar panel. The seismic sensor was bolted to the roof of cave. We rented the equipment from Matheson Mining Consultants, Denver, CO, who also independently confirmed MSU's interpretations of the data records. The equipment is routinely used to monitor mining blasts and blasts at construction sites.

### Sound

Sound levels were monitored by MSU using a sound meter to record the sound levels and the time (events) at which they occurred. Two sound meters were deployed on a battery system attached to a solar panel for long-term monitoring. The sound meters were placed at the entrance to King Cave in the morning of October 8, 2018. Data were recorded until the morning of October 25, 2018. For reference the Federal limit is 133 dBL. The data recorded by the Blastmate is in psi; however, these numbers can be converted to decibels (dBL) using dBL= 20 log(P/Po) where P is pressure in psi and the reference pressure Po is 2.9 x10^9.

### Seismic

Seismic activity was monitored by MSU using two seismic monitoring systems, which recorded seismic levels and the time (events) at which they occurred. The seismometers were deployed on external battery systems with a solar panel so recording can occur for multiple weeks at a time. The seismic monitors were placed at the entrance to King Cave in the morning of October 8, 2018. Data were recorded until the morning of October 25, 2018. One seismometer was attached to the roof of King Cave at its entrance (Figures 3 and 4) and a second seismometer was attached to bedrock on the floor of the cave at its entrance. The second seismometer (attached to the cave floor) failed after 5 days of recording as the solar panel failed to work. The other seismometer recorded data the entire time it was deployed including the date of the blast on October 22, 2018.

For both the sound and seismic recording, the stations were installed on October 8, 2018, one site visit to check on the batteries and collect data occurred on October 15, 2018 and the stations were removed on October 25, 2018.

Figure 5 shows the output of the machine once an event occurs. The trigger level for a seismic event was set 0.01 in/sec. The seismic sensor records three components, vertical and two horizontals (transverse and longitudinal).

**RESULTS**

**Seismic and Sound Data**

During the recording of the data, several events were identified on the seismic records. Three of these events were caused by disturbances by project team members from our or another group during the touching or picking up of the geophones and vocal correspondence near the instruments while at the site. We will not show the records of these events. The other events evaluated were as follows:

Event 1 (Figure 5): a sound event occurred on 10/8 with a peak dBL level of 119.5 dBL. There was no seismic event associated with this sound event;

Event 2 (Figure 5): a series of sound events (maybe somebody at the site) occurred on 10/10 with a peak dBL level of 117.4 dBL. There were no seismic events associated with this event;

Event 3 (Figure 5): a series of sound events occurred on 10/10 with a peak dBL level of 116.3 dBL. There were no seismic events associated with this event;

Event 4 (Figure 5): a series of sound events occurred on 10/10 with a peak dBL level of 107.3 dBL. There were no seismic events associated with this event;

Event 5 (Figures 5 and 6): a seismic event occurred on 10/12 with a peak particle velocity of 0.232 in/s on the transverse component. There was no sound event associated with this event:

Event 6 (Figure 6): a seismic event occurred on 10/14 with a peak particle velocity of 0.020 in/s on the vertical component. There was no sound event associated with this event:

Event 7 (Figure 6): a sound event occurred on 10/15 with a peak dBL level of 137.4 dBL. There was no seismic events associated with this event. The source of this sound event is unknown, but was above the federal limit of 133 dBL:

Event 8 (Figure 7): a sound event occurred on 10/16 with a peak dBL level of 139.8 dBL. There was no seismic events associated with this event. The source of this sound event is unknown, but was above the federal limit of 133 dBL: and

Event 9 (Figure 7): a sound event occurred on 10/22 with a peak dBL level of 120.3 dBL. There was no seismic events associated with this event. This event was associated with the MICLIC blast and was below the federal level of 133 dBL and the 126 dBL threshold identified in the BA.

## DISCUSSION AND CONCLUSIONS

Seismic and sound data were collected for over a two week period at King Cave (Figures 1 and 2) using an Instantel Blastmate seismic recorder and linear microphone. The data (Figures 5-7) show several seismic and sound events, but during the MICLIC blast on 10/22 there were no seismic events (larger than the trigger level of 0.01 in/s), thus the MICLIC blast was well below the 0.20 in/s threshold identified in the BA. However, a sound event associated with the air blast was recorded with a peak sound level of 120.3 dBL which is about 13 dBL (or 10%) below the federal level of 133 dBL as well as 6 dBL (or 5%) below the threshold of 126 dBL identified in the BA. Two events did occur at levels slightly above the Federal level (137 and 140 dBL), but these are of unknown source and not associated with the blast.

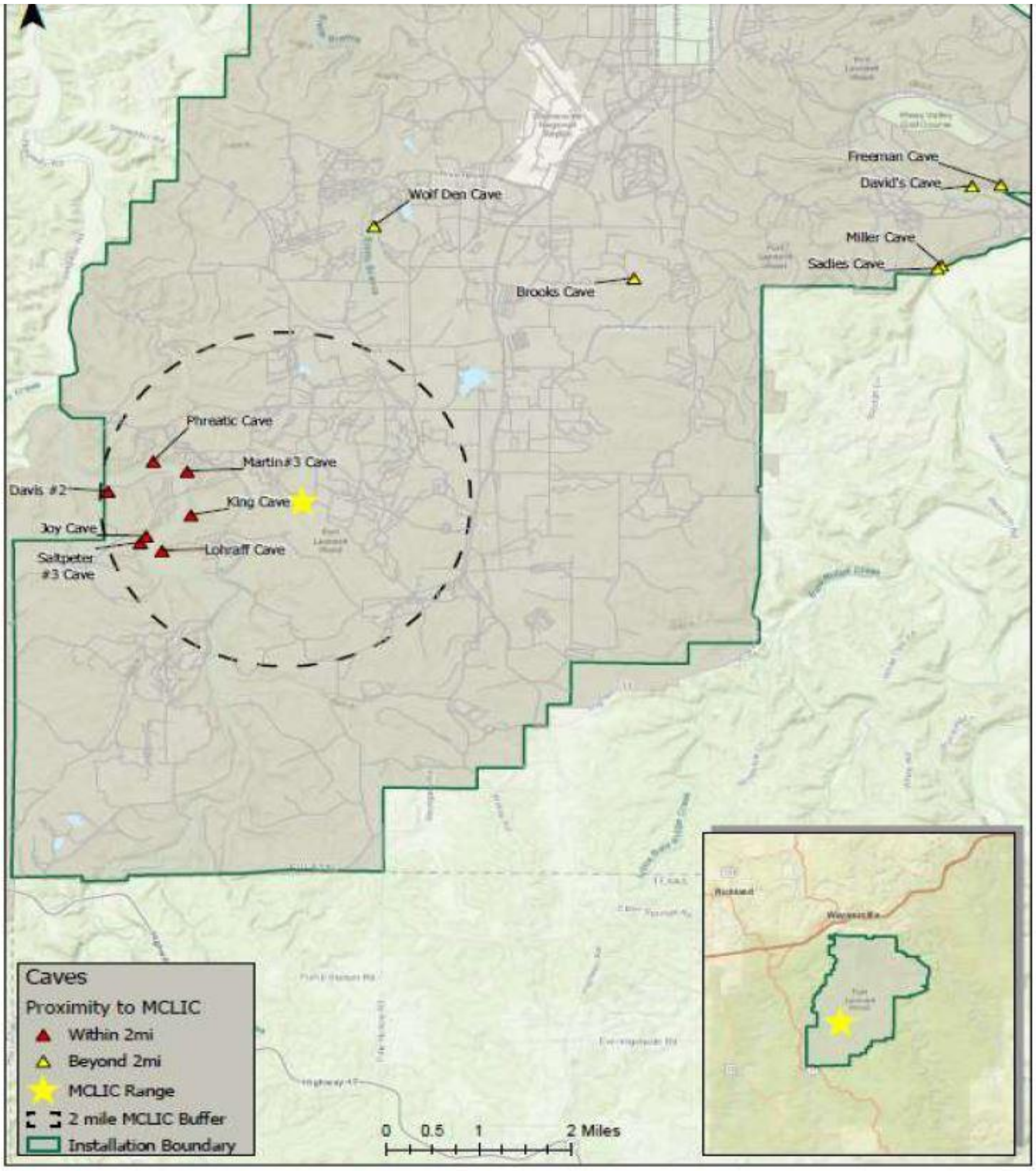



**Figure 1. Location of caves associated with MICLIC Range.**

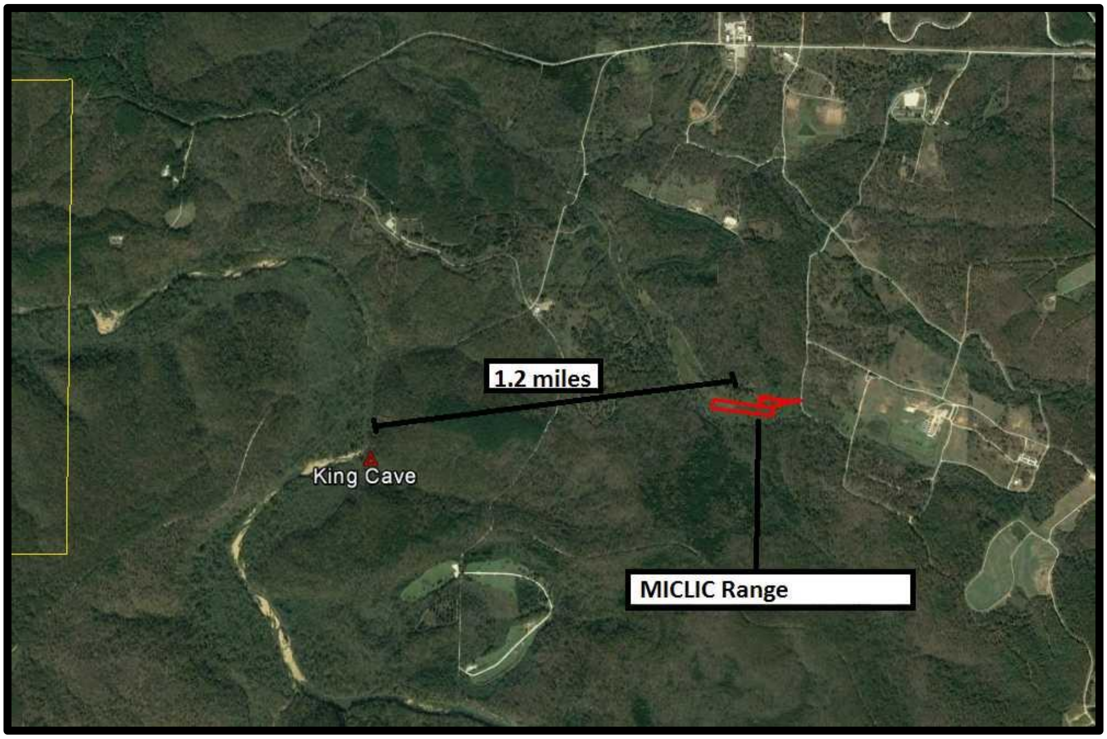



**Figure 2. Location of King Cave in relation to the MICLIC Range.**

**Figure 3. Seismic recorders at King Cave.** The seismic sensor is attached to the top of the cave while the round containers contain the data recorders/batteries and solar panels. The sound meters were attached to the round containers.

**Figure 4. The data recorders (blue boxes) inside while the round containers.** The sound meters were placed inside the round tube coming out of the containers (upper portion of the bottom container).

Instantel

## Event Report

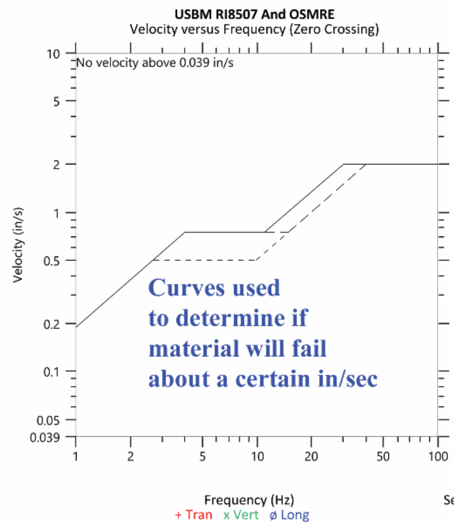
| | | | |
|---|---|---|---|
| **Start** | October 12, 2018 20:44:35 | **Serial Number** | UM11902 |
| **Finish** | October 15, 2018 09:21:09 | **Model Number** | Micromate ISEE 10.89 |
| **Number of Intervals/Interval** | 242.44/900 sec | **Battery Level** | 3.8 volts |
| **Sample Rate** | 1024 sps | **Unit Calibration** | April 25, 2018 by Instantel |
| **Operator/Setup File Name** | Operator/MO-State_rental_Mic.mmb | **Event File Name** | UM11902_20181012204435.IDFH |
| | | **USB Sensor Support** | Disabled |

**Notes**
**Location**
**Client**
**Company**
**General Notes**
**Extended Notes** Not text to be displayed.

**Post Event Notes** No text to be displayed.

| **Geophone** | **Tran** | **Vert** | **Long** |
|---|---|---|---|
| Peak Particle Velocity | 0.037 in/s | 0.034 in/s | 0.009 in/s |
| Zero Crossing Frequency | <1 Hz | <1 Hz | N/A |
| Date | Oct 13, 2018 | Oct 13, 2018 | Oct 12, 2018 |
| Time | 00:14:35 | 00:14:35 | 20:59:35 |
| Sensor Check | ✓ Passed | ✓ Passed | ✓ Passed |
| Frequency | 7.5 Hz | 6.7 Hz | 7.5 Hz |
| Overswing Ratio | 3.5 | 5.0 | 3.3 |
| Peak Vector Sum | 0.037 in/s at October 13, 2018 00:14:35 | | |

| **ISEE Linear Microphone** | |
|---|---|
| Peak Sound Pressure Level | 0.021553 psi |
| Date | Oct 15, 2018 |
| Time | 03:44:35 |
| Zero Crossing Frequency | 22.3 Hz |
| Sensor Check | ✓ Passed |
| Frequency | 19.7 Hz |
| Test Amplitude | 1493 mv |



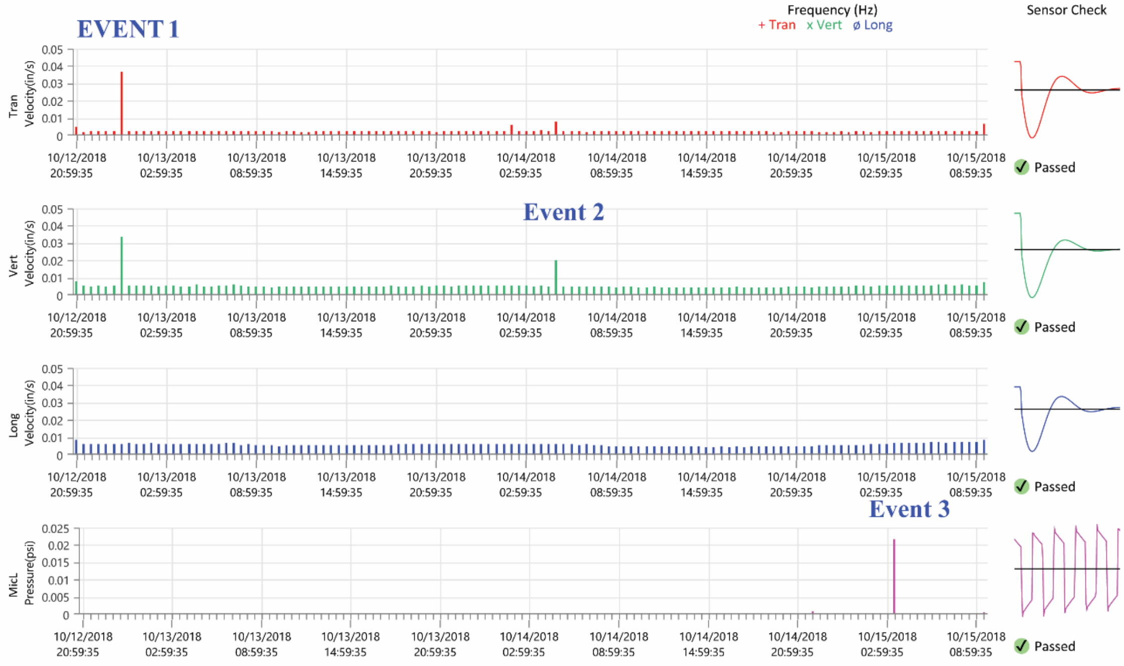




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**Figure 5. Output from the Instanel Blastmate seismic and sound recorder: October 12 to 15, 2018.** The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.

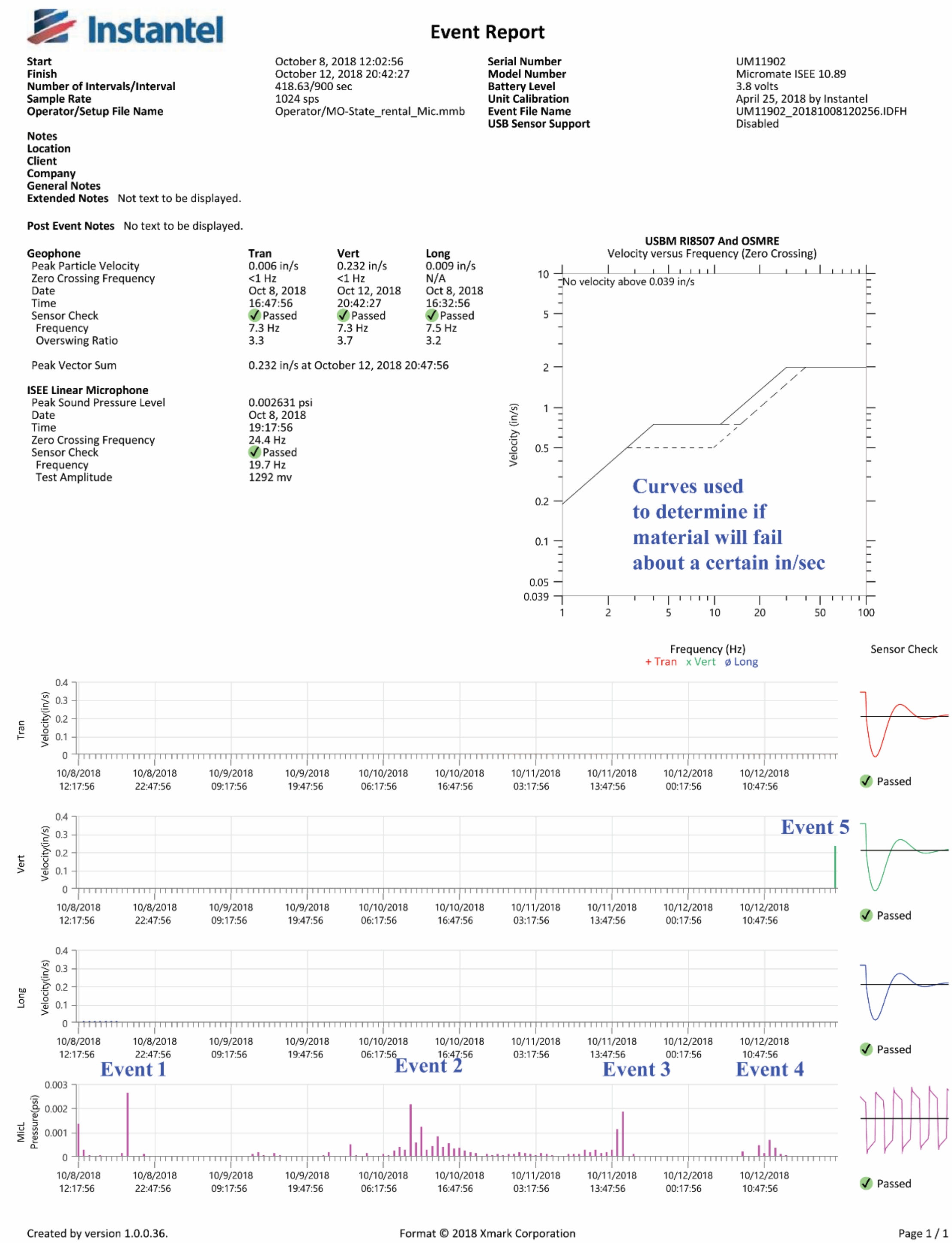
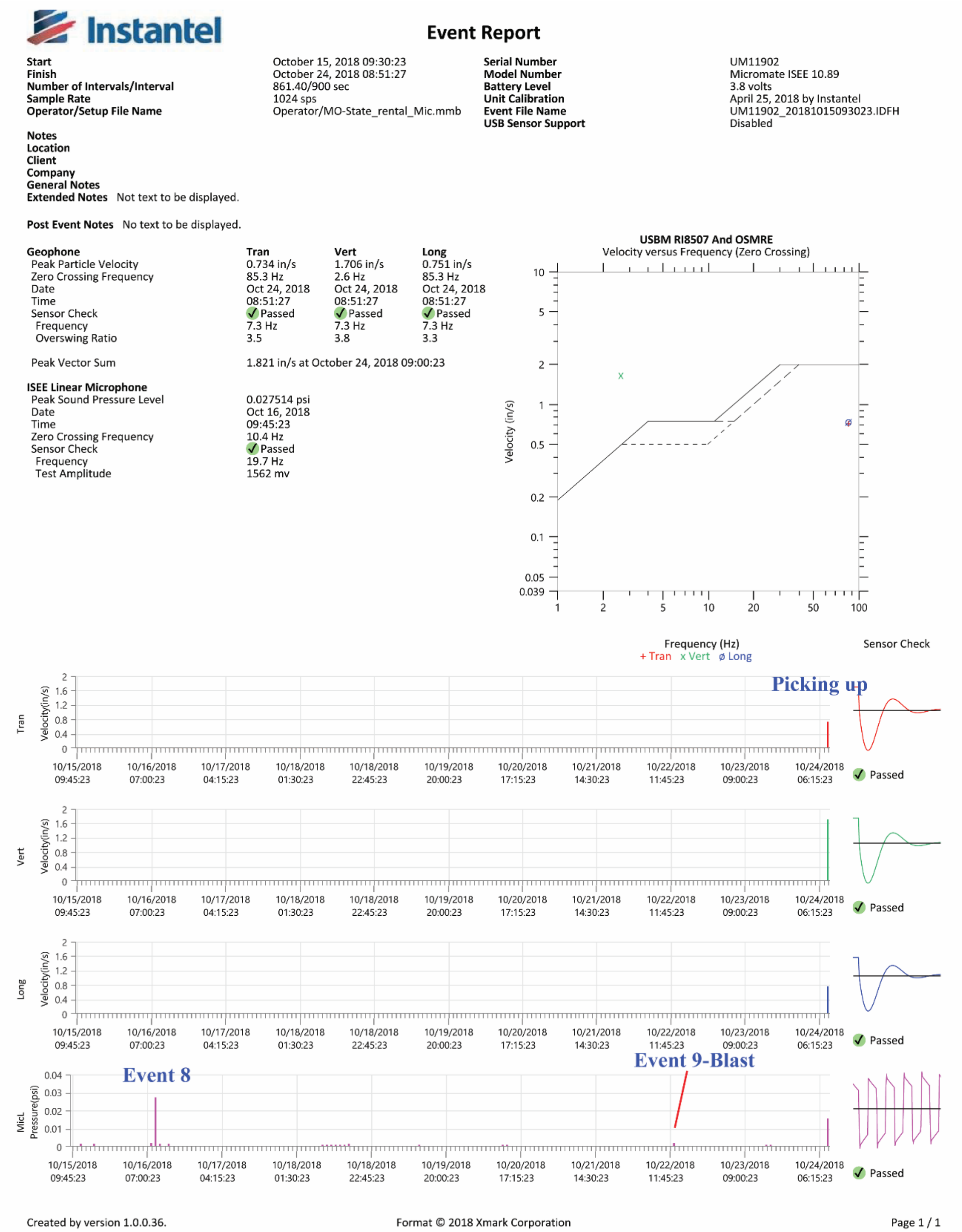



**Figure 6. Output from the Instanel Blastmate seismic and sound recorder: October 8 to 12, 2018.** The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.



Instantel

**Event Report**

| | | | |
|---|---|---|---|
| **Start** | October 15, 2018 09:30:23 | **Serial Number** | UM11902 |
| **Finish** | October 24, 2018 08:51:27 | **Model Number** | Micromate ISEE 10.89 |
| **Number of Intervals/Interval** | 861.40/900 sec | **Battery Level** | 3.8 volts |
| **Sample Rate** | 1024 sps | **Unit Calibration** | April 25, 2018 by Instantel |
| **Operator/Setup File Name** | Operator/MO-State_rental_Mic.mmb | **Event File Name** | UM11902_20181015093023.IDFH |
| | | **USB Sensor Support** | Disabled |

**Notes**
**Location**
**Client**
**Company**
**General Notes**
**Extended Notes** Not text to be displayed.

**Post Event Notes** No text to be displayed.

| **Geophone** | **Tran** | **Vert** | **Long** |
|---|---|---|---|
| Peak Particle Velocity | 0.734 in/s | 1.706 in/s | 0.751 in/s |
| Zero Crossing Frequency | 85.3 Hz | 2.6 Hz | 85.3 Hz |
| Date | Oct 24, 2018 | Oct 24, 2018 | Oct 24, 2018 |
| Time | 08:51:27 | 08:51:27 | 08:51:27 |
| Sensor Check | ✓ Passed | ✓ Passed | ✓ Passed |
| Frequency | 7.3 Hz | 7.3 Hz | 7.3 Hz |
| Overswing Ratio | 3.5 | 3.8 | 3.3 |

Peak Vector Sum 1.821 in/s at October 24, 2018 09:00:23

| **ISEE Linear Microphone** | |
|---|---|
| Peak Sound Pressure Level | 0.027514 psi |
| Date | Oct 16, 2018 |
| Time | 09:45:23 |
| Zero Crossing Frequency | 10.4 Hz |
| Sensor Check | ✓ Passed |
| Frequency | 19.7 Hz |
| Test Amplitude | 1562 mv |



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**Figure 7. Output from the Instanel Blastmate seismic and sound recorder: October 15 to 24, 2018.** The bottom graphs show seismic events on the vertical (vert), transverse (Tran) and longitudinal (Long) components in in/s, and the sound events from the linear microphone (MicL) in psi. Three significant events are marked on the graphs.