CONSTRUCTION MATERIALS MINING ACTIVITIES CONSULTATION AND STUDY PREPARATION SERVICES

FINAL REPORT

CONTRACT FM410

PREPARED FOR
State of Florida
Department of Financial Services
200 East Gaines Street, Larson Building
Tallahassee, Florida 32399

JULY 2018

RSI-2822

RESPEC

RESPEC.COM

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EXECUTIVE SUMMARY

RESPEC was contracted by the Florida Division of Financial Services Florida State Fire Marshal (FSFM) under Contract FM410 (February 1, 2018) to complete a comprehensive review of the US Bureau of Mines (USBM) Report of Investigations (RI) 8507, the data points that were used in RI 8507, subsequent studies related to RI 8507, and their relevance to Florida's unique geological setting. RESPEC was also required to review Florida regulations, local regulations, and federal regulations related to blasting vibration limits. Finally, RESPEC reviewed geologic and soil characteristics, blasting activities reports, complaint reports, and blast vibration records, as well as RESPEC-recorded blast vibration waveforms, for the six representative construction materials mines selected by the FSFM. This report focuses on the action items in the following sections.

ACTION ITEM 1

An analysis of the current ground-vibration limits set by RI 8507, with respect to Florida and its soil conditions, particularly in areas surrounding construction materials mines.

The USBM analyses, as described in RI 8507, apply to Florida and its soil conditions, particularly in areas surrounding construction materials mines. RESPEC recommends that the Florida Administrative Code (FAC) be written to use only the RI 8507 Alternative Blasting Limit Criteria (ABLC) to limit ground vibrations that are produced by Florida construction materials mining operations based on frequency content and particle velocity amplitude, regardless of distance from the mines.

The FSFM currently uses the ABLC as the limit for construction mines that do not have an urban development within 2 miles of the blast. RESPEC recommends that the FAC remove distance requirements for seismograph monitoring and requirements based on "urban development" and only use the ABLC, regardless of distance from the blast to the nearest residential structure.

ACTION ITEM 2

An analysis of reports, regulatory permits, and related correspondence produced by a representative sample of construction materials mines in Florida, including a summary of all documentation provided by the FSFM that documents blasting activities at the same representative sample of construction materials mines in Florida and complaints by residents who are located near those same mines.

The dataset included all of the following reports that are required by a statute and/or administrative rule:

- Blasting activities reports
- Complaint reports (i.e., requests for investigation, preliminary report, and letters)
- Regulatory permits issued by federal, state, and local governmental agencies that apply to construction materials mines.

RESPEC reviewed reports, regulatory permits, and correspondence that related to six representative mine sites and were provided by the FSFM. The peak particle velocity (PPV) amplitudes that were

recorded in Florida are low, which means that the vibrations are outside of any range that could damage or settle residential structures, regardless of frequency content.

RESPEC recommends that the FSFM include additional information on blasting activities reports and complaint reports, so the FSFM can conduct more thorough reviews of any complaints and blasting operations. The FSFM needs to collect global positioning system (GPS) coordinates of the seismograph location and nearest point of the blast location; the complete vibration waveform (particle velocity amplitudes and associated frequencies); and the date, time, and case number of each complaint on a standard statewide template. The FSFM must collect particle velocity and frequency information to use the ABLC.

ACTION ITEM 3

An analysis of the effects of current ground vibration limits on the communities surrounding Florida's construction materials mines and whether the current blasting vibration limits set by statute are still appropriate, including a review of measured vibration amplitudes and frequencies, structure responses, and theoretical analyses of material strength and strains.

RESPEC determined that the current blasting vibration limits set by the ABLC are appropriate to protect residential structures. RESPEC did not evaluate the social impact on the residents of communities because the social impact on residents is outside of the scope of contract FM410.

SUMMARY OF FINDINGS AND CONCLUSIONS

This section provides a summary of important findings and conclusions. Refer to Chapter 7.0 for details on the conclusions of this report.

- General Information
  - Drywall and plaster are the weakest materials used in residential structures.
  - The first sign of damage caused by any source is likely to be crack initiation or extension of drywall joints.
  - Weather and natural events cause cracks to form in residential structures because of daily environmental changes or long-term environmental changes.
  - In general, weather or environmentally induced displacements can be over 10 times the displacements caused by large blast-induced displacements.
  - Human activity in a house can cause similar strains in structures as 0.5 inch per second (in/sec) blast vibrations.
- Structure Response
  - Whole-structure response is more important than midwall response with respect to limiting potential structural damage.
  - Typical residential structures have structural natural frequencies that range from 4 to 12 Hertz (Hz).
  - Structures amplify driving ground vibrations with frequencies between 4 to 12 Hz by a factor of 2 to 4, which is why the ABLC is stricter in this frequency range.
  - The lowest level of observed vibration-induced damage in drywall in RI8507 was 0.8 in/sec.

- Blast Vibration Limits
  - The RI 8507 ABLC limits blast vibrations using both frequency and particle velocity because both are equally important to understanding a ground vibration's effect on structural response.
  - The RI 8507 ABLC limits apply to residential structures that are sited on a firm foundation, do not exceed 2 stories, and have the dimensions of typical residences, and that the vibration wave trains are not longer than a few seconds. Engineered structures are more resistant to vibrations than residential structures.
  - The RI 8507 ABLC accounts for structural response, so the ABLC only applies to ground vibrations at the base of residential structures.
  - Nondamage events observed during the RI 8507 study occurred at ground vibrations measuring up to approximately 2.0 in/sec between 6 Hz and 70 Hz. Previous studies showed nondamaged events at vibration levels that exceeded 2.0 in/sec.
  - The ABLC applies to the low frequency, long duration vibrations that occur in Florida.
  - The ABLC may only be inadequate for one specific scenario: pre-1950s constructed houses with plaster-on-lath interiors that experience a blast vibration with a driving ground vibration particle velocity above 0.5 in/sec and in the frequency range between 12 Hz and 40 Hz. In this case, 0.5 in/sec should be the PPV limit.
  - The unique geology of Florida causes blast vibrations to be lower frequency and longer duration than in other areas of the United States; however, the geology does not affect how a residential structure responds to blast vibrations. Only the characteristics of a blast vibration at the base of a residential structure are important when evaluating the impact of the blast vibration on the residential structure.
  - Residential structures are not affected by repeated blast vibration events; therefore, they do not have fatigue-related damage.
  - The ABLC applies to the residential structures in Florida.
  - The soils in Florida are not settling because of blast vibration events.
- Blast Vibration Data
  - Blast vibrations that RESPEC measured in Florida were low energy vibrations and did not exceed the ABLC.
  - RESPEC found that one site exceeded the ABLC on three occasions in 2017; however, these three events likely did not cause any damage. There could have been more occasions when the ABLC was exceeded, but construction materials mining operations are not required to report enough information for the FSFM to know if the ABLC is exceeded or not.
  - RESPEC found one instance from the complaint investigation report events where a site was out of compliance because of improper seismograph placement location.
  - The FSFM investigators found two airblast exceedance events; however, ground vibration limits were not exceeded during complaint investigations.
  - Most residential complaints are likely caused by the long-duration, low-frequency vibrations that occur in the southeastern and southwestern regions, considering that the vibrations that were recorded at the complainant's residences had such low PPVs.
  - Permanent seismograph installations may have an issue if the blasting location changes frequently at the mining operation.

- FSFM Task Items:
  - The FSFM should sponsor a study to determine if current industry seismograph standards are not sufficient to ensure that the blast vibrations in Florida can be measured accurately.
  - The FSFM needs to periodically review seismograph placement at construction materials mining operations.
  - The FSFM should standardize complaint reporting statewide.
  - The FSFM inspectors should continue community outreach by following the Public Outreach Plan (submitted by RESPEC) to educate the community and construction materials mining operations and ensure that the community understands the content of this document and RESPEC's conclusions.
- Suggested Updates to the FAC:
  - The FAC should require that full waveforms and complete seismograph report printouts of blast vibration events be available to the FSFM for review, so the FSFM can determine if a mining operation exceeds the ABLC limits. These reports will provide particle velocity and frequency information. The FAC could also require that digital seismograph files be available to the FSFM if requested.
  - The FAC should continue to refrain from placing blast design constraints on construction materials mining operations.
  - The FAC should require construction materials mining operations to provide GPS coordinates of the blast location and GPS coordinates of the monitoring location.
  - The FAC should require the ABLC limits for blast vibrations, regardless of the number of residential structures within 2 miles of the blast location.
  - The FAC should require training and recertification of blasters, seismograph operators, and FSFM inspectors.
  - The FAC should not require both Table 8A from the National Fire Protection Association (NFPA) 495 1996 Edition and the RI 8507 ABLC because these are two separate criteria. Because the FSFM requires seismographs to monitor, the FSFM should require only the ABLC, which is now included in the NFPA 495 2018 Edition.
  - The FAC should not reference the 17th edition of the International Society of Explosives Engineers (ISEE) Blasters' Handbook.

This document presents RESPEC's findings and supporting evidence for these conclusions in the following chapters:

1. Introduction
2. Report of Investigations 8507
3. Representative Mines and Data in Florida
4. Applying Report of Investigations 8507 to Florida and Its Soils
5. Blast Vibration Limits and Regulations in Florida
6. Other Florida Blast Vibration Studies
7. Conclusions
8. Bibliography.

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DEFINITIONS

Term	Definition	Source
BLAST TERMS		
Airblast	The airborne shock wave or acoustic transient generated by an explosion.	IME [2013]
Blast Pattern	The plan of the drillholes as laid out for blasting.	IME [2013]
Blasthole	A hole drilled in the material to be blasted, for the purpose of containing an explosive charge.	IME [2013]
Charge Weight	The total weight of explosives that detonate within any given 8 millisecond time interval.	ISEE [2011]
Delay Interval	The nominal time between the detonations of delay detonators of adjacent periods in a delay series; the nominal time between successive detonations in a blast.	IME [2013]
Detonation	An explosive reaction that moves through an explosive material at a velocity greater than the speed of sound in the material.	IME [2013]
Explosive Density	The mass of an explosive per unit of volume, usually expressed in grams per cubic centimeter or pounds per cubic foot.	IME [2013]
Millisecond	One-thousandth of a second (0.001 or 1/1000 sec.)	IME [2013]
Powder Factor	The amount of explosive used per unit of rock.	IME [2013]
US Bureau of Mines (USBM)	A former bureau of the Department of Interior (dissolved in 1996) that was active in promoting safety in coal mines and in carrying out broad programs in mining and related fields.	IME [2013]
VIBRATION TERMS		
Acceleration	The rate at which a particle changes its velocity over time.	ISEE [2011]
Attenuation	(b) A reduction in the amplitude of seismic waves, as produced by divergence, reflection and scattering, and absorption. (c) That portion of the decrease in seismic or sonar signal strength with distance characteristics of the transmitting medium.	AGI [1997]
Blast Vibration	The energy from a blast that manifests itself in vibrations which are transmitted through the earth away from the immediate blast site.	IME [2013]
Displacement	The distance that a particle moves with respect to its resting position as a wave passes a given location, a particle in the ground or in the air is displaced either above or below its resting position at any given point in time.	ISEE [2011]
Dominant Frequency	The most recurring frequency value in a waveform.	Rouse [2015]
Duration	The length in time of a blast vibration.	Dowding [1985]
Frequency	The inverse of one period, or the time interval of one complete cycle. A vibrating particle will start from its resting point, move to a positive peak, return to zero, then move to a negative peak, and finally return to zero to complete one cycle.	ISEE [2011]
Ground Vibration	Vibrations, or seismic energy, from blasting that are a side product of using explosives to fragment rock for mining, quarrying, excavation, and construction.	Siskind et al. [1980]
Particle Velocity	A measure of the intensity of ground vibration, specifically the velocity of motion of the ground particles as they are excited by the wave energy.	IME [2013]

Term	Definition	Source
Peak Particle Velocity	The maximum velocity of a vibrating particle that is moving around its resting point.	ISEE [2011]
Principal Frequency	The frequency associated with the greatest amplitude pulse (PPV pulse).	Dowding [1996]
Propagation Velocity	The speed of a wave in the material concerned, such as the propagation velocity of a detonation wave front that is traveling through an explosive or the propagation velocity of a seismic wave from a blast that is traveling through the ground.	AGI [1997]
Sinusoidal Waveform	A curve or waveform with a smooth, periodic oscillation.	Davis [2000]
BLAST VIBRATION MONITORING TERMS		
Accelerometer	Acceleration-measuring devices. A constant mass is used to serve as a front-end element to convert acceleration into force.	De Silva [2007]
Geophone	Velocity transducer (sensor). Output from a velocity transducer is generated by a coil that moves through a magnetic field. The voltage induced by the coil is directly proportional to the relative velocity between the coil and the magnetic field.	Dowding [1985]
Seismograph	Complete instrumentation system that consists of transducers (geophone), amplifiers, a power supply, and a recorder.	Dowding [1996]
VIBRATION ANALYSIS TERMS		
Fast Fourier Transform (FFT)	Transform time-domain information (i.e., a "time" history) into the frequency domain. Such a transform results in a group of continuous sinusoidal waves with unique amplitudes, phases, and frequencies that can be added to produce the time-varying history.	Dowding [1996]
Frequency Spectrum	The graph form of amplitude and frequency information calculated by using an FFT.	Dowding [1996]
Scaled Distance	A factor that relates similar blast effects from various weight charges of explosive material at various distances. Scaled distances that refer to blasting effects are obtained by dividing the distance of concern by a fractional power of the weight of the explosive materials.	IME [2013]
Seismogram	The seismograph-produced record of vibratory motion in the earth.	AGI [1997]
Zero-crossing (ZC) frequency	The inverse of two times the time difference between the two crossings on either side of a peak of the time history. The calculation assumes that the single peak is isolatable and symmetrical.	Dowding [1996]
STRUCTURAL TERMS		
Amplification Factor	The amplification factor is the ratio of the peak particle velocity (PPV) of the structure to the corresponding particle velocity peak of the ground vibration at the base of the structure at the same moment in time or immediately preceding the peak structural vibration.	Crum [1997]
Midwall Response	Bending response of individual walls of a residential structure.	Siskind et al. [1980]
Damage (Threshold)	Loosening of paint, small plaster cracks at joints between construction elements, and lengthening of old cracks.	Siskind et al. [1980]
Damage (Minor)	Loosening and falling of plaster: cracks in masonry around openings near partitions; hairline to 3-millimeter (mm) cracks (0 to 1/8 inch [in]); fall of loose mortar.	Siskind et al. [1980]
Damage (Major)	Cracks of several millimeters in the walls; rupture of opening vaults; structural weakening; fall of masonry (e.g., chimneys); load support ability affected.	Siskind et al. [1980]

Term	Definition	Source
Damping	A structure's resistance to vibrations. It is proportional to the rate at which a structure's natural vibration decays with time during free vibration	Dowding [1985]
Drywall	See Gypsum Board	
Gypsum Board	Sheet products with a noncombustible core primarily of gypsum with paper surfacing	ASTM [2018]
Natural Frequency	See Resonance	
Resonance	A term that denotes a variety of phenomena characterized by the abnormally large response of a system that has a natural vibration period to a stimulus of the same, or nearly the same, frequency.	AGI [1997]
Strain	Change in length divided by original length. This ratio is the same as the change in displacement per unit distance	Dowding [1996]
Stress	The force applied on a material per unit area	Davis [2000]
Structural Damping	A structure's resistance to vibrations. Percentage damping is generally 5% or less.	Dowding [1996]
Plaster-on-Lath	Interior walls constructed with plaster covering on wood lath. In this document, residences with plaster-on-lathe interior walls are pre-1950s homes that were subjected to years of nonblasting damage and degradation due to long-term weathering and distortion.	Dowding et al. [2018], Siskind et al. [1980]
Structural Natural Frequency	The number of times per second that a structure will oscillate back and forth when excited.	Dowding [1985]
Whole Structure Response	Racking or shearing motions of the gross structure	Siskind et al. [1980]

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1.0 INTRODUCTION

As promulgated by Florida Statute 552.30 *Construction Materials Mining Activities*, the Florida State Fire Marshal (FSFM) regulates and has the exclusive authority regarding the use of explosives in Florida's construction materials mining operations (limestone mining operations). In response to many complaints received by the Fire Marshal's office regarding possible blast damage to nearby residential properties, RESPEC was selected by the Florida Department of Financial Services to review the existing statewide ground-vibration limits for limestone mine blasting activities and evaluate the claims of possible damages caused by blasting activities at construction materials mining operations.

The following background was provided in Request for Proposal (RFP) Number: DFS FM RFP 1718-12 *Construction Materials Mining Activities Consultation and Study Preparation Services*:

> *Pursuant to section 552.30, F.S., the Department's Division of State Fire Marshal regulates and licenses approximately 100 construction materials mines in the State. These mines use explosives in conjunction with their construction materials mining activities. The use of explosives in these mines causes ground vibrations. The ground vibration limitations are mandated by section 552.30, F.S., to conform with those limits established in the United States Bureau of Mines, Report of Investigations 8507, Appendix B – Alternative Blasting Level Criteria (Figure B-1). In some areas of the State, construction materials mine properties are situated within five miles of residential areas. The residents in the vicinity of these construction materials mine properties have questioned whether the blasting vibrations are causing damage to their property. The Florida Legislature appropriated funds via 2016-2017 General Appropriations Act, specific appropriation number 2374, to the Department allowing it to contract for a study to review whether the established statewide ground vibration limits for construction materials mining activities are still appropriate and to review any legitimate claims paid for damages caused by such mining activities.*

Section 552.30, F.S. also states:

> *The State Fire Marshal is directed to conduct or contract for a study to review whether the established statewide ground vibration limits for construction materials mining activities are still appropriate and to review any legitimate claims paid for damages caused by such mining activities. The study must include a review of measured vibration amplitudes and frequencies, structure responses, theoretical analyses of material strength and strains, and assessments of home damages.*

This document was produced under the above directive.

Note that the Florida Division of Administrative Hearings (DOAH) possesses exclusive jurisdiction over all claims for property damages caused by the use of explosives in connection with construction materials mining activities. The only claim for damages caused by the use of explosives in connection with construction materials mining activities awarded by DOAH occurred in the matter of GATEWAY ESTATES PARK CONDOMINIUM ASSOCIATION v. SDI QUARRY, A/K/A ATLANTIC CIVIL, INC., DOAH Case No.: 16-001025CM. The case was still pending in the First District Court of Appeal as case

number 1D17-1086 by contract FM410's deadline of April 14, 2018; therefore, the Gateway Estates claim is outside of the scope of this study.

This report is organized into eight chapters, including this introduction, and eleven appendices with additional pertinent information. Chapter 2.0 provides details about the US Bureau of Mines (USBM) Report of Investigations (RI) 8507. Representative mines and data in Florida are included in Chapter 3.0, and the application of RI 8507 to Florida and its soils is provided in Chapter 4.0. The blast vibration limits and regulations in Florida are described in Chapter 5.0, and other Florida blast vibration studies are included in Chapter 6.0. Conclusions are provided in Chapter 7.0, and citations for documents that are cited throughout this report are included in Chapter 8.0.

Appendix A contains a sensor overview, and Appendices B and C contain the Blasting Activities and Blast Vibration report summaries, respectively. Appendix D includes a summary of citizen complaint data. RESPEC's instrumentation is described in Appendix E, and a summary of RESPEC's data is provided in Appendix F. Appendix G details a seismograph placement analysis, and Appendix H describes the geology of the representative mines in Florida. A complaint investigation report summary is included in Appendix I, and the FSFM investigative report formats are incorporated in Appendix J. Appendix K provides the Public Outreach Plan for this report.

2.0 REPORT OF INVESTIGATIONS 8507

The USBM RI 8507, titled *Structure Response and Damage Produced by Ground Vibration From Surface Mine Blasting*, describes the USBM's work to assess blast vibration damage potential, blast vibration annoyance potential, and proper instrumentation for collecting blast vibration data [Siskind et al., 1980]. The study was a result of (1) direct field measurements of 219 production blasts in 76 homes and (2) damage data presented in nine previous blast vibration studies.

The USBM had previously established safe blasting vibration limits in Bulletin 656 [Nicholls et al., 1971]. USBM Bulletin 656 concluded that peak particle velocity (PPV) (described in units of inches per second [in/sec]) be used to assess the potential for ground vibrations to cause structural damage, rather than displacement. In Bulletin 656, the USBM recommended 2.0 in/sec (the 2.0 in/sec safe level originated in USBM RI 5968 in 1962) as the safe ground vibration limit for residential structures, independent of vibration frequencies over the range of 2.5 to 400 hertz (Hz).

In 1974, the USBM started to reexamine blasting regulations and conduct further research on blast vibration-induced structural damage because the USBM realized that damage was occurring below 2.0 in/sec in some conditions, namely low frequencies below 40 Hz [Siskind et al., 1980]. Additionally, the blanket 2.0 in/sec limits needed review because of the general growth of the mining industry, increasing proximity of mining and quarrying to residential neighbors, and greater environmental awareness. That effort resulted in RI 8507.

RI 8507 resulted in safe blasting limits based on both blast vibration particle velocity and blast vibration frequency [Siskind et al., 1980]. The particle velocity limits in RI 8507 are frequency-dependent; therefore, the particle velocity limit changes based on the ground-vibration frequencies. The limits are both frequency-dependent and particle velocity-dependent because particle velocity and frequency are equally important and cannot be considered separately.

This chapter discusses the following topics presented in RI 8507:

- Structural damage and material failure characteristics
- Structural damage caused by nonblasting sources
- Structural damage caused by blast vibrations.

2.1 STRUCTURAL DAMAGE AND MATERIAL FAILURE CHARACTERISTICS

This section discusses structural damage as defined by the USBM in RI 8507 and failure characteristics of common building materials that are used in residential structures.

2.1.1 DEFINITIONS

Any discussion on structural damage and building material failure characteristics requires the following key terms be defined.

- **Plaster-on-lath** is used in this document to refer to pre-1950s homes that were studied by the USBM with plaster-on-lath interior walls that were subjected to long-term weathering and distortion [Dowding et al., 2018]. When the plaster-on-lath homes were studied by the USBM (late 1970s), the structures were degraded with years of previous nonblasting damage [Dowding et al., 2018].
- **Drywall**, which is also called gypsum wallboard, is used in this document to refer to sheet products with a noncombustible core primarily of gypsum with paper surfacing [American Society for Testing and Materials, 2018]. The drywall damage data that are discussed in this document were collected from drywall that was made to lower standards than today's drywall.
- **Strain** is the change in length divided by original length. This ratio is the same as the change in displacement per unit distance [Dowding, 1996].
- **Natural Frequency** is the number of times per second that a structure will oscillate back and forth when excited [Dowding, 1985]. The natural frequency of a structure, f, can be approximated using the number of stories of a structure, N [Dowding, 1996]:

$$f = \frac{1}{0.1\ N} \tag{2-1}$$

  For example, a one-story structure will likely have a natural frequency of approximately 10 Hz.
- **Damping** is proportional to the rate at which a structure's natural vibration decays with time during free vibration [Dowding, 1985]. Damping is a structure's resistance to vibrations.
- **Damage** is classified by the USBM [Siskind et al., 1980] into the following categories:
  - Threshold Damage: "loosening of paint, small plaster cracks at joints between construction elements, and lengthening of old cracks."
  - Minor Damage: "loosening and falling of plaster: cracks in masonry around openings near partitions; hairline to 3-millimeter (mm) cracks (0–1/8 inch [in]); fall of loose mortar."
  - Major Damage: "cracks of several millimeters in walls, rupture of opening vaults, structural weakening, fall of masonry (e.g., chimneys), and load support ability affected."

  Threshold damage can also be defined as "the occurrence of cosmetic damage; that is, the most superficial interior cracking of the type that develops in all homes independent of blasting" [Siskind et al., 1980].

  Most damage concerns caused by blast vibrations focus on cosmetic cracking, which is considered threshold damage. Threshold damage is the most important level of damage because this level is the difference between nondamage and damage. These definitions are referenced throughout this report.

2.1.2 BUILDING MATERIAL FAILURE CHARACTERISTICS

During the RI 8507 study, the USBM evaluated failure characteristics of typical building materials. The materials of interest to the USBM were drywall (gypsum board), paint, wallpaper, and plaster wash because these are the weakest materials used when constructing a residential structure and typically the first materials to have noticeable cracking [Siskind et al., 1980].

2.1.2.1 DRYWALL AND PLASTER-ON-LATH

Drywall (gypsum wallboard) and plaster-on-lath were common interior wall coverings in the houses used in the RI 8507 study. The older homes that were studied by the USBM with plaster-on-lath interior walls were special cases because they were typically old, degraded structures at the time (late 1970s) with years of previous nonblasting damage to the structure [Dowding et al., 2018]. The USBM cited three previously published studies with wallboard and plaster-on-lath damage strain data. The USBM also conducted many tests as part of RI 8507.

Note that none of the studies that RESPEC reviewed stated how strain values were calculated. RESPEC's analysis assumes that all strains were calculated or measured accurately; however, RESPEC cannot confirm this assumption.

The USBM conducted their own tests on drywall failure, which included drywall with and without paper laminates; static and fatigue tests of plaster and drywall in both tensile and shear directions; and some prestrained, or preloaded, drywall tests [Siskind et al., 1980]. RI 8507 shows that drywall failure that was identified in laboratory tests can range from 340 to 1,200 microstrains (µin/in). In 1974, a study by Wiss and Nichols that is discussed in RI 8507, stated that 1,162 µin/in as a failure strain level for drywall, which falls within the range found by the USBM. The USBM attributes the wide range of failure levels to experimental setup, moisture differences, and methods of determining the strain. The USBM used this data, in part, to determine the safe vibration limits that discussed later in this chapter.

A later USBM study, RI 8896, highlights additional laboratory studies on wallboard and masonry walls by the USBM [Stagg et al., 1984]. The USBM observed cracking in the wallboard corner joints because, in general, the weakest component of drywall is the paper tape-plaster joint, not the drywall-board itself. Corner cracks were primarily caused by drying, shrinkage, and human activity. Wallboard cracking was limited to joint compound over nail heads for ground vibrations that ranged from approximately 1.8 to 2.2 in/sec.

2.1.2.2 MASONRY AND CONCRETE

Cracks in masonry and concrete are common occurrences in residential structures. The USBM cited three studies with threshold cracking of masonry and concrete [Siskind et al., 1980]. The three studies cited by RI 8507 showed that failure strains fall in a range from 30 to 375 µin/in in masonry. All of these measurements reportedly corresponded to particle velocities of 3.0 to 3.1 in/sec.

One of the three studies as discussed in RI 8507, which was published in 1965 by Crawford and Ward, showed that mortar joints have strain level concentrations, so strains on the joints can be 10 times those on blocks [Siskind et al., 1980], which is on reason why hairline cracking is first noticed at the interface of mortar and blocks. Monolithic concrete is much more resistant to cracking than concrete block and mortar [Siskind et al., 1980]. Monolithic concrete reportedly does not crack until particle velocities exceed 10 in/sec or strains exceed 100 µin/in [Siskind et al., 1980].

In 1984, the USBM published the results of a 2 year study (RI 8896) during which a full-scale contractor-built house was constructed on a surface coal mine property [Stagg et al., 1984]. The mine progressed toward the house, which allowed the USBM to study the house as the blasting operations moved close to the house. This study was a follow-up study to RI 8507. The USBM instrumented the house over the

2 year period to study the effect of fatigue on the house from repeated blasts. Masonry hairline cracks were primarily found at the interface of mortar and blocks, but the USBM found that visually identifying the start of cracks in masonry in the study was difficult [Stagg et al., 1984]. Additionally, initial inspections of the test structure in RI 8896 already showed shrinkage cracking at brick-and-mortar joints before blasting, so cracking at block joints naturally occurred because of natural events and settling. The study showed that natural events cause significant cracking; little evidence showed blast-induced cracking. The USBM found some blast vibration-induced cracking in masonry walls at mortar joints and bricks or concrete blocks at PPVs of approximately 3.4 and 6.2 in/sec. The USBM also observed a step-like diagonal crack in a basement concrete block wall that started at ground height; however, the USBM authors did not know if the crack existed before a series of four blasts (1.03 to 1.47 in/sec PPV) when the crack was found [Stagg et al., 1984]. Only one blast widened a crack beyond any naturally caused crack widening; that blast produced a 6.94 in/sec ground vibration, which is significantly higher than the vibration limits outlined in RI 8507.

More recently, Heath et al. [2016] studied the effect of blast vibrations on a scaled, single-room, brick veneer residential structure by using a shake table. The authors subjected the structure to 564 mechanically reproduced blast vibration events and increased peak velocity from 0.04 to 15.1 in/sec and frequencies that ranged from 3.8 to 22.3 Hz dominant frequencies. The lowest threshold damage, or the lowest differential movement (peak eave displacement to peak table displacement) before initiating the first visible cracking, occurred because of a 5.8 in/sec blast vibration, which was preceded by 347 vibration signals in the shake table. The lowest amplitude where crack initiation occurred was 5.0 in/sec, and the first recorded crack offset occurred at 5.8 in/sec. This study supports that brick veneer and similar materials can withstand significantly higher vibration amplitudes than old drywall and old plaster-on-lath or drywall.

2.1.2.3 FATIGUE

The USBM conducted a fatigue test of a scaled residential structure model in cooperation with the US Army Corps of Engineers for the RI 8507 study [Siskind et al., 1980]. The scale model was 8 foot (ft) × 8 ft square constructed out of 2 in × 4 in wood studs and gypsum wallboard on a 12 ft × 12 ft vibratory table. The test structure also had a built-in door and two windows. The USBM programmed a quarry blast vibration into the vibrating table to test the fatigue resistance of the model [Siskind et al., 1980]. The USBM used the horizontal (26 Hz dominant frequency) and vertical (30 Hz dominant frequency) vibrations from a quarry blast they recorded at a previous time. The USBM ran 666 tests at each of the following levels: 0.1, 0.5, 1.0, 2.0, 4.0, 8.0, and 16.0 in/sec.

The scale tests resulted in the first damage after six blast events at 4.0 in/sec PPV, which was after a total of 2,669 nondamage events. At 4.0 in/sec, drywall pulled away from the bottom plate of the vibratory table. Subsequently, six tests at 8.0 in/sec produced nail popping, and 66 events at 8.0 in/sec produced cracked corners. At 16 in/sec, the scale model showed cracks at the window openings.

The USBM noted that the results from the scale model test could not be related directly to a full-scale case because the excitation motions were not scaled [Siskind et al., 1980]. In other words, the natural frequency of the model was too high, relative to full-scale residential structures, to properly model the vibration levels that cause structural amplification of full-size residential structures.

After 2 years of blasting in RI 8896, the mine stopped blasting near the test house, so the USBM also outfitted the house with mechanical shakers to simulate a greater number of vibration cycles than what would be expected from blasting [Stagg et al., 1984]. The USBM vibrated the test house by using motors at strain levels in the house that were estimated to be equivalent to mining blasts at 0.5–2.0 in/sec at the structure's natural frequency, as shown in Table 2-1. The wallboard did not crack until 361,500 cycles (at the structural frequency) produced a hair-sized crack. A wallboard tape joint cracked at 56,000 cycles (at the structure's natural frequency), at a strain level equivalent to a mining blast at 0.5 in/sec, which the USBM estimated to be equivalent to 28 years of blasting twice a day.

Table 2-1. Summary of Report of Investigations 8896 Shaker Tests and Observed Damage [Stagg et al., 1984]

Test No.	Number of Cycles	Ground Vibration Equivalency Range (in/sec)[a]	Frequency (Hz)	Number of Cycles Cracking Identified[b]	Information[c]
1	100,192	0.44/0.61	7.2	56,000	Tape joint crack, joint compound crack over nail head, fireplace mortar joint crack extension
2	100,171	0.55/0.71	8.65	>108,500	Chimney trim broke loose, mortar joint crack
3	60,000	0.3/0.29[d]	7.0	229,500	Brick veneer mortar joint crack
				239,000	Four joint compound cracks over nail heads
4	60,070	0.73/0.49	6.45	293,500	Brick veneer mortar crack
				339,500	Cracks in joint compound over nail heads, basement block mortar joint crack extensions
5	36,240	1.1/0.53	5.9	>339,500	Brick veneer mortar falling out, basement block mortar joint crack extensions
				361,500	Crack in wallboard

(a) This number is an estimate that assumes that the initial calculation of the structure had an amplification factor of 3. The left ground vibration approximation is a high corner response (west wall accelerometer) and the right ground vibration approximation is the response over a doorway (Kaman displacement sensor mounted over a door near the center of the house).

(b) Cycles include blast vibrations and test sweeps of the structure that were used to identify the structure's natural frequency.

(c) Information is transposed; some detail has been redacted for readability.

(d) Four joint compound cracks occurred over nail heads at approximately 0.3 in/sec; however, this cracking was after 293,500 cycles at the structure's natural frequency. Blast vibrations would never cause a structure to vibrate at 0.3 in/sec at 293,5000 cycles at a structure's natural frequency or at 0.5 in/sec at 56,000 cycles at a structure's natural frequency. These tests show that blasting cannot create a scenario that could cause fatigue damage to a residential structure.

The USBM showed that vibrations would have to impact a structure over many cycles (approximately 56,000 cycles at the structure's natural frequency) at particle velocities of approximately 0.5 in/sec at a structure's natural frequency to potentially produce threshold damage. This scenario is significantly more impactful than a realistic environment. Additionally, the USBM studied the number of cracks and new cracks on a periodic basis during the RI 8896 study. In the RI 8896 study, the USBM also found that "the number of new cracks per week did not increase with time, indicating that blast vibrations do not cause fatigue-related damage." Therefore, the USBM proved that, in a realistic environment, blasting does not damage structures through fatigue.

2.1.3 SUMMARY OF STRUCTURAL DAMAGE AND MATERIAL FAILURE CHARACTERISTICS

Damage is defined in various ways, with threshold damage being the occurrence of cosmetic damage, such as small cracks and crack lengthening. This section shows that wallboard and plaster-on-lath are the weakest materials used in construction.

The USBM conducted tests on drywall and plaster-on-lath; however, most of the material that they tested was constructed differently than today's building materials. The USBM showed that drywall is the weakest at taped joints and on joint compound over nail heads. The USBM found that joint compound over nail heads could crack at approximately 1.8–2.0 in/sec.

Masonry and concrete are construction materials that are much stronger than drywall and plaster-on-lath. Masonry and concrete fail at higher levels of strain than drywall joint tape. Most cracks occur in brick and mortar along the joints at approximately 3.0 in/sec. Monolithic concrete is stronger and may start to crack because of blast vibration amplitudes of 10 in/sec.

Finally, residential structures are not susceptible to fatigue caused by blast vibrations. Blast vibrations would have to occur over long periods with many cycles of vibration at the natural frequency of residential structures to cause any sort of fatigue damage. Blast vibrations are complex waveforms that do not repeat cycles at a structural natural frequency; therefore, these vibrations do not cause fatigue. Also, all structures are damped, which dramatically affects structure response [Dowding, 1996].

The primary issue with the potentially damage-producing particle velocities listed in this section is that no information is available regarding how ground vibrations are translated into the residential structure and impact each individual building component. Therefore, the USBM used the RI 8507 data to evaluate how the amplitude and frequency of blast-induced ground vibrations affect residential structures.

The next section discusses the structural damage caused by nonblasting sources to provide a background of how construction practices, natural events, and human activity can affect structures. This document covers the USBM research that was used to study how blast-induced ground vibration amplitude and frequency impact residential structures.

2.2 EFFECT OF NONBLASTING SOURCES ON RESIDENTIAL STRUCTURES

Cracks in structures can occur because of various influencing nonblasting factors over time. The following list from RI 8896 [Stagg et al., 1984] quotes potential causes of cracking in structures:

1. *Differential thermal expansion*
2. *Structural overloading*
3. *Chemical changes to mortar, bricks, plaster, and stucco*
4. *Shrinkage and swelling of wood and wood-paper products*
5. *Fatigue and aging of wall coverings*
6. *Differential foundation settlement.*

Prestraining the materials can also influence the impact of the transient vibrations and affect material failure levels. Prestraining from static stresses includes any weight on the material, including unplanned

sources such as the impact of root systems, consolidation of soil, and differential foundation settlement [Stagg et al., 1984]. Additionally, any differential decay of materials caused by the environment could cause prestraining.

The following subsections describe nonblasting sources of structural damage. RESPEC grouped damage that is caused by nonblasting sources into the following categories: construction, natural events, and human activity.

2.2.1 CONSTRUCTION

Many crack-inducing factors to houses are related to design and construction. Oriard [1999] provides a suitable summary of construction factors that can cause cracking. Cracking can occur because of normal curing and aging of building materials, such as lumber warping and shrinkage during curing [Oriard, 1999]. Shrinkage caused by curing and aging can occur to lumber, concrete, plaster, stucco, blocks, bricks, mortar, and other materials [Oriard, 1999; Stagg et al., 1984]. High temperatures and humidity can accelerate the deterioration, shrinkage, and swelling of materials, which increase the chance of cracking. Site preparation, inadequate building foundation design, or building on fill can also cause cracking.

Apart from construction practices, certain locations within a residential structure can have concentrated stresses because of the physics of a static structure. For example, stress can concentrate in corners, such as window and door openings. Corners are likely areas to find cracks, regardless of the cause [Crum, 1997].

2.2.2 NATURAL EVENTS

All homes are cracked from natural events [Siskind et al., 1980]. Cracks expand on an hourly basis from natural causes, including temperature and humidity changes, wind, and groundwater and soil settlement. For example, weather (e.g., temperature, humidity, and wind) can cause internal strains equivalent to 0.5 in/sec [Siskind et al., 1993]. In general, weather or environmentally induced displacements can be over 10 times the displacements caused by large blast-induced displacements [Dowding and Lucole, 1988]. Natural events can also affect homes by the normal curing and aging of building materials, effects of site preparation, building foundations, external water, and quality of materials and workmanship as discussed previously in Section 2.2.1 [Oriard, 1999].

Oriard [1999] dedicated half of his textbook to the effects of environmental forces on structures. Typical environmental forces that affect structures include changes in moisture content, temperature changes and thermal shock, daily weather cycles, and extended periods of dry or wet weather. All of these environmental factors can also affect moisture content in soils. Siskind et al. [1980] state that "Soil moisture changes are notorious for causing foundation cracks." Additionally, certain clay soils can shrink or swell as a function of changes to water content [Holtz and Kovacs, 2010].

Table 2-2 shows the maximum strains caused by natural events [Stagg et al., 1984] and compares those strains to the corresponding blast vibration level. Natural changes include cyclic changes in temperature, humidity, and wind. These data were taken during limited blasting activity on the USBM test structure during the RI 8896 study. The corresponding blast vibration levels were taken from a

strain-versus-ground particle velocity envelope that was created by using empirical data. The corresponding ground vibration levels are the worst-case predictions based on the strain-producing ground vibrations. The table shows that daily environmental changes can have the same effect as blast vibrations from 1.2 to 3.0 in/sec.

Table 2-2. Comparison of Strain Levels by Daily Environmental Changes, Household Activities, and Blasting [Stagg et al., 1984]

Loading phenomena	Site[1]	Induced strain, µin/in	Corresponding blast vibration level,[2] in/s
Daily environmental changes.	K_1	149	1.2
	K_2	385	3.0

Another study reviewed the response of cracks in a southern Florida residence to natural events, weather, and blasting [Kosnik, 2009]. Kosnik [2009] collected data during 2007 and showed that the maximum frontal effect, which is "the absolute value of the difference between peak 24 hour central moving average values and the 30 day central moving averages," and maximum daily effect of weather have significantly higher crack response than human activities and blast-induced ground motion. These data are further illustrated in Figure 2-1.

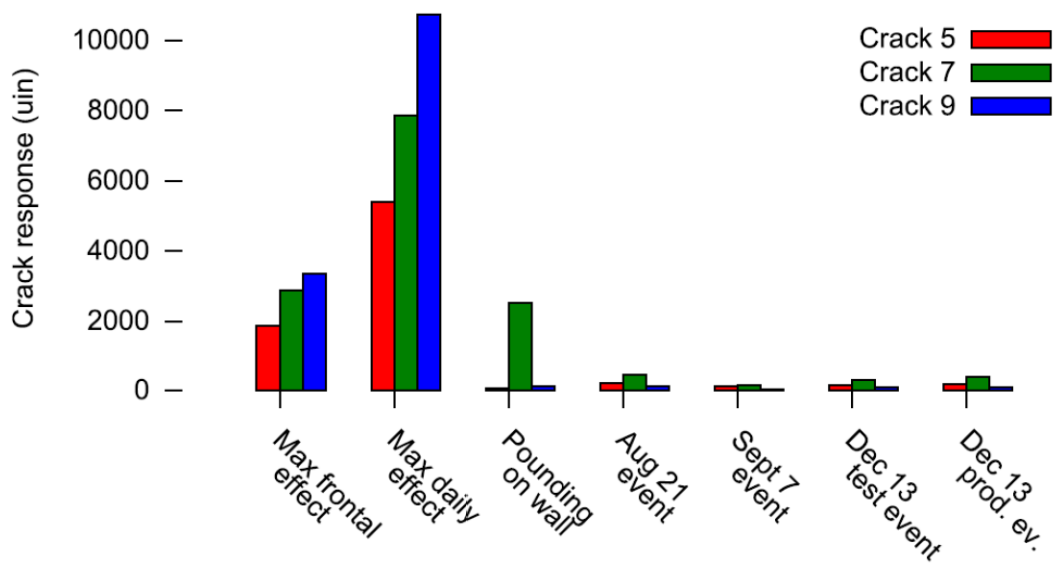

Figure 2-1. Comparison of Crack Responses Caused by Weather Effects, Human Activities, and Blast Vibrations [Kosnik, 2009].

Temperature changes caused crack responses of over 10,000 µin. The August 21 event (0.087 in/sec PPV, 456 µin crack response) was the largest blast vibration-induced crack response (nondamage) recorded during the study, while the September 7 event (0.037 in/sec PPV, 456 µin max crack response) represents a more typical blast vibration event (nondamage). This study was conducted in Florida and supports Dowding and Lucole [1998] in that displacement caused by seasonal changes of temperature and humidity are at least 10 times the displacement caused by blast vibrations in the range of blast vibration amplitudes recorded by Kosnik [2009]. The maximum daily effect of the crack response shown in Figure 2-1 is over 20 times the crack response caused by the highest recorded blast-induced crack response.

All houses in Florida are subject to many adverse environmental conditions caused by natural events, such as hurricanes and sun exposure, that can create heavy wind, rain, and heat. These events only accelerate the aging of the residential structures.

2.2.3 HUMAN ACTIVITY

Everyday human activity causes a significant amount of vibration to residential structures [Siskind et al., 1980]. The USBM published tables in RI 8507 that compared mining blast vibration strains to strains caused by human activity in various stress concentration locations of residential structures. The USBM also compared blast vibration PPVs that were caused by mining to those caused by human activity in various stress concentration locations of residential structures. Tables 2-3 and 2-4 are examples of these comparisons from RI 8507.

Table 2-3. Strains in Test Residential Structure From Blasting and Human Activity [Siskind et al., 1980]

Strain locations	Maximum structure strains, µin/in						
	Mine blasts	Jumps	Heel drops	Door slams: Entrance	Door slams: Sliding glass	Nail pounding	Walking
Over sliding glass door	[1]22,[2]15	24	9.2	13	22	21	Low
Over south window in master bedroom	[3]18	42	20	12	19	9.3	9.1
Over large doorway in living room	[4]24,[3]11	17	6.1	8.3	6.2	28	Low
Over picture window	[4]33	17	11	21	3.6	32	3.2
Over entrance door	[4]36,[3]43	13	5.8	140	Low	Low	Low

[1] From peak ground vibration of 0.300 in/sec, 129 dB airblast.
[2] From peak ground vibration of 0.210 in/sec, 124 dB airblast.
[3] From peak ground vibration of 0.290 in/sec, 124 dB airblast.
[4] From peak ground vibration of 0.470 in/sec, ~~117~~ dB airblast. 119
[5] From peak ground vibration of 0.320 in/sec, 125 dB airblast.

Table 2-4. Structure Vibrations in Test Residential Structure From Blasting and Human Activity [Siskind et al., 1980]

Vibration location	Mine blasts	Maximum structure vibrations, in/sec					
		Jumps	Heel drops	Door slams: Entrance	Door slams: Sliding glass	Nail hammering	Walking
NW corner, low horizontal living room	[1]~~0.472~~, 377 [2].483	0.190	0.055	0.220	0.110	0.100	0.056
NW corner, low vertical living room	—	.200	.069	.120	.041	.180	.180
NW corner, high horizontal living room	[1].316 [2].345	.170	.037	.260	.100	.064	.054
SE corner, low horizontal master bedroom	[5].227 [4].222	.310	.139	.182	.164	.508	.157
SE corner, low vertical master bedroom	[5]~~.392~~, .314 [3].194	.286	.133	.121	.029	.118	.126
Midsouth wall, master bedroom	[5].508 [4].700	1.44	.783	1.29	.136	.241	.225
Mideast wall, master bedroom	—	2.63	1.42	.934	.111	3.81	.285
Midwest wall, living room	[1].964 [2]1.37	1.00	.486	1.05	.124	.365	.086
Midfloor, [redacted] room	—	5.58	4.08	1.25	.031	.063	1.49
Midfloor, living room	[1]1.18 [2].85	10.1	5.84	.453	.272	.067	.286

[1] From peak ground vibration of 0.470 in/sec, ~~117~~ dB airblast. 119
[2] From peak ground vibration of 0.320 in/sec, 125 dB airblast.
[3] From peak ground vibration of 0.210 in/sec, 124 dB airblast.
[4] From peak ground vibration of 0.300 in/sec, 129 dB airblast.
[5] From peak ground vibration of 0.290 in/sec, 124 dB airblast.

As shown in Table 2-3, induced strains from blast vibrations on the structures ranged from 11 to 43 µin/in. The blast-induced ground vibration PPVs ranged from 0.21 to 0.47 in/sec. Comparatively, human-induced responses caused strains that ranged from 3.2 µin/in and lower to 140 µin/in. Door slamming, jumping, and nail pounding produced the highest strains, which, in these cases, were sometimes significantly higher than the strains induced by the mine blasting.

In Table 2-4, those same blasts caused structural vibrations that ranged from 0.85 to 1.37 in/sec. Human-induced responses caused PPVs that ranged from 0.03 to 10.1 in/sec. Not including midfloors (which are not representative of whole structure response), the maximum structural vibrations were

3.81 in/sec (caused by nail hammering). Jumping, door slamming, and nail hammering produced the highest maximum structure vibrations; however, low-impact events, such as walking, still caused significant structural vibrations.

The USBM confirmed that household activities can induce strains in residential structures of up to nearly 1 in/sec-equivalent during the RI 8896 study, which showed that household activities can range from 0.03 to 0.88 in/sec, as seen in Table 2-5 [Stagg et al., 1984]. Other reports also suggest that everyday human activities such as door closing and walking can cause internal strains equivalent to 0.5 in/sec (RI 9455 and RI 8896). For example, a front door slam could produce significant strains over the entire residence (RI 8507).

Table 2-5. Comparison of Strain Levels by Daily Environmental Changes, Household Activities, and Blasting [Stagg et al., 1984]

Loading phenomena	Site[1]	Induced strain, μin/in	Corresponding blast vibration level,[2] in/s
Household activities:			
Walking.....	S_2	9.1	.03
Heel drop.....	S_2	20.0	.03
Jumping.....	S_2	37.3	.28
Door slam.....	S_1	48.8	.50
Pounding a nail....	S_{12}	88.7	.88

[1]From figure 13.
[2]Based on envelope line of strain versus ground vibration plot.

2.2.4 SUMMARY OF EFFECT OF NONBLASTING SOURCES ON RESIDENTIAL STRUCTURES

The USBM and other authors have shown that many factors affect residential structures, including construction, natural events, and human activity. In most cases, nonblasting events cause significantly more strain on residential structures than typical blast events.

Construction practices can affect residential structures by causing prestraining, which affects the integrity of the structure. Aging can cause shrinkage in many construction materials that are used today, including lumber, concrete, plaster, stucco, blocks, bricks, mortar, and other materials. Additionally, building a residential structure to code does not prevent cracking because all structures crack over time from the curing of materials and settlement.

Natural events can cause significant strains in residential structures through daily and monthly fluctuations in factors such as temperature, humidity, and soil moisture. Multiple studies have shown that natural events can have over 10 times the impact on residential structures as typical blast vibrations. Daily environmental changes can affect cracks equal to or more than blast vibrations of 1.2–3.0 in/sec. Human activity is also a significant cause of transient strains to residential structures. Household activities can cause equivalent PPVs in the structure of up to 3.81 in/sec.

The studies discussed in this section show that any residential structure will undergo significant strains on a daily basis. Daily strains, which can be caused by human activity and natural events, can cause equivalent strains to blast vibrations over 3.0 in/sec.

2.3 EFFECT OF BLAST VIBRATIONS ON RESIDENTIAL SOURCES

The USBM developed RI 8507 to address the effects of blast vibrations on residential structure response and damage with an equal focus on both PPV and frequency. Before RI 8507, no scientifically based studies reviewed acceptable blast vibration levels with respect to both the amplitude and frequency of blast vibrations. The mining industry needed recommendations from the USBM to guide regulators [Siskind, 1981]. This section describes the effects of blast vibrations on residential structures, which were only starting to be understood after the conclusion of the USBM's work for RI 8507.

2.3.1 REPORT OF INVESTIGATIONS 8507 TEST STRUCTURES

The USBM studied and measured vibrations that impacted 76 residential structures during 219 production blasts [Siskind et al., 1980]. All but five structures were single-family houses. One of the five nonsingle-family houses was a mobile home. The remaining four were one- or two-story structures that were slightly larger than single-family residences.

After the USBM's study concluded, 14 of the 76 residences that were studied by the USBM had high enough ground vibration amplitudes from multiple blast events to produce significant amounts of damage data and nondamage data. The volume of damage and nondamage data provided the USBM with enough statistically relevant data to have confidence in their results [Siskind et al., 1980].

The test structures' characteristics are as follows:

- Dimensions
  - The structures were one to two stories tall and ranged from 12 to 30 ft in height.
  - The floor area ranged from 150 square feet (ft^2) to 8,600 ft^2 and averaged 1,600 ft^2.
- Superstructure
  - A total of 68 of the structures (or 89 percent) that were studied had a wood-frame superstructure.
  - Seven of the remaining eight structures were brick and concrete block superstructure.
  - One superstructure was steel.
- Exterior Covering
  - Exteriors included a range of various types of covering.
  - These types included wood, stone, brick, asbestos, asphalt, stucco, steel, aluminum, and derivations of these materials.
- Interior Covering
  - Interior coverings were typically gypsum wallboard or plaster-on-lath.
  - A total of 53 of the structures had wallboard or a combination with wallboard.
  - Fifteen of the structures had plaster-on-lath or a combination with plaster-on-lath.
  - Two of the houses were counted above in both categories (wallboard and plaster-on-lath).
  - The rest of the houses were mostly interior paneling.

- Foundation
  - Foundations were concrete slab, full or partial basements, crawl space, or footings.
- Age
  - Most houses were older, wood-frame (stick-built) structures that had been in existence and occupied for many years.

Siskind et al. [1980] states:

> *All the responses discussed in this paper are applicable to residential-type structures with wood frame superstructures. The values do not apply to multistory steel frame structures or large structures with masonry load-supporting walls. The natural frequencies of vibration of these structures could be considerably lower than the 4 to 24 Hz range for residences and their midwalls.*

This statement was made in RI 8507 because engineered structures consist of materials that are stronger than those used to build residential houses. Engineered structures were likely to be built with beams and columns with concrete masonry units (CMUs) or brick infill and have different response characteristics [Dowding et al., 2018]. The RI 8507 results are overly conservative for engineered structures.

2.3.2 DATA COLLECTED UNDER REPORT OF INVESTIGATIONS 8507

Outside of the residential structures, the USBM measured ground vibrations and air overpressure levels [Siskind et al., 1980]. Inside the residences, the USBM calculated midwall and corner-of-wall responses for every blast they measured. The following typical instrumentation setup for each residential structure included [Siskind et al., 1980]:

- Ground vibration measurement
  - Ground vibration was measured by using three orthogonal, 2.5 Hz velocity gauges.
  - The sensors were buried approximately 12 inches (in) in the soil next to the residential structures' foundations.
  - Airblast was also measured, but airblast is outside of the scope of this study.
- Structural vibration measurement
  - Two gauges were mounted on first-floor vertical walls in the corner closest to the direction of the blast to measure horizontal motions. These sensors measured the whole-structure response.
  - Typically, a third gauge was placed in the same corner to measure vertical motion.
  - One or more gauges were placed on midwalls of the residential structures.
  - If possible, additional gauges were placed in the residential structures.

Note that the authors of RI 8507 do not detail each type of sensor that was used inside the residential structures (Appendix A).

2.3.2.1 STRUCTURAL RESPONSE

The USBM measured structural response from blasting vibrations with two varieties of monitoring locations, as illustrated in Figure 2-2. One location measured the midwall response, which is primarily responsible for window rattling and any movement of small knick-knacks [Siskind et al., 1980]. The midwall response is typically a bending motion, which does not primarily induce cracking. Midwall response can also be caused by airblast.

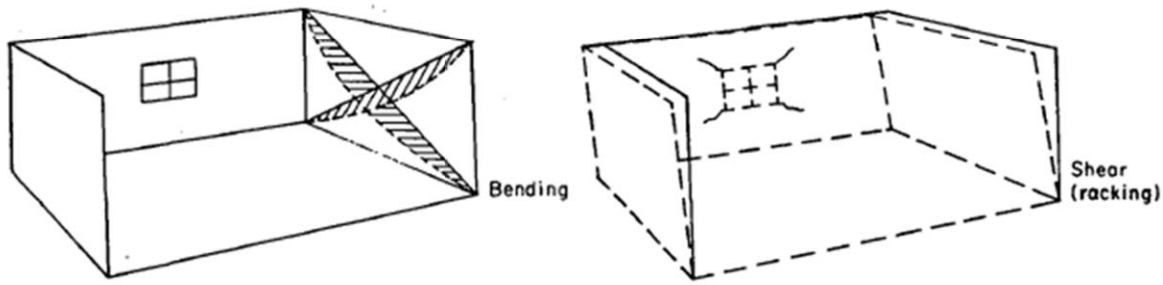

Figure 2-2. Depiction of Structural Response to Blast Vibrations [Siskind et al., 1980]. The left image shows the midwall response, while the right shows the whole-structure response.

The second location that was measured by the USBM was on wall corners because wall corners were assumed to correspond to whole-structure response [Siskind et al., 1980]. The whole-structure response is responsible for structural damage because cracking occurs in the corners and within the planes of the walls where excessive stresses and strains are produced. Tensile strains are produced by shearing instead of bending. Shearing would be caused by whole-structure response (racking) rather than bending. Whole structure responses should be measured to characterize potential structural damage that is caused by blast vibrations.

Two important structural response characteristics include: natural frequency and damping [Siskind et al., 1980]. Natural frequency is the frequency at which the structure amplifies excitation motions the most. Natural frequency is proportional to stiffness per unit mass [Siskind, 2000]. Damping is the structure's resistance to vibrations and causes the motion of residential structures to die down or decay.

The blast vibration data and structural damage data that were collected during the RI 8507 study show that typical residential structures have structural natural frequencies that range from 4 to 12 Hz; this range is shown in Figure 2-3 [Siskind et al., 1980]. Individual midwalls have structural natural frequencies from 10 to 25 Hz. In the 4–12 Hz range, single-story structures tend to have natural frequencies closer to 10 Hz, while two-story structures tend to have natural frequencies closer to 5 Hz (Equation 2-1).

Note that part of the challenge of calculating frequencies results from the difficulty of determining the dominant frequency, as described in Dowding [1996]. Frequency can be determined by the zero-crossing (ZC) frequency, the peak (±70 percent of the peak frequency) of the Fourier frequency of the full wave form, or the peak of the response spectrum [Dowding et al., 2018]. The measurements of frequency can produce variable results (each method is not exact), but the USBM used the ZC method to determine frequencies [Dowding et al., 2018].

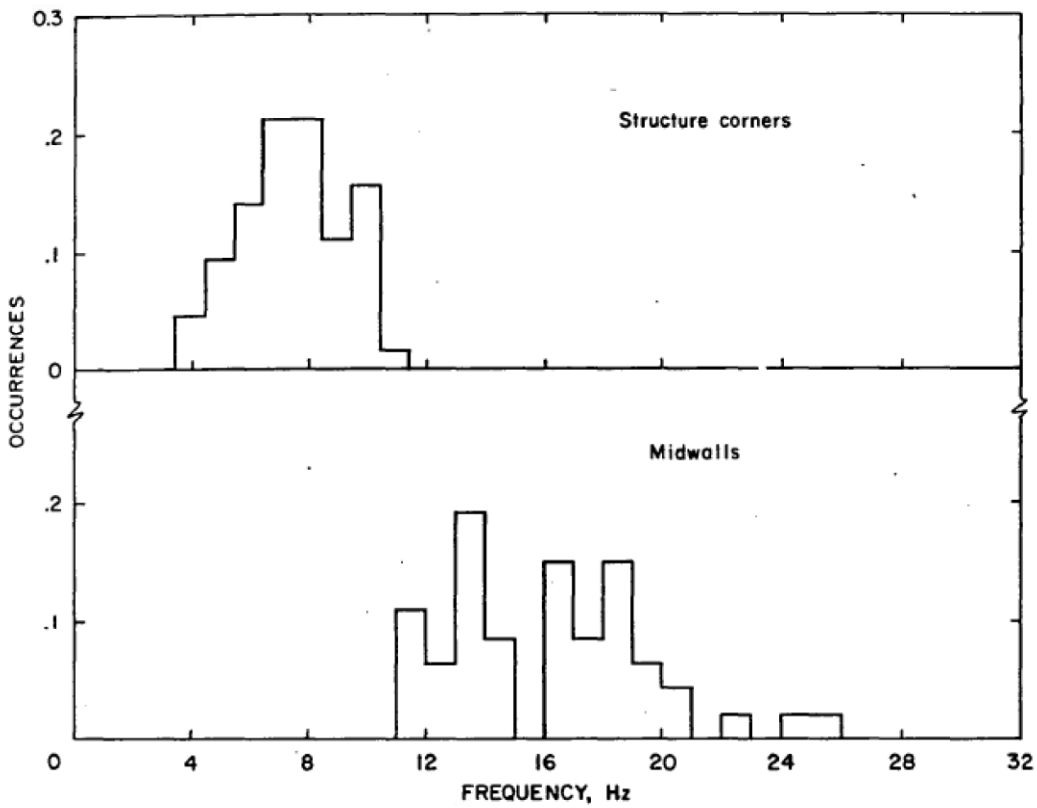

Figure 2-3. Residential Structure Natural Frequencies Measured From Corner Motions [Siskind et al., 1980].

2.3.2.2 AMPLIFICATION FACTOR

Residential structures amplify blast vibrations if the blast-induced ground vibration frequencies fall within the natural frequency range of residential structures (4–12 Hz) [Siskind et al., 1980]. Outside of the natural frequency range of residential structures (both above and below the 4–12 Hz range), residential structures typically have an approximate amplification factor of unity (ground vibration and structural response nearly equal or equal). The amplification factor-structural natural frequency relationship is discussed later in this document.

Residential structure movement, relative to input ground vibration, is described by using amplification factors. The amplification factor is the ratio of the PPV of the structure to the corresponding particle velocity peak of the ground vibration at the base of the structure at the same moment in time or immediately preceding the peak structural vibration; Figure 2-4 demonstrates this ratio. The ground velocity at the same moment in time as the maximum structure response is referred to as the driving ground vibration. The amplification factor is not the ratio of the PPV of the wall to the PPV of the ground.

The USBM found that structures have different amplification factors depending on the ground-vibration frequencies [Siskind et al., 1980]:

- Below 40–45 Hz
  - Whole structure (shown in Figure 2-5)
    - Whole structures typically respond with PPVs at 1.5 times the driving ground vibration particle velocity.

- Whole-structure maximum PPV response values were up to 4 times the driving ground vibration particle velocities between 5 and 12 Hz. This range corresponds to the natural frequencies measured at 4–12 Hz.

» Midwalls (as seen in Figure 2-6)

- Typically, midwalls respond at 4 times the ground vibrations in the natural frequency range.
- Maximum response values were up to 8 times the ground vibrations.

/ Above 40–45 Hz

» Whole-structure and midwall data showed that structural response was less than unity, or less than the ground vibrations (Figures 2-5 and 2-6).

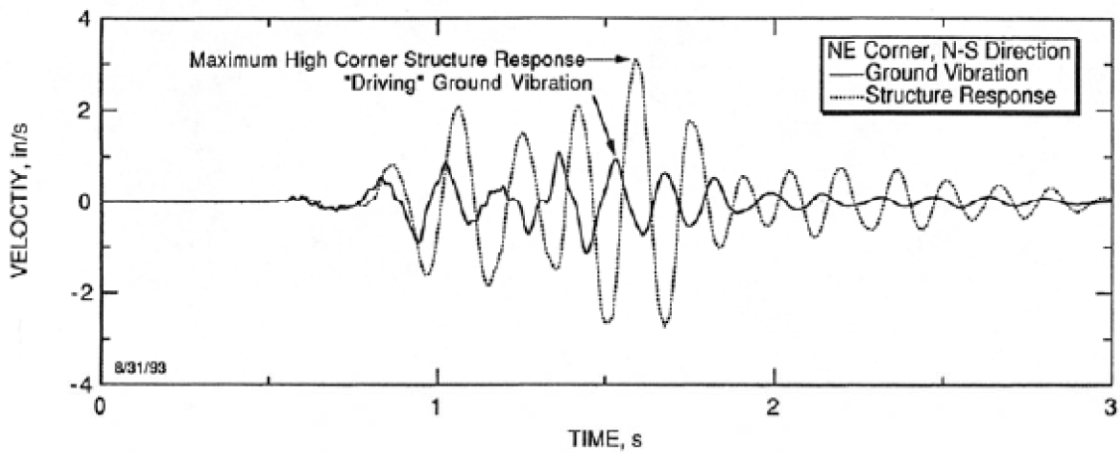

Figure 2-4. Ground Vibration and Structure Response. This figure is an example of how amplification is calculated by the ratio of peak structure corner response to corresponding driving ground vibration [Crum, 1997].

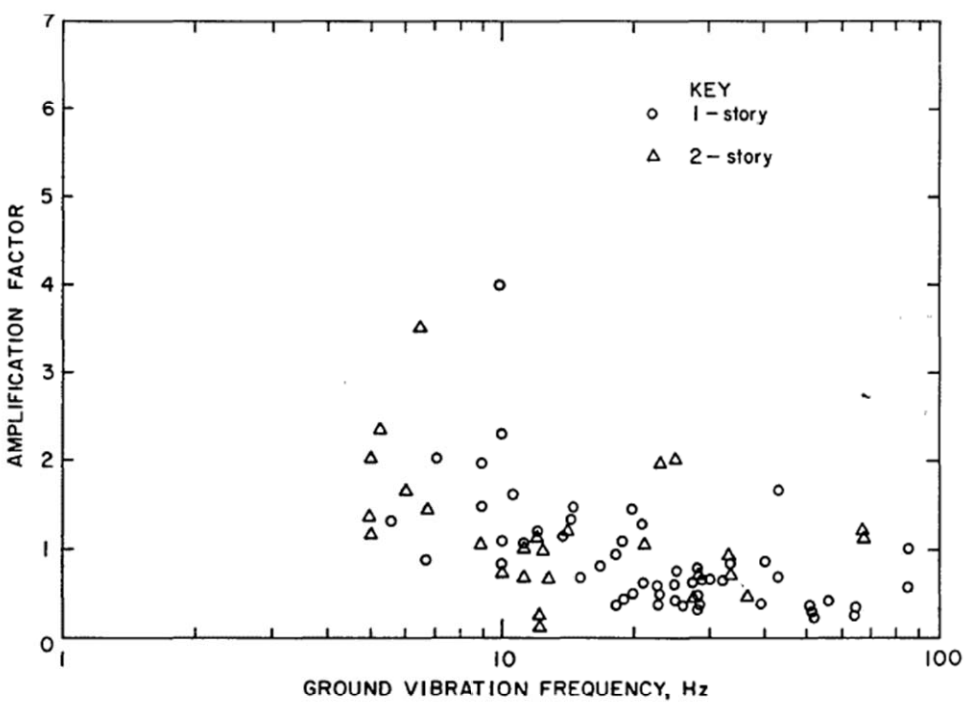

Figure 2-5. Amplification Factors for Blast Vibration-Induced, Whole-Structure Vibration [Siskind et al., 1980].

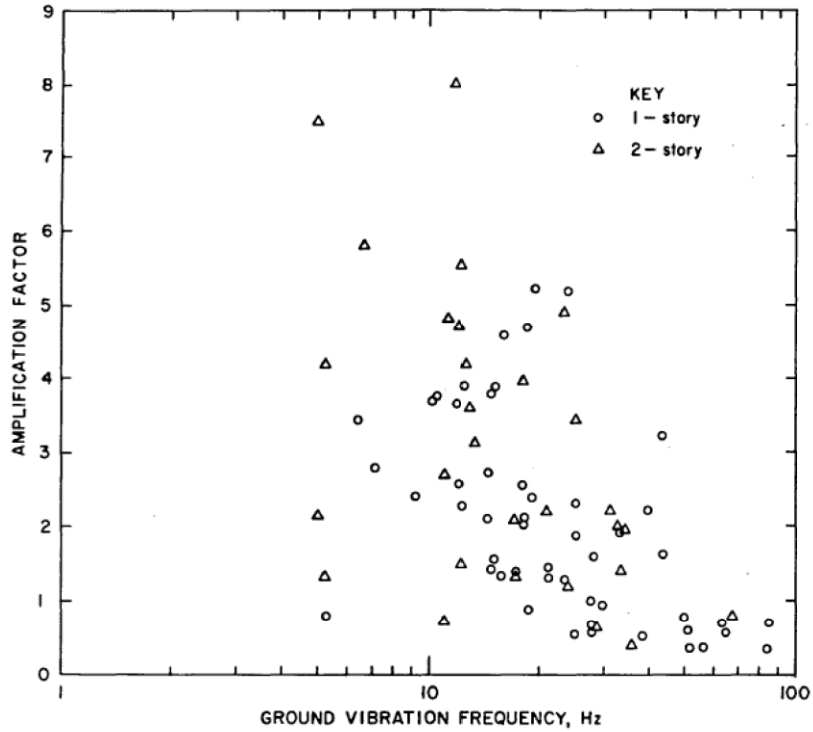

Figure 2-6. Amplification Factors for Blast Vibration-Induced Midwall Vibration [Siskind et al., 1980].

The USBM used this analysis to prove that ground vibration frequency is just as important to consider as ground vibration particle velocity. The results led the USBM to study the effects of vibrations above and below 40 Hz separately. Note that ground motions with significant energy lower than 4–5 Hz were not recorded in the study.

2.3.2.3 REPORT OF INVESTIGATIONS 8507 DAMAGE DATA

The USBM used data sourced from nine previous studies plus field research that the USBM completed as part of the RI 8507 work [Siskind et al., 1980]. The USBM collected data that ranged in frequencies from 1.5 to 420 Hz. Nondamage vibration events and threshold, minor, and major vibration-caused damage events were noted in drywall, plaster-on-lath, masonry, bricks, and stone walls. Basements and one- and two-story structures were studied. The geology of the studies ranged from rock to glacial till and soft wet sand and clay. Instrumentation included displacement, acceleration, and velocity gauges in the ten studies (Appendix A).

Note that the USBM states in RI 8506 [Stagg and Engler, 1980], a study that was published at the same time as RI 8507 and used data recorded during the RI 8507 study, that:

> *The values that occurred below 2 Hz could not be quantified because of instrument limitations, but they were present nonetheless. Frequency values below 2 Hz occurred for shots that were measured at a long distance and had thick overburden. Additional research is needed to quantify this low-frequency energy and to determine its effects.*

Additionally, "blast vibration energy below 2 Hz were present, but amount and significance were indeterminate because of limitations in measurement and analysis systems" [Stagg and Engler, 1980].

These statements refer to data collected by the USBM at the time that the RI 8507 study was completed; however, RI 8506 does not specifically mention that these statements apply to the data that the USBM collected and analyzed in the RI 8507 study.

RI 8507 used available blast vibration data; the USBM avoided analyzing earthquake vibration data and other data with vibrations that have much lower and longer durations than blast vibrations because the authors only wanted to evaluate blasting vibrations [Siskind et al., 1980]. Table 2-6 provides a summary of the observations used in RI 8507.

Table 2-6. Report of Investigations 8507 Nondamage and Damage Observation Count

Type Observation	Number of Shots	Nondamage Observations	Threshold Damage Observations	Minor Damage Observations	Major Damage Observations	Total Damage Observations	Total Nondamage and Damage Observations
Blast	555	261	71	65	37	173	434
Shaker Table	163	103	26	34	0	60	163
Total	718	364	97	99	37	233	597

Figure 2-7 shows the threshold damage and minor damage observations collected by the USBM in their study during the RI 8507 work. The threshold damage events occurred at low particle velocities in four residential structures (Figure 2-7). Three of those residences (19, 27, and 51) had threshold damage to interior walls constructed with plaster-on-lath. The fourth residence, Residence 20, was a more recently constructed (at the time), single-story home with drywall. Only threshold damage (minor superficial crack extensions) was observed in Residence 20. The threshold damage occurred at a PPV of 0.79 in/sec, which is the lowest level cracking that was observed in drywall by the USBM.

Note that many more observations of noncracking events were made at levels greater than 2.0 in/sec. Observations of nondamaging events included events with measured particle velocities of approximately 0.2 in/sec up to approximately 2.0 in/sec at frequency ranges of approximately 6 Hz to approximately 70 Hz.

2.3.3 VIBRATION ANALYSES AND LIMITS

The vibration limits that were determined in RI 8507 were created by using statistical evaluation from the ten studies described in RI 8507, including the RI 8507 research [Siskind et al., 1980]. The study essentially split data into two groups: data below 40 Hz and data above 40 Hz.

The USBM split the data into various sets to conduct statistical analyses. The following datasets were defined by using the sources of the data:

1. The first two sets included low-frequency data in glacial till soil and wallpaper left on walls. This data showed no damage below 3 in/sec. The data also show a 2 percent or less probability of damage below 2 in/sec, which means that a near-zero chance of threshold structural damage at ground vibrations below 2 in/sec exists.
2. Set Five used the same data as Set Four but also included masonry damage data from a 1962 study by A. Dvorak, which were highly suspect [Siskind et al., 1980].

a. The RI 8507 authors essentially dismissed all of the Dvorak data because Dvorak did not publish much of his actual data, original time histories were lost, and old instrumentation likely resulted in poor data quality that showed in implausibly low levels of observed threshold damage.

b. The dataset includes the anomalous data point from the old USBM shaker test described above. Not counting the anomalous data point, the lower limit of threshold damage in this dataset is 0.51 in/sec, which is highly suspect data.

c. Set 5 had a 5 percent damage probability of 0.53 in/sec. The 5 percent probability should be higher because of the anomalous data point and because the validity of the Dvorak data is highly suspect.

3. The sixth dataset was high-frequency data. The lowest damage point observed was 2.2 in/sec. This set had a 5 percent probability of 3.2 in/sec.

4. The seventh dataset was an overall summary of all of the damage data.

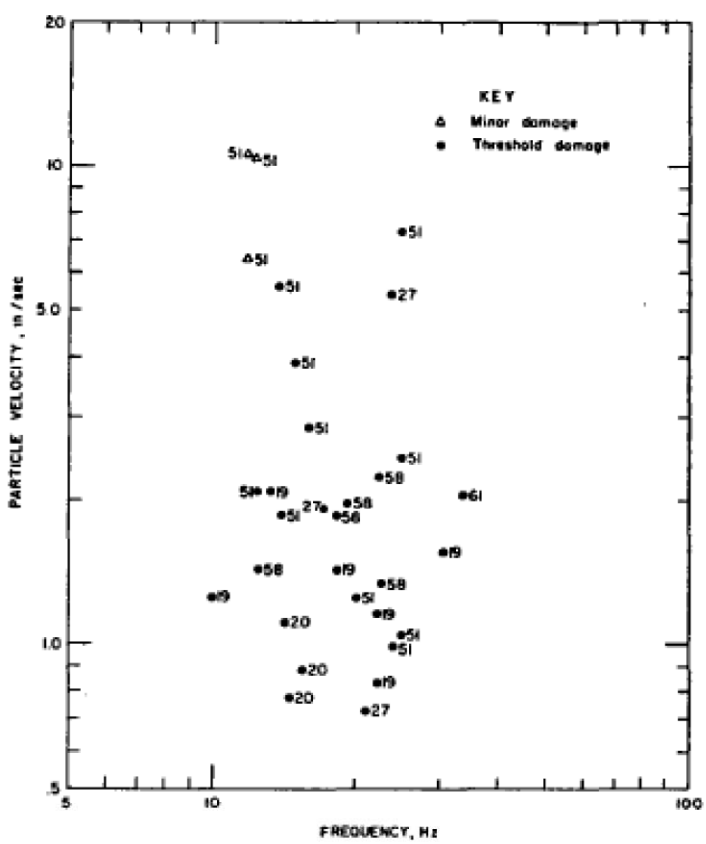

Figure 2-7. Damage Observations Collected During the Report of Investigations 8507 Study From Production Blasting in Surface Mines [Siskind et al., 1980].

Note that the anomalous shaker test from old USBM shaker tests produced a damage observation at a 0.31 in/sec-equivalent amplitude at 40 Hz. This measurement came from old shaker tests reported in USBM Bulletin 442 [Thoenen and Windes, 1942] that only approximated PPV without providing the methods that the authors used to calculate the approximate PPV. The RI 8507 authors stated that this

data point was anomalous and highly suspect, and no scientifically supported reason exists to base any regulation on this data point, because of the following points:

1. This point was a shaker test rather than a full-scale test and was the only damage point that the USBM observed close to that low particle velocity amplitude.
2. This damage observation occurred at 40 Hz, which is outside of the residential structure natural frequency range of 4–12 Hz. Residential structures will not amplify a vibration at 40 Hz. Damage would have to occur at a much higher vibration (over 2 in/sec) at 40 Hz to cause damage.
3. The damage point is significantly below the 95 percent probability of threshold damage of Set 5 (at 0.53 in/sec) [Siskind, 1981]. As described early in Section 2.3.3., the 0.53 in/sec limit is already artificially low because of the inclusion of Dvorak's high suspect data.
4. The threshold damage data below the 95 percent probability "roll off" at 0.5 in/sec; in other words, a limit of damage appears to be at approximately 0.5 in/sec, regardless of frequency (refer to Figures 56 and 57 in RI 8507).
5. The shakers were attached to the test structure's walls, and the PPV values were those of the wall itself, which means that the shaker test results are likely caused by an imperfect replication of the full-structure excitation of real mine blasts, such as those recorded during the RI 8507 tests.

Overall, the high-frequency data had low amounts of scatter [Siskind et al., 1980]. The low-frequency plots had a higher amount of scatter, partly because they occur in the structural frequency range and all structures have slightly different natural frequencies within a typical range of 4–12 Hz and partly because of the questionable validity of the old data that the RI 8507 authors used in their analyses. Despite the variability in the low frequency data (under 40 Hz), the USBM decided to use the probability analysis results (5 percent probability) and the lowest threshold damage observations to determine safe blasting levels [Siskind et al., 1980].

Note that the 5 percent probability of threshold cracking at a PPV of 0.5 in/sec is a calculated value. An extension of this mathematical conclusion (that threshold cracking occurs some percentage [below 5 percent] at lower values) is also a mathematical conclusion; threshold cracking at particle velocities below 0.5 in/sec has not been observed. The reason for this cracking was believed to be the natural and cultural stresses that affect homes and correspond to vibrations of approximately 0.5 in/sec and over 1.2 in/sec in some cases. Essentially, every home has cracking because the homes responded to causes of stress, including thermal cycles, humidity, material aging and shrinking, frost, soil expansion and shrinkage, slope creep, settlement, human activities, wind, and construction deficiencies [Siskind, 2000].

2.3.4 REPORT OF INVESTIGATIONS 8507 LIMITS AND ALTERNATIVE BLASTING LEVEL CRITERIA

Because of the vibration analyses, the USBM identified three vibration limit levels, based on frequency [Siskind et al., 1980]:

- The USBM adopted 0.5 in/sec from the low-frequency fifth dataset (and overall data), which assumes a 5 percent probability of superficial cracking below 0.5 in/sec, which is lower than the lowest level of observed blast vibration damage cases. The majority of the low-level damage was caused by old plaster-on-lath cracking in older structures.

- Two studies examined drywall damage from blasting, and one of those was the research that the USBM conducted while studying blasting vibrations for RI 8507. The lowest vibration level that corresponded to minor crack extensions was 0.79 in/sec. Many nondamaged observations were made at vibrations of over 2.0 in/sec for drywall construction as well. Therefore, the USBM suggested using 0.75 in/sec as the safe level criterion for modern construction rather than 0.5 in/sec or anything lower.
- The USBM justifies that 2.0 in/sec was still a safe level for high-frequency (over 40 Hz) blasts; although, the corresponding 5 percent probability value was 3.2 in/sec. The USBM decided to choose 2.0 in/sec because damage at 2.2 in/sec in the over 40 Hz frequency range was observed once.

Table 2-7 summarizes the three points listed above and provides the first safe level criteria developed by the USBM for RI 8507.

Table 2-7. Report of Investigations 8507 Safe Levels of Blasting Vibrations for Residential-Type Structures [Siskind et al., 1980]

Type of structure	Ground vibration—peak particle velocity, in/sec	
	At low frequency[1] (<40 Hz)	At high frequency (≥40 Hz)
Modern homes, Drywall interiors	0.75	2.0
Older homes, plaster on wood lath construction for interior walls	.50	2.0

[1] All spectral peaks within 6 dB (50 pct) amplitude of the predominant frequency must be analyzed.

Note that the USBM later confirmed these limits in RI 8896, which showed that the first corner crack extensions appeared after one blast event in this study that had 0.88 in/sec PPV [Stagg et al., 1984].

The USBM also developed an alternative blasting level criteria (ABLC) that combined the particle velocity limits shown in Table 2-7 and displacement limits (Figure 2-8). The ABLC decreases particle velocity limits at frequencies lower than 4 Hz with a constant displacement of 0.03 in. Between 14 and 40 Hz, the ABLC gradually increases the particle velocity limit at a constant displacement of 0.008 in. In Figure 2-9, RESPEC plotted the Table 2-5 safe levels (blue lines in the figure) on the ABLC. This figure illustrates the differences between the initial blasting level criteria and the ABLC.

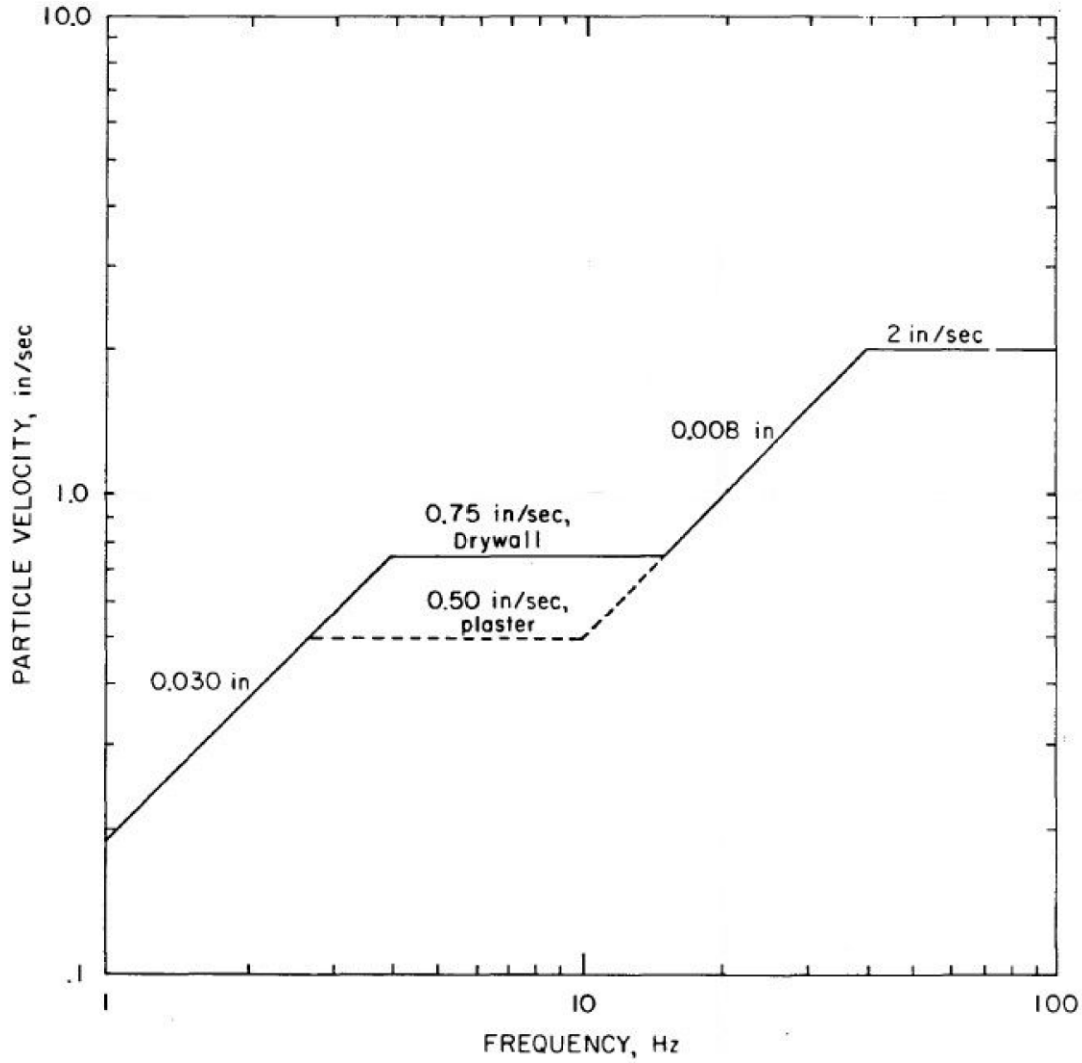

Figure 2-8. Alternative Blasting Level Criteria [Siskind et al., 1980].

The following points are quoted conclusions from RI 8507 that are of interest to this study [Siskind et al., 1980]:

1. *Particle velocity is still the best single ground motion descriptor.*
2. *Particle velocity is the most practical descriptor for regulating the damage potential for a class of structures with well-defined response characteristics (e.g., single-family residences).*
3. *Damage potentials for low-frequency blasts (< 40 Hz) are considerably higher than those for high-frequency blasts (> 40 Hz), with the latter often produced by close-in construction and excavation blasts.*
4. *Home construction is also a factor in the minimum expected damage levels. Gypsum board (Drywall) interior walls are more damage resistant than older, plaster on wood lath construction.*

5. *Practical safe criteria for blasts that generate low-frequency ground vibrations are 0.75 in/sec for modern gypsum board houses and 0.50 in/sec for plaster-on-lath interiors. For frequencies above 40 Hz, a safe particle velocity maximum of 2.0 in/sec is recommended for all houses.*

6. *All homes eventually crack because of a variety of environmental stresses, including humidity and temperature changes, settlement from consolidation and variations in ground moisture, wind, and even water absorption from tree roots. Consequently, there may be no absolute minimum vibration damage threshold when the vibration (from any cause, for instance slamming a door) could in some case precipitate a crack about to occur.*

7. *The chance of damage from a blast generating peak particle velocities below 0.5 in/sec is not only small (5 percent for worst cases) but decreases more rapidly than the mean prediction for the entire range of vibration levels (almost asymptotically below about 0.5 in/sec).*

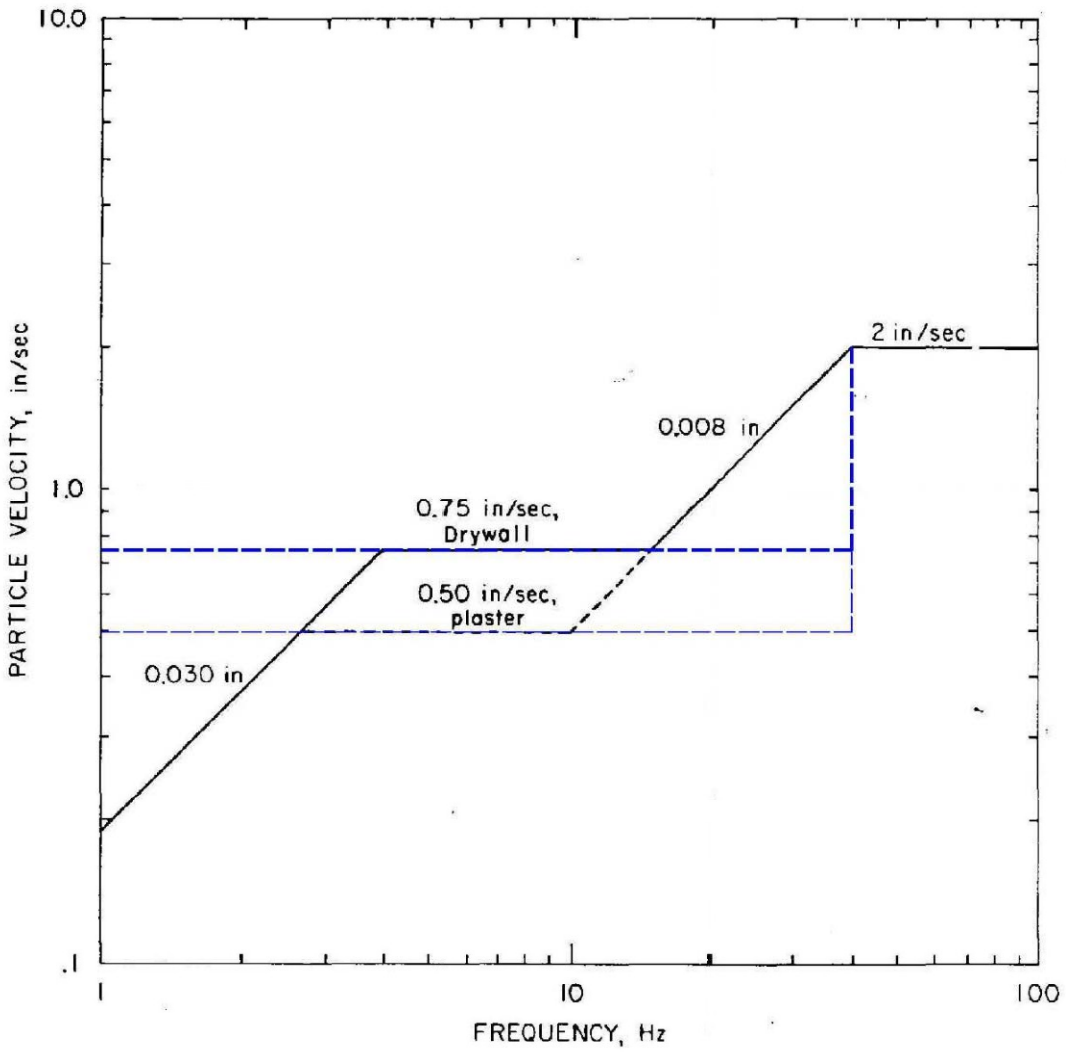

Figure 2-9. Alternative Blasting Level Criteria and Safe Levels of Blasting Table (Blue Lines) Combined.

2.3.5 SUMMARY OF THE EFFECT OF BLAST VIBRATIONS ON RESIDENTIAL SOURCES

This section summarizes the dataset used by the USBM when writing RI 8507. The USBM's analyses resulted in the ABLC, which is used by many regulatory agencies, including Florida, to limit blast vibrations. RI 8507 states that the ABLC applies to the following [Siskind et al., 1980]:

> *The structures are sited on a firm foundation, do not exceed 2 stories, and have the dimensions of typical residences, and that the vibration wave trains are not longer than a few seconds.*

The ABLC limits only apply to ground vibrations at a residential structure; the ABLC does not apply to vibrations that are measured within the structure because the ABLC accounts for the structural response.

The ABLC does not have a significant amount of supporting documentation in RI 8507 for how it was developed, so RESPEC researched outside of RI 8507 to understand the ABLC's development and applicability to Florida construction materials mining operations. RESPEC included the results of this research in Chapter 4.0 of this report.

3.0 REPRESENTATIVE MINES AND DATA IN FLORIDA

The FSFM required RESPEC to evaluate blasting data of representative construction materials mining operations during this project. RESPEC used data provided by the FSFM and data collected by RESPEC during this project to quantify blast vibration characteristics in Florida to determine the applicability of the RI 8507 blast vibration limits to Florida.

The FSFM chose six mines to represent Florida construction materials mining operations for this project. The mines were chosen from three regions: north, southwest, and southeast. The FSFM provided RESPEC with the following data on those operations:

- Blasting activities and blasting reports from 2017 and 2018 (Appendix B). These data come from Blasting Activities Reports (BAR) or operators' internal drill and blast reports.
- Blast vibration reports from 2017 and 2018 (Appendix C). These data come from BARs or operators' internal seismic records produced by seismographs.
- Citizen complaint data from 2017 (Appendix D)
- Past technical reports.

Table 3-1 provides the names and locations of the representative mines, as well as the construction materials mining regions that they represent. Figure 3-1 shows the locations of the six representative mines and the construction materials mining regions in Florida.

Table 3-1. Representative Mines Used in This Study

Mine Name[a]	Florida Department of Environmental Protection (FDEP) Environmental Resource Program (ERP) MMR Permit Holder[a]	Earliest Operator Date[b]	Region	County[b]
Marianna Mine	North Florida Rock, LLC	May 1, 1998	North	Jackson
Branford Quarry[b]	Suwannee American Cement, LLC	Jan. 1, 1983	North	Suwannee
West Lakes Mine[d]	Youngquist Brothers Rock, Inc	Sept. 1, 1992	Southwest	Lee
Brooksville Quarry	CEMEX Construction Materials Florida, LLC	Pre-2000[c]	Southwest	Hernando
White Rock Quarries	Vecellio and Grogan, Inc.	Dec. 1, 1986	Southeast	Miami-Dade
Krome Quarry	Kendall Properties & Investments	May 1, 1994	Southeast	Miami-Dade

(a) Mine Name and FDEP ERP MMR Permit Holder is the Florida Department of Environment Resources Environmental Resource Permit Mining and Reclamation Permit Holder.

(b) Earliest operator date and county were taken from the Mine Safety and Health Administration's (MSHA's) Mine Data Retrieval System on April 7, 2018.

(c) The MSHA database has separate mine IDs for the Brooksville Cement Plant, which shows operator history back to 1988, and Google Earth™ images show the operation back to 1995, so Brooksville was in operation before 1988.

(d) West Lakes Mine also includes University Lakes Mine. These two ERP MMR Permits are separate; however, they were both assumed to be a single operation for the purposes of this study.

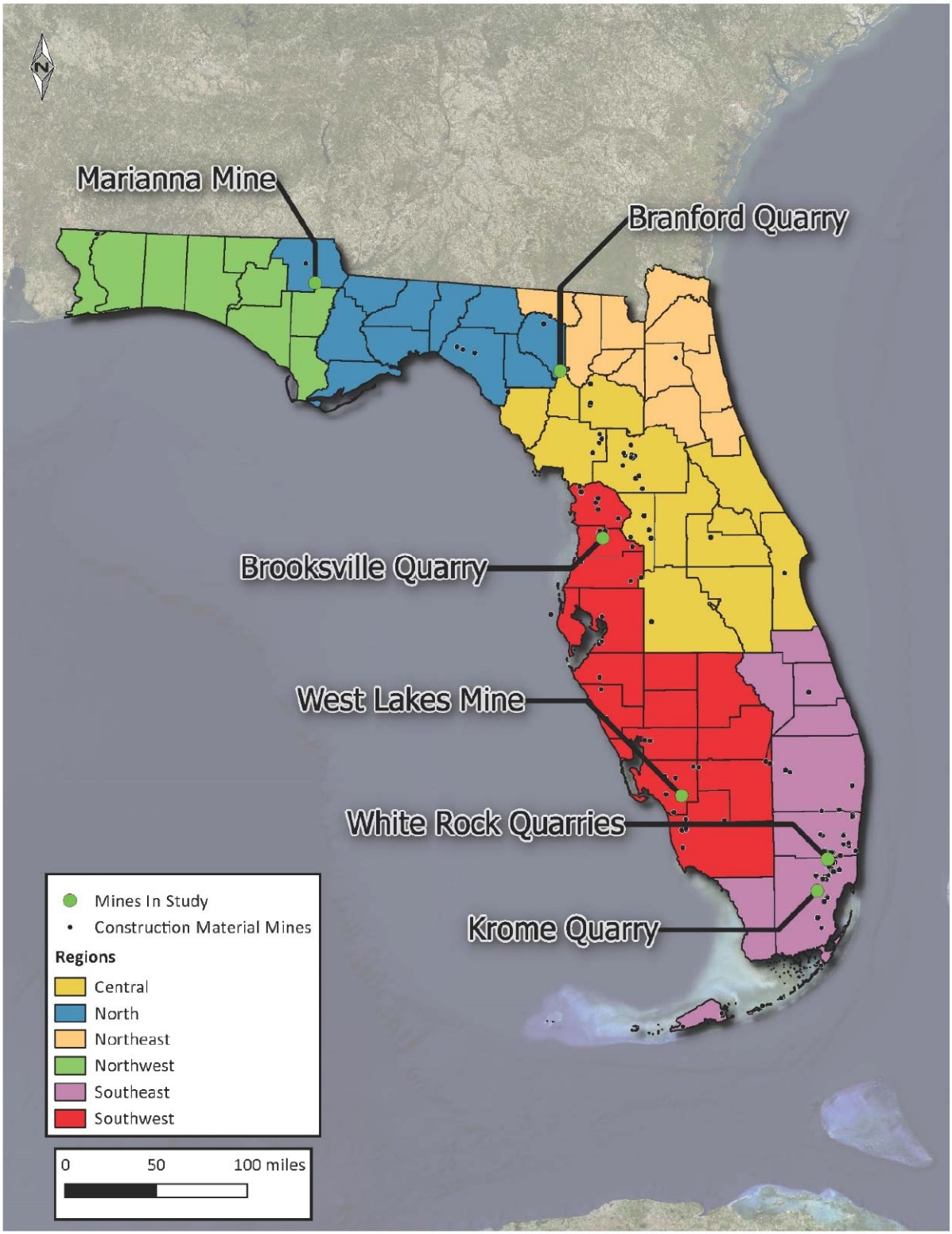

Figure 3-1. Representative Construction Materials Mining Operations and Florida Construction Materials Mining Regions.

This chapter describes the representative mines' blasting activities and representative mines' collected blast vibration data from data provided by the FSFM, vibration data collected by RESPEC during this study, citizen complaints received from the FSFM, and RESPEC's data summary.

3.1 BLASTING ACTIVITIES AND SEISMOGRAPH REPORTS

The FSFM supplied 477 blasting activity and blasting reports from 2017 and 2018 (Appendix B). The majority of the blast reports (79 percent) were provided from 2017. The following two notes concerning this data review are important to discuss:

1. The impact of blast vibrations is only determined by using both the particle velocity amplitude and frequency of the ground vibration at the residential structure.
2. A blasting activity report or internal operators report does not necessarily give the full story of a blast event, and RESPEC has not personally visited these mine sites to understand the intricacies of each mine's drilling and blasting operation.

The FSFM also provided 931 seismograph event reports from 2017 and 2018 (Appendix C). Seismographs recorded vibrations with PPVs that ranged from 0.01 to 0.80 in/sec, and every representative mine operation had a median PPV at or under 0.16 in/sec. Only three events exceeded the ABLC limits, and these occurred at West Lakes Mine; however, the events likely did not cause any structural damage because the exceedances were all less than 0.75 in/sec and under 4 Hz.

Table 3-2 provides a summary of the blasting activities and seismograph data supplied by the FSFM for this study.

Table 3-2. Summary of Blasting Activities and Seismograph Reports

Mine Name	2017			2018		
	Blast Records[a]	Date Range	Seismograph Reports	Blast Records[a]	Date Range	Seismograph Reports
Marianna Mine	9	04/04–12/14	9	0	–	–
Branford Quarry	40	01/04–12/14	80	11	01/10–03/29	22
Brooksville Quarry	56	01/05–12/21	0	17	01/08–03/28	0
West Lakes Mine	76	01/09–12/29	224	26	01/02–03/29	30
White Rock Quarries	145	01/09–12/21	0	32	01/08–03/26	0
Krome Quarry	50	01/10–12/20	0	15	01/09–03/28	0

(a) Blast Records includes both blasting activities reports or blast reports provided by the FSFM.

Note that RESPEC cannot confirm that all blasts were monitored with correct seismograph placement, so RESPEC cannot conclude that all vibration recordings are accurate.

RESPEC conducted an analysis to identify the possibility that seismographs are correctly located; however, this analysis is only preliminary and requires further review to ensure the conclusions are current. The analysis shows that over 20 percent of the seismographs may not have been placed at the nearest structure (Appendix F). This analysis only includes four of the six representative mines and was completed by using aerial images without ground-truthing; therefore, the results cannot be confirmed.

Regardless, the FSFM should inspect the permanent seismograph monitoring setups at each mining site to ensure that the seismographs are placed at the residential structure nearest to each blast.

3.1.1 MARIANNA MINE

The FSFM provided the following blasting activities documents for the Marianna Mine:

- 9 blast event records from 2017
- 9 seismograph event records from 2017.

The Marianna Mine only blasted 9 times in 2017. Table 3-3 provides the maximum, minimum, and average values for various blast parameters for the Marianna Mine in 2017. The Marianna Mine monitors their blasts with a single seismograph placed to the nearest residence to the east of the quarry. Table 3-4 provides the minimum, maximum, and average values for various vibration parameters that were recorded during the Marianna Mine blasts in 2017. Note the principal frequencies, which fall as low as 3.6 Hz. The longitudinal and transverse frequencies can fall within the structural frequency range of 4–12 Hz.

Table 3-3. Marianna Mine Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	9	4	100	75
Hole Diameter (in)	9	6.75	7	7
Hole Depth (ft)	8	20	75	22
Stemming Length (ft)	9	8	20	9
Water Depth (ft)	8	10	70	15
Number of Wet Holes	8	0	100	72
Total Explosives Weight in Blast (lbs)	7	15,750	26,920	18,540
Maximum Holes/8 Millisecond Delay	9	1	1	1
Charge Weight/Delay (lbs)	9	185	880	302
Scaled Distance (ft/lb$^{0.5}$)	0	N/R	N/R	N/R
Powder Factor (lb/yd^3)	0	N/R	N/R	N/R
Reported Distance to the Nearest Structure (ft)	0	N/R	N/R	N/R

Note that, if report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.

lbs = pounds.

ft/lb$^{0.5}$ = feet per square root of the weight per 8 millisecond delay.

lb/yd^3 = pounds per cubic yard.

3.1.2 BRANFORD QUARRY

The FSFM provided the following blasting activities documents for the Branford Quarry:

- 40 blast event records from 2017
- 11 blast event records from 2018
- 80 seismograph event records from 2017

- 22 seismograph event records from 2018
- 6 seismograph event records that do not correspond to Branford Quarry blasts. These events were likely caused by blasts at the quarry to the north of Branford Quarry and were not included in RESPEC's analysis.

The Branford Quarry blasted 51 times in 2017 and the first part of 2018. The quarry shot both production blasts and caprock blasts, so the blasting parameters vary significantly because of the two types of blasting. Table 3-5 provides the maximum, minimum, and average values for various blast parameters for the Branford Quarry in 2017 and 2018.

Table 3-4. Marianna Mine Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
Longitudinal PPV (in/sec)	9	0.03	0.18	0.09
Longitudinal Principal Frequency (Hz)	9	4.9	22.7	11.4
Longitudinal Duration (seconds)	0	N/R	N/R	N/R
Transverse PPV (in/sec)	9	0.03	0.14	0.08
Transverse Principal Frequency (Hz)	9	3.6	19.2	9.6
Transverse Duration (seconds)	0	N/R	N/R	N/R
Vertical PPV (in/sec)	9	0.04	0.21	0.09
Vertical Principal Frequency (Hz)	9	7.6	31.3	12.5
Vertical Duration (seconds)	0	N/R	N/R	N/R
Airblast (dB)	9	110	118	115

Note that, if a report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.
in/sec = inches per second.
dB = decibel.

Table 3-5. Branford Quarry Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	51	24	137	45
Hole Diameter (in)	51	4.25	4.5	4.25
Hole Depth (ft)	51	25	70	70
Stemming Length (ft)	51	6	25	20
Water Depth (ft)	46	0	65	65
Number of Wet Holes	51	0	70	33
Total Explosives Weight in Blast (lbs)	50	8,688	19,488	13,122
Maximum Holes/8 Millisecond Delay	39	1	5	2
Charge Weight/Delay (lbs)	51	138	764	358
Scaled Distance (ft/lb$^{0.5}$)	38	22	129	67
Powder Factor (lb/yd^3)	39	0.37	1.11	0.44
Reported Distance to the Nearest Structure (ft)	51	608	2,212	1,236

Note that, if a report was missing data, that report was excluded from each calculation.

The Branford Quarry monitors their blasts with two permanent seismographs. The seismographs are placed to the north and to the east of the quarry at the nearest two residences. During the study, the eastern seismograph was moved closer to the residential structure. Table 3-6 provides the minimum, maximum, and average values for various vibration parameters recorded during the Branford Quarry blasts in 2017 and 2018.

Table 3-6. Branford Quarry Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
Longitudinal PPV (in/sec)	44	0.02	0.34	0.12
Longitudinal Principal Frequency (Hz)	44	4.1	39.0	11.5
Longitudinal Duration (seconds)*	33	2.0	4.2	2.7
Transverse PPV (in/sec)	44	0.01	0.37	0.09
Transverse Principal Frequency (Hz)	44	3.5	34.0	18.5
Transverse Duration (seconds)[a]	33	1.5	3.5	2.5
Vertical PPV (in/sec)	44	0.01	0.62	0.10
Vertical Principal Frequency (Hz)	43	6.5	47.0	27.0
Vertical Duration (seconds)[a]	33	1.2	3.2	2.2
Airblast (dB)	44	96	122	113

Note that, if a report was missing data, that report was excluded from each calculation.

(a) Duration values were estimated by RESPEC when the full waveform was provided.

The Branford Quarry data were taken from a combination of summary reports and seismograph reports. Not all blast and seismograph reports were provided, so data for the blasts without the seismograph reports were taken from operator logs. In two instances, the PPV in the operator's log was lower than from the seismograph report. A total of seven blasts did not trigger seismographs.

Note that both the August 30, 2017, and September 20, 2017, blasts were labeled Shot #27; all of the 2017 reports thereafter are incorrectly labeled in the provided reports.

3.1.3 BROOKSVILLE QUARRY

The FSFM provided the following blasting activities documents for the Brooksville Quarry:

- 56 blast event records from 2017
- 17 blast event records from 2018
- 81 PPV and airblast values from 2017
- 27 PPV and airblast values from 2018.

Brooksville Quarry seismograph reports were not available. The PPV and airblast levels were noted from the blasting activities reports. The Brooksville Quarry blasted 73 times in 2017 and the first part of 2018. Table 3-7 provides the maximum, minimum, and average values for various blast parameters for the Brooksville Quarry in 2017 and 2018.

Table 3-7. Brooksville Quarry Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	73	1	80	30
Hole Diameter (in)	73	6.75	6.75	6.75
Hole Depth (ft)	73	10	51	40
Stemming Length (ft)	73	6	16	14
Water Depth (ft)	0	N/R	N/R	N/R
Number of Wet Holes	0	N/R	N/R	N/R
Total Explosives Weight in Blast (lbs)	73	842	24,316	14,385
Maximum Holes/8 Millisecond Delay	73	1	3	1
Charge Weight/Delay (lbs)	73	101	1,218	587
Scaled Distance (ft/lb$^{0.5}$)	0	N/R	N/R	N/R
Powder Factor (lb/yd^3)	0	N/R	N/R	N/R
Reported Distance to the Nearest Structure (ft)	0	N/R	N/R	N/R

Note that, if a report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.

The Brooksville Quarry monitors their blasts with up to two seismographs. Only 95 of the 108 seismograph entries in the blasting activities reports showed that seismographs were triggered; the remaining 13 entries showed that the seismographs did not trigger over 0.02 in/sec ground vibration amplitude. Table 3-8 provides the minimum, maximum, and average values for various vibration parameters recorded during the Brooksville Quarry blasts in 2017 and 2018.

Table 3-8. Brooksville Quarry Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
PPV (in/sec)	95	0.02	0.42	0.08
Airblast (dB)	95	102	128	113

Note that, if a report was missing data, that report was excluded from each calculation.

3.1.4 WEST LAKES MINE

The FSFM provided the following blasting activities documents for the West Lakes Mine:

- 76 blast event records from 2017
- 26 blast event records from 2018
- 224 seismograph event records from 2017
- 30 seismograph event records from 2018.

The West Lakes Mine blasted 102 times in 2017 and the first part of 2018. Table 3-9 provides the maximum, minimum, and average values for various blast parameters for the West Lakes Mine in 2017 and 2018.

Table 3-9. West Lakes Mine Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	102	1	64	32
Hole Diameter (in)	102	4.5	4.5	4.5
Hole Depth (ft)	102	55	72	56
Stemming Length (ft)	102	18	47	21
Water Depth (ft)	0	N/R	N/R	N/R
Number of Wet Holes	29	20	64	40
Total Explosives Weight in Blast (lbs)	102	222	19,268	8,812
Maximum Holes/8 Millisecond Delay	102	1	3	1
Charge Weight/Delay (lbs)	102	222	876	294
Scaled Distance (ft/lb$^{0.5}$)	47	26	282	86
Powder Factor (lb/yd^3)	47	0.20	0.37	0.32
Reported Distance to the Nearest Structure (ft)	102	485	4,956	2,422

Note that, if a report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.

The West Lakes Mine reported as many as three seismographs per blast. In total, 254 blast vibration event records were provided, 230 of these events were represented with full seismograph vibration reports. Table 3-10 provides the minimum, maximum, and average values for various vibration parameters recorded during the West Lakes Mine blasts in 2017 and 2018.

Table 3-10. West Lakes Mine Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
Longitudinal PPV (in/sec)	230	0.01	0.52	0.07
Longitudinal Principal Frequency (Hz)	230	1.5	23.8	11.7
Longitudinal Duration (seconds)[a]	174	2.3	11.6	6.1
Transverse PPV (in/sec)	230	0.01	0.55	0.06
Transverse Principal Frequency (Hz)	230	1.2	55.6	12.7
Transverse Duration (seconds)[a]	174	2.3	11.5	6.1
Vertical PPV (in/sec)	230	0.01	0.80	0.12
Vertical Principal Frequency (Hz)	230	1.9	55.6	2.4
Vertical Duration (seconds)[a]	174	2.2	12.1	8.2
Airblast (dB)	254	81	125	111

Note that, if a report was missing data, that report was excluded from each calculation.

(a) Duration values were estimated by RESPEC when the full waveform was provided.

3.1.5 WHITE ROCK QUARRIES

The FSFM provided the following blasting activities documents for White Rock Quarries:

- 145 blast event records from 2017
- 32 blast event records from 2018
- 205 PPV and airblast values from 2017
- 40 PPV and airblast values from 2018.

White Rock Quarries seismograph reports were not reported by White Rock Quarries because only PPV values and airblast levels are required to be reported. The PPV and airblast levels were noted from the blasting activities reports. White Rock Quarries blasted 177 times in 2017 and the first part of 2018. Table 3-11 provides the maximum, minimum, and average values for various blast parameters for White Rock Quarries in 2017 and 2018.

Table 3-11. White Rock Quarries Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	177	1	126	75
Hole Diameter (in)	177	4.5	6.0	4.5
Hole Depth (ft)	177	65	85	84
Stemming Length (ft)	177	12	21	16
Water Depth (ft)	177	62	84	82
Number of Wet Holes	0	N/R	N/R	N/R
Total Explosives Weight in Blast (lbs)	177	515	74,291	46,789
Maximum Holes/8 Millisecond Delay	177	0.5	3	1
Charge Weight/Delay (lbs)	177	247	1,665	557
Scaled Distance (ft/lb$^{0.5}$)	0	N/R	N/R	N/R
Powder Factor (lb/yd^3)	0	N/R	N/R	N/R
Reported Distance to the Nearest Structure (ft)	177	1,704	7,284	3,468

Note that, if a report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.

The White Rock Quarries monitor their blasts with up to three seismographs for each blast. Table 3-12 provides the minimum, maximum, and average values for various vibration parameters recorded during the White Rock Quarries blasts in 2017 and 2018.

Table 3-12. White Rock Quarries Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
PPV (in/sec)	244	0.04	0.44	0.16
Airblast (dB)	244	95	137	110

Note that, if a report was missing data, that report was excluded from each calculation.
One of the records was unavailable, so we count 244 records of the 245 provided records.

3.1.6 KROME QUARRY

The FSFM provided the following blasting activities documents for Krome Quarry:

- 50 blast event records from 2017
- 15 blast event records from 2018
- 150 PPV and airblast values from 2017
- 45 PPV and airblast values from 2018.

The Krome Quarry seismograph reports were not reported by Krom Quarry because only PPV values and airblast levels are required to be reported . The PPV and airblast levels were noted from the blasting activities reports. Krome Quarry blasted 65 times in 2017 and the first part of 2018. Table 3-13 provides the maximum, minimum, and average values for various blast parameters for Krome Quarry in 2017 and 2018.

Table 3-13. Krome Quarry Blasting Parameters

Blast Parameter	Count	Minimum	Maximum	Median
Number of Holes	65	28	61	42
Hole Diameter (in)	65	4.5	4.5	4.5
Hole Depth (ft)	65	50	50	50
Stemming Length (ft)	65	9	9	9
Water Depth (ft)	65	50	50	50
Number of Wet Holes	65	28	61	42
Total Explosives Weight in Blast (lbs)	65	10,470	21,289	14,658
Maximum Holes/8 Millisecond Delay	65	1	2	1
Charge Weight/Delay (lbs)	65	348	698	349
Scaled Distance (ft/lb$^{0.5}$)	0	N/R	N/R	N/R
Powder Factor (lb/yd^3)	0	N/R	N/R	N/R
Reported Distance to Nearest Structure (ft)	65	1,576	7,192	2,012

Note that, if a report was missing data, that report was excluded from each calculation.

Krome Quarry's blasting activity reports provide the frequency and peak component (the maximum PPV between the three monitoring directions: vertical, longitudinal, and transverse) for each PPV recording. The reports also list the recordings taken by three seismographs for each blast; twelve seismographs did not have a ground vibration or airblast trigger during the time period. Table 3-14 provides the minimum, maximum, and average values for various vibration parameters recorded during the Krome Quarry blasts in 2017 and 2018.

3.1.7 BLASTING ACTIVITIES AND SEISMOGRAPH REPORT SUMMARY

In general, the representative mine data show that blast geometries in Florida can vary because operating requirements and other variables affect the requirements of the operation with respect to each blast, as shown in Table 3-15. For example, the representative mines detonated blasts with the following characteristics:

- Bench heights ranging from 10 ft (Brooksville Mine) to 85 ft (White Rock Quarries)
- Number of blastholes ranging from 1 (Brooksville Mine, West Lakes Mine, and White Rock Quarries) to 137 (Branford Quarry)
- Maximum charge weight per 8 millisecond delay ranging from 101 pounds (lbs) (Brooksville Mine) to 1,665 lbs (White Rock Quarries)
- Total explosives weight in the blast ranging from 222 lbs (West Lakes Mine) to 74,291 lbs (White Rock Quarries)
- Reported distances to nearest residential structure ranging from 485 ft (West Lakes Mine) to 7,284 ft (White Rock Quarries).

Table 3-14. Krome Quarry Seismograph Reports

Vibration Parameter	Count	Minimum	Maximum	Median
Longitudinal PPV (in/sec)	164	0.03	0.40	0.12
Longitudinal Principal Frequency (Hz)	164	19.0	83.0	42.0
Transverse PPV (in/sec)	7	0.02	0.18	0.03
Transverse Principal Frequency (Hz)	7	4.0	42.0	5.0
Vertical PPV (in/sec)	12	0.03	0.16	0.08
Vertical Principal Frequency (Hz)	12	1.7	42.0	3.0
Airblast (dB)	183	79	130	107

Note that, if a report was missing data, that report was excluded from each calculation.

Table 3-15. Summary of Blasting Parameters by Quarry

Mine Name	Region	Number of Holes	Hole Diameter (in)	Hole Depth (ft)	Total Explosives Weight in Blast (lbs)	Charge Weight/Delay (lbs)	Reported Distance to Nearest Structure (ft)
Marianna Mine	North	4–100	6.75–7.00	20–75	15,750–26,920	185–880	N/R
Branford Quarry	North	24–137	4.25–4.50	25–70	8,688–19,488	138–764	608–2,212
Brooksville Quarry	Southwest	1–80	6.75–6.75	10–51	842–24,316	101–1,218	N/R
West Lakes Mine	Southwest	1–64	4.50–4.50	55–72	222–19,268	222–876	485–4,956
White Rock Quarries	Southeast	1–126	4.50–6.00	65–85	515–74,291	247–1,665	1,704–7,284
Krome Quarry	Southeast	28–61	4.50–4.50	50–50	10,470–21,289	348–698	1,576–7,192

Note that, if a report was missing data, that report was excluded from each calculation. N/R means that none of the reports identified that information.

Table 3-16 provides a summary of the seismograph data provided by the FSFM.

- Particle velocities are generally low (the highest median value, or value with an equal number of values greater than or less than, was 0.16 in/sec at White Rock); however, records state that the PPV has reached 0.80 in/sec at the West Lakes Mine, which was the highest value recorded.
- Vibration frequencies can fall below the 4 Hz (both principal and dominant frequencies). The southwestern and southeastern regions can have lower principal frequencies than the north

region operations. Operations are not required to provide all of these data, but RESPEC will reported the data when available.

- Only three events exceeded the ABLC based on the files where the full waveform was provided. Events that exceeded the ABLC do not indicate structural damage caused by the vibrations. A waveform that exceeds the ABLC only indicates that blast vibrations have sufficient energy to potentially start causing threshold damage to residential structures.

Table 3-16. Summary of Seismograph Reports by Quarry

Mine Name	Region	PPV Range (in/sec)	Principal Frequency Range (Hz)	Duration Range (s)[a]	Airblast (dB)
Marianna Mine	North	0.03–0.21	3.6–31.3	N/R	110–118
Branford Quarry	North	0.01–0.62	3.5–47.0	1.2–4.2	96–122
Brooksville Quarry[b]	Southwest	0.02–0.42	N/R	N/R	102–128
West Lakes Mine	Southwest	0.01–0.80	1.2–55.6	2.2–12.1	81–125
White Rock Quarries[b]	Southeast	0.04–0.44	N/R	N/R	95–137
Krome Quarry[b]	Southeast	0.02–0.40	1.7–83.0	N/R	79–130

(a) Duration values were estimated by RESPEC when the full waveform was provided.
(b) Seismograph reports were not provided for any blast, so blasting activity report data were used.

Note that the duration estimates are highly subjective, and estimates can sometimes vary as much as a few seconds. Identifying a repeatable method for determining vibration durations could be difficult because of the subjectivity. Regardless, the general conclusions based on durations in this document are valid.

Because of the variation in operating characteristics at each mine, which requires these ranges of design factors, RESPEC does not recommend codes or regulations that limit these variables, except with respect to vibrations that result at the nearest residential structure. Only vibration particle velocity and frequency should be regulated because the state of Florida requires using seismographs for every blast. Chapter 5.0 of this report elaborates on this regulation.

3.2 RESPEC-COLLECTED VIBRATION DATA

RESPEC placed six seismographs and four crack monitors at selected residences chosen from a list of 20 citizen complaint sources (from 2017) provided by the FSFM (Appendix E). Because of the timeline of the study, RESPEC chose the locations based on the first six complainants who allowed the team to set up seismographs at their residences. For confidentiality purposes, the names and addresses of those residences are not disclosed in this document.

The FSFM suggested this method of identifying placement locations because it was the best for choosing monitoring locations on such a short timeframe. Therefore, the seismographs were not placed at the nearest residential structures to the blast. Instrumentation setup details are provided in Appendix E.

Seismographs were placed in the following general locations:

- East of Branford Quarry (representing the northern region)
- North of Branford Quarry (representing the northern region)
- North of White Rock Quarries (representing the southeastern region)
- East of White Rock Quarries (representing the southeastern region)
- East of Krome Quarry (representing the southeastern region)
- South of West Lakes Mine (representing the southwestern region).

RESPEC placed the following crack monitors at select locations:

- Branford Quarry: crack monitors were placed at the north and east residences.
- White Rock Quarry: crack monitors were placed at the north and east residences.
- West Lakes Mine: a crack monitor was not placed at the resident's request.
- Krome Quarry: a crack monitor was not placed because the resident was not available in person for RESPEC to request that a crack monitor be set up.

Seismographs and crack monitors were not placed at the Brooksville Mine or Marianna Mine because complainants near the Brooksville mine did not respond to requests from RESPEC, and the FSFM did not have any complainants near the Marianna Mine.

Data were collected between February 12, 2018, and May 9, 2018 (this study began on February 1, 2018). Table 3-17 summarizes the ranges of PPV, principal frequency, and duration collected by RESPEC (Appendix F).

Table 3-17. Vibration Data Collected by RESPEC

Region	Mine Name	Monitoring Direction	Date Range	Count	PPV Range (in/sec)	Principal Frequency Range (Hz)	Duration Range (seconds)
North	Branford Quarry	North	02/21–05/08	15	0.02–0.49	3.6–44.5	1.6–4.5
North	Branford Quarry	East	02/21–05/08	16	0.01–0.34	7.3–33.0	2.0–3.3
Southwest	West Lakes Mine	South	02/14–04/24	17	0.01–0.07	1.2–31.0	8.1–15.0[a]
Southeast	White Rock Quarries	North	02/13–05/08	32	0.01–0.12	1.7–44.5	3.4–16.6*
Southeast	White Rock Quarries	East	02/13–05/08	30	0.01–0.12	1.4–40.9	8.5–17.5*
Southeast	Krome Quarry	East	03/05–04/25	15	0.02–0.05	1.9–68.2	3.5–15.0

(a) RESPEC recorded some blast vibrations that were longer than 20 seconds; however, RESPEC did not record the start or end of the vibration so the actual duration is unknown. The particle velocity levels of these waveforms were low, so the waveforms did not trigger the seismograph upon first contact.

3.2.1 RESPEC-COLLECTED PEAK PARTICLE VELOCITY

The PPVs that were recorded at all of the monitoring sites are significantly below ABLC vibration limits (Appendix F). Table 3-18 includes the minimum and maximum particle velocities of each component recorded at each monitoring location.

Table 3-18. Peak Particle Velocity Vibration Data Collected by RESPEC

Region	Mine Name	Monitoring Direction	Longitudinal PPV Range (in/sec)	Transverse PPV Range (in/sec)	Vertical PPV Range (in/sec)
North	Branford Quarry	North	0.03–0.47	0.02–0.26	0.02–0.49
North	Branford Quarry	East	0.02–0.34	0.01–0.12	0.02–0.28
Southwest	West Lakes Mine	South	0.01–0.06	0.01–0.05	0.01–0.07
Southeast	White Rock Quarries	North	0.02–0.12	0.02–0.10	0.03–0.08
Southeast	White Rock Quarries	East	0.01–0.10	0.01–0.07	0.03–0.12
Southeast	Krome Quarry	East	0.02–0.05	0.02–0.04	0.02–0.04

3.2.2 RESPEC-COLLECTED FREQUENCY

Vibration amplitudes are significantly lower than any amplitude where damage was found during the RI 8507 study, so RESPEC also studied vibration frequencies and durations. The frequencies have differing characteristics by region (Appendix F).

In the north, frequencies range from 3.6 to 44.5 Hz, while the southeastern and southwestern regions have frequencies that can range from below 2 Hz to 68.2 Hz; this is illustrated in Table 3-19. RESPEC recorded 74 percent of vibrations in the two southern regions that had waveforms with one or more peaks with frequencies below 2 Hz, which are listed in Table 3-20. Typically, vibrations exhibit low-frequency, long-duration wavetrains in the two southern regions that are atypical of vibrations in the northern region, which had zero waveforms with one or more peaks below 2 Hz. Low-frequency, long-duration tails of the blast vibrations, which occur primarily in the vertical and longitudinal (or radial) directions, are essentially Raleigh waves, which travel on the surface.

Table 3-19. Principal Frequency Vibration Data Collected by RESPEC

Region	Mine Name	Monitoring Direction	Longitudinal Principal Frequency Range (Hz)	Transverse Principal Frequency Range (Hz)	Vertical Principal Frequency Range (Hz)
North	Branford Quarry	North	5.9–29.6	4.3–34.1	3.6–44.5
North	Branford Quarry	East	7.3–22.2	13.2–20.0	9.3–33.0
Southwest	West Lakes Mine	South	2.1–24.0	1.2–19.6	1.8–31.0
Southeast	White Rock Quarries	North	3.1–44.5	2.3–43.5	1.7–41.7
Southeast	White Rock Quarries	East	3.6–20.0	1.4–17.6	1.8–40.9
Southeast	Krome Quarry	East	28.0–53.8	2.6–68.2	1.9–49.9

Table 3-20. Waveforms With Peaks Below 2 Hertz

Region	Mine Name	Monitoring Direction	Count of Waveforms	Count of Waveforms With One or More Peaks Below 2 Hz	Percentage of Waveforms With One or More Peaks Below 2 Hz (%)
North	Branford Quarry	North	15	0	0
North	Branford Quarry	East	16	0	0
Southwest	West Lakes Mine	South	17	17	100
Southeast	White Rock Quarries	North	32	31	97
Southeast	White Rock Quarries	East	30	7	23
Southeast	Krome Quarry	East	15	15	100
Total for North Region			31	0	0%
Total for Southwest and Southeast Regions			94	70	74%

The RI 8507 study did not include data collected with frequencies below 4 Hz. Therefore, further documentation needs to be reviewed to determine if the RI 8507 limits apply to low-frequency vibrations.

Note that the International Society of Explosives Engineers (ISEE) seismograph standards require seismographs to be calibrated down to 2 Hz [ISEE, 2017], though Florida codes do not have calibration specifications. RESPEC recorded vibrations with zero crossing frequencies less than 2 Hz. Therefore, seismographs may not be reporting accurate vibration amplitudes with frequency content below 2 Hz; this statement does not necessarily mean that the PPV was incorrectly reported for events (Appendix A). Despite this point, the vibrations are still low enough that any amplitude correction would likely still result in amplitudes less than the RI 8507 particle velocity limits.

3.2.3 RESPEC-COLLECTED DURATION

The typical duration of each blast vibration event also depends on the region (Appendix F). RESPEC identified that blast vibrations in the southeastern and southwestern regions can have significantly longer durations than blast vibrations in the northern region, which is shown in Table 3-21. Because of the low-frequency wavetrains, the blast vibrations in the southeastern and southwestern regions can last 20 seconds. The values in Table 3-21 do not show durations up to 20 seconds because RESPEC did not record vibration duration values if the start and end of the waveform could not be identified. RESPEC recorded multiple waveforms with over 20 second durations around White Rock Quarries; however, RESPEC could not identify the full duration of any of the over-20 second waveforms.

The blast durations themselves could cause vibration wavetrains to be longer than 20 seconds; however, the blasts are detonated within 1–2 seconds (not all data provided by the FSFM had blast duration); therefore, the Florida geology contributes to the vibrations having such long durations (Appendix H). Despite the effect of the geology, the vibration at each residential structure is what causes structural response, regardless of what happens to the vibration between the blast and the structure [Siskind et al., 1980].

Table 3-21. Duration Vibration Data Collected by RESPEC

Region	Mine Name	Monitoring Direction	Longitudinal Duration Range (seconds)	Transverse Duration Range (seconds)	Vertical Duration Range (seconds)
North	Branford Quarry	North	1.8–4.5	1.6–3.7	1.7–2.8
North	Branford Quarry	East	2.2-3.3	2.2–3.1	2.0–3.0
Southwest	West Lakes Mine	South	8.1-14.3	9.9-13.5	10.0–15.0
Southeast	White Rock Quarries	North	8.0-13.3	3.4-7.6	9.7-16.6
Southeast	White Rock Quarries	East	10.5–17.3	8.5-14.9	12.0-17.5
Southeast	Krome Quarry	East	3.5–13.0	3.6–9.5	10.3–15.0

RI 8507 states that it applies to "vibration wave trains that are not longer than a few seconds." RESPEC feels that a few seconds does not apply to vibrations with wavetrains typical of those in the two southern Florida regions due to the extended duration values. Therefore, further study is needed to determine if the ABLC applies to long-duration vibrations.

3.2.4 RESPEC-COLLECTED CRACK MONITORING DATA

RESPEC used crack monitors to collect crack movement data during the seismograph study (Appendix E). RESPEC set up four crack monitors: two at Branford Quarry in the northern region and two at White Rock Quarries in the southeastern region. The data collected during the study are shown and summarized in Appendix F. Table 3-22 provides a summary of the average daily temperature and displacement change before and after blast events. The monitoring data were recorded on 10 minute intervals, so the discreet data points that were collected immediately before and immediately after each blast vibration event were used to calculate the data in the table. Table 3-22 shows that the temperature may change by 1–2 degrees in the 10 minute time period before and after the blasts (on average), but the displacement does not change more than 0.0001 inch on average. This displacement value is under 2 percent of the daily change in crack width that is caused by temperature changes during the day.

Table 3-22. RESPEC-Collected Crack Monitoring Summary

Region	Mine Name	Monitoring Direction	Average Temperature Differential Pre- and Postblast (°F)	Average Displacement Differential Pre- and Postblast (in)	Displacement % of Daily Total
North	Branford Quarry	North	1	0.0001	1.2
North	Branford Quarry	East	2	0.0001	1.6
Southeast	White Rock Quarries	North	0	0.0001	1.7
Southeast	White Rock Quarries	East	1	0.0000	1.9

°F = degrees Fahrenheit.

Figure 3-2 shows an example of a 24 hour period over March 9, 2018, at the monitoring point north of White Rock Quarries. The data show that the temperature has a significant impact on the crack width, while the blast has essentially no impact on the crack width.

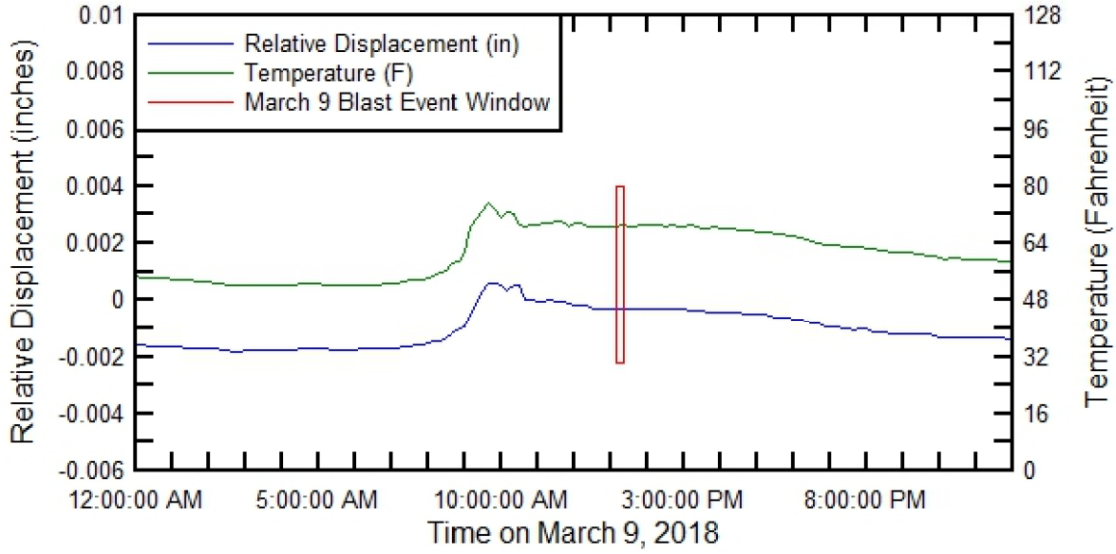

Figure 3-2. Example of Crack Displacement and Temperature Change During the 24 Hour Period Over March 9, 2018, at White Rock Quarries North.

Appendix F shows each blast and the crack change during the blast event. The data presented in Appendix F show that crack widths do not change because of the blast vibration levels RESPEC recorded. The appendix also supports the fact that crack widths vary because of daily changes in temperature.

3.2.5 RESPEC-COLLECTED CRACK MONITORING DATA

RESPEC conducted a secondary vibration study north of White Rock Quarries because a seventh residence that was a relatively short distance from the quarry became available. RESPEC set a seismograph at the new residence (White Rock Quarries North Seismograph B) while continuing to monitor at the original White Rock Quarries North Seismograph location. The original six monitoring locations were not the nearest residential structures to the representative quarries, so this study gave RESPEC the opportunity to evaluate blast vibrations at a closer residence to a quarry. RESPEC did not tell anyone about this extended monitoring period because local residents were concerned that the quarries were purposefully reducing blasting efforts during the study. This secondary study shows that White Rock Quarries continued to blast at similar levels as recorded by RESPEC previously.

Finally, RESPEC used two seismographs to measure the seismic propagation velocity of the soils at the White Rock Quarries North Seismograph B residence. The calculated propagation velocity was used in the soil response section that was discussed previously in this study (Section 4.4).

3.2.5.1 PHASE 2 SEISMOGRAPH RESULTS

RESPEC collected vibration data for 12 blasts during the monitoring period, which are shown in Table 3-23; one blast did not trigger the seismograph RESPEC placed at the original monitoring location (Seismograph A) north of White Rock Quarries. The vibrations at the new seismograph location (Seismograph B) were between 1.3 and 2.6 times the PPV value at Seismograph A, which is farther from the quarry (Appendix F). Despite the higher recordings at Seismograph B, the PPV values were still low compared to those that caused damage in RI 8507.

Table 3-23. Vibration Data Collected by RESPEC

Region	Mine Name	Monitoring Direction	Date Range	Count	PPV Range (in/sec)	Principal Frequency Range (Hz)	Duration Range (seconds)
Southeast	White Rock Quarries	Seismograph A	05/09–05/31	11	0.01–0.08	1.7–25.2	3.0-16.7
Southeast	White Rock Quarries	Seismograph B	05/09–05/31	12	0.01–0.16	1.1–44.5	7.8–14.3

The seismograph records also further proved that seismographs need to be studied to determine whether they produce accurate particle velocity amplitude values at frequencies below 2 Hz. The duration of the vibrations are also up to 20 seconds, which add to the annoyance factor of the vibrations. This study further confirmed the results that had been collected during the primary monitoring program.

3.2.5.2 PROPAGATION VELOCITY

RESPEC placed two seismographs at the White Rock Quarries North Seismograph B residence 100 ft apart in an array along the vibration travel direction from the quarry. The seismographs were programmed so that the first seismograph triggered the second seismograph to record on the same time signature as the first seismograph, which allowed RESPEC to note the time difference between the time the vibration contacted each seismograph. The seismographs produced the waveforms shown in Figure 3-2.

Because of the noise (i.e., fuzziness) in the waveform data, RESPEC digitally smoothed the data by using a smoothing window and then identified the time when the particle velocity passed a threshold particle velocity value for each graph (Figure 3-3). RESPEC used 0.008 in/sec as the threshold value (the particle velocity value used to identify the time the vibration contacts the seismograph) for the smoothed vibration waveforms (Figure 3-4). Table 3-24 shows the values identified by RESPEC. Propagation velocity was calculated using Equation 3-1.

RESPEC used the time difference between the seismic wave that contacted the first seismograph to the time the seismic wave contacted the second seismograph (T) to calculate the propagation velocity (V):

$$V = \frac{D}{T} \tag{3-1}$$

where D is the distance between the two seismographs. The propagation velocity was measured to be approximately 13,200 ft/sec. Note that this value is referenced in Section 4.4.

3.3 CITIZEN COMPLAINTS, INVESTIGATION REPORTS, AND CONSTRUCTION MINING PERMITS

The FSFM supplied citizen complaints and complaint investigation reports concerning the six representative construction materials mine sites. Complaint investigation reports are reports that are officially opened by the FSFM after a citizen complaint is submitted/routed to the appropriate regional office for investigation and a request is made by the complainant for an in-person investigation to be conducted.

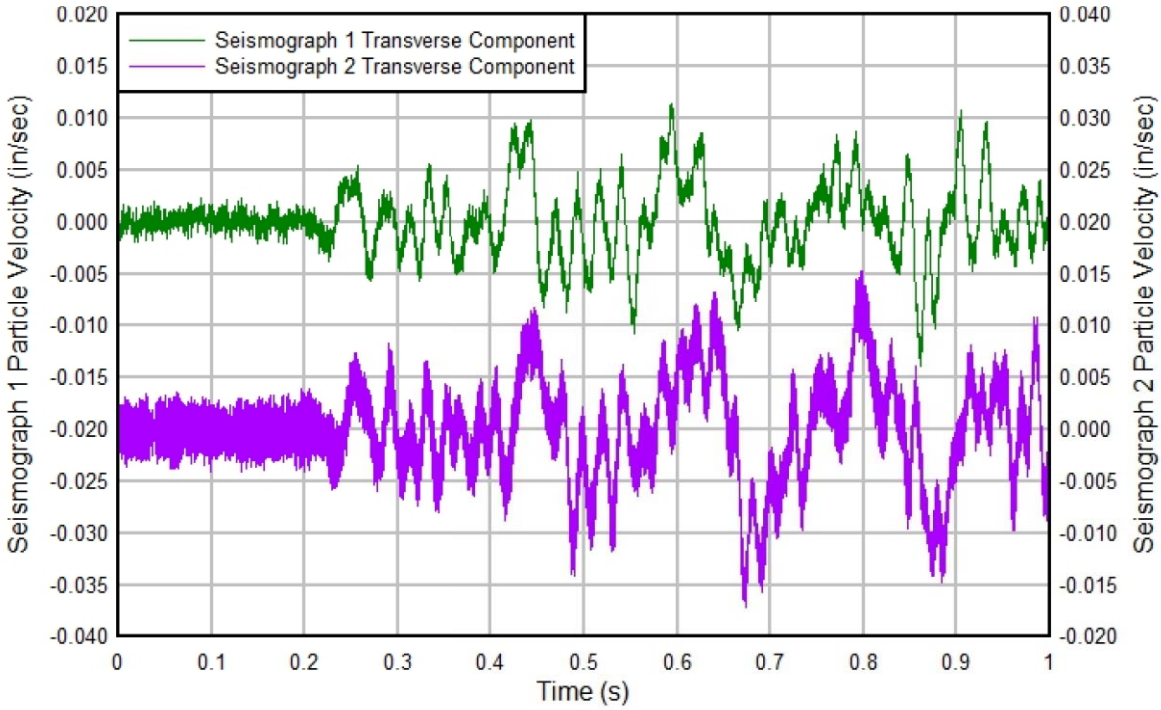

Figure 3-3. Vibration Data That Were Used to Calculate Propagation Velocity.

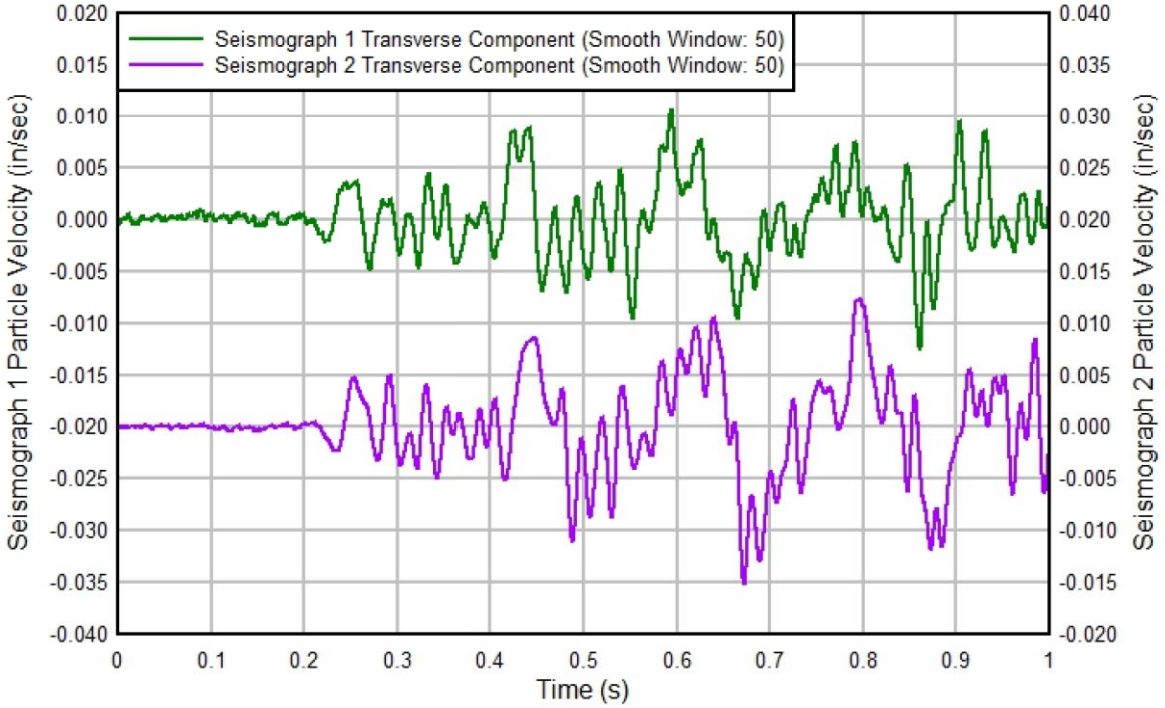

Figure 3-4. Vibration Data That Were Used to Calculate Propagation Velocity With Smoothing Window Value of 50 Applied.

Table 3-24. Vibration Data Collected by RESPEC

Smoothing Window Value	Time Vibration Reached Seismograph 1 (s)	Time Vibration Reached Seismograph 2 (s)	Time Difference (s)	Distance Between Seismographs (ft)	Calculated Propagation Velocity (ft/sec)
20	0.214172	0.221497	0.007324	100	13,700
50	0.213623	0.221436	0.007813		12,800
Average					13,200

3.3.1 CITIZEN COMPLAINTS

RESPEC also reviewed the provided citizen complaints regarding White Rock Quarries and West Lakes Mine (Appendix D). No complaints were provided concerning the other construction materials mines. However, 1,500 pages of complaints covering 360 individual complaints are associated with White Rock Quarries, and 48 pages of complaints covering 30 individual complaints are associated with West Lakes Mine.

3.3.1.1 WHITE ROCK QUARRY

RESPEC received and reviewed approximately 1,500 pages of complaints from residents around White Rock Quarries; however, many of the pages were redundant email chains from previous complaints. Three hundred and sixty unique complaints were identified. Approximately 40 percent of the complainants claimed damage to their residences or personal property. Of the remaining 60 percent, some follow-up complaints were from homeowners who had already claimed damage in a previous complaint and did not necessarily restate the damage in subsequent complaints. Therefore, stating that 60 percent of the residents did not claim damage would be incorrect. Many of the nondamage complaints included general annoyance, startling, sleep disruption, window rattling, furniture shaking, and fear of damage. The consensus of the homeowners is that damage is being done to their homes or they are simply concerned about the potential for damage.

Key observations from the complaint reports include the following:

- 42 percent of complaints included damage claims
- 61 percent of damage claims included either interior or exterior cracking
- 23 percent of damage claims were related to cracking in concrete
- 17 percent of damage claims did not provide description of damage type
- Approximately 20 percent of the total complaints were filed by one individual
- 9 percent of the damage claims included items falling from walls and shelves.

Note that most damage claims included multiple types of damage; therefore, the following breakdown of damage claims does not sum to 100 percent.

Types of Damage Claims From Residents Near White Rock Quarry

Bold text points are examples of social impact rather than structural damage. Italic text items (e.g., driveway cracking, pool cracking, roof tiles falling, and water lines breaking) and many other items in this list are considered minor or major damages, and many of these points would require high energy blast vibrations and permanent ground movement that would be found only near to a blast. RESPEC

only considers two of the points (interior cracking on walls and ceilings and cracks extending) as potential threshold damage complaints; however, none of the particle velocity and frequency levels from the event reports reviewed by RESPEC or events monitored by RESPEC could have produced this damage.

- Interior cracking on walls and ceilings
- *Exterior stucco cracking and detachment*
- Cracks extending
- *Driveway sinking and cracking*
- *Garage floor cracking*
- *Patio cracking*
- *Pools leaking*
- *Pool deck cracking*
- *Tile floor cracking*
- *Tiles breaking*
- *Tiles on walls coming off*
- *Wood floor cracking and buckling*
- *Roof tiles loosening and falling*
- *Sprinkler system becoming damaged*
- *Foundation cracking*
- **Pictures, heirlooms, and artwork falling off walls and shelves**
- *Water leaking and damaging property*
- *Water lines breaking and leaking*
- *Granite countertop cracking*
- *Sinkholes forming*
- *Boat ramped cracking in half*
- **Wine shelf collapsing**
- *A/C line broke under house*
- **Smoke detector detaching from ceiling**
- **Alarm systems being set off**
- *Doors not shutting/staying open properly*
- *Masonry blocks shifting*
- *Recessed lighting detaching from ceiling*
- *A/C and water heater needing to be replaced*
- *Windows cracking*
- *Facia cracking*
- *Crown molding cracking.*

Damage Claim Summary From Residents Near White Rock Quarry

- 28 percent reported interior cracking
- 15 percent reported exterior cracking in stucco
- 19 percent reported general cracking but did not specify
- 23 percent of damage claims involved cracking in driveways, sidewalks, garage floors, and outdoor patios
- 4 percent claimed foundation damage
- 17 percent involved tile floor cracking and becoming loose
- 10 percent of claims involved pool cracks and leaks
- Several counts of roof tile damage were found including tiles falling from the roof
- Several water pipe leaks were claimed.

3.3.1.2 WEST LAKES MINE

Approximately 30 complaints were reviewed regarding the West Lakes Mine. Approximately 20 percent claimed damage, and the remaining 80 percent were mostly related to fear of damage to homes and foundations. Damage claims include general damage, structural damage, foundation damage, pictures falling off of walls, and exterior cracks.

3.3.2 COMPLAINT INVESTIGATION REPORTS

The complaint investigation reports provided by the FSFM were each individually reviewed (Appendix I). Sometimes the investigation report was related to a specific blast date and time, while others regarded more general time frames. Approximately 23 percent of the reports contained specific damage claims. The remaining investigation reports resulted from complaints because of general annoyance, noise, window rattling, furniture shaking, concern of property value, and fear of damage. More details of the investigations based on each site are provided in the following sections.

RESPEC received and reviewed the following complaint investigation reports:

- Branford Quarry – 1 report
- Brooksville Quarry – 1 report
- West Lakes Mine – 27 reports
- White Rock Quarries – 2 reports
- Krome Quarry – 1 report.

3.3.2.1 NORTH

One investigation report was provided and reviewed regarding Branford Quarry. The resident stated that ornaments had been knocked off of their Christmas tree because of blast vibrations. After reviewing the blast report, the blast coordinates showed that this specific blast was at the far northern end of the quarry, which is the closest quarrying area to the residence. The PPV of 0.385 in/sec recorded was at the higher end of the range typically experienced at this residence and was likely caused by the shorter distance.

3.3.2.2 SOUTHWEST

Only one investigation report was received and reviewed regarding the Brooksville Quarry. This report stated that the resident had lived at the location for over 50 years and had not experienced a blast response as strong as that from the March 9, 2017, blast at 11:09 a.m. No damage was reported by the resident. The inspector noted that the mine was moving closer to the residence at this time. Blasting records were reviewed by the FSFM investigator, who found no violations. Despite that, RESPEC found that the residence was approximately 20 percent closer to the blast (400 ft closer) than the nearest seismograph listed on the blast report and was placed 90 degrees in the wrong direction based on coordinates reported by the mine site.

A total of 28 investigation reports were provided regarding West Lakes Mine. Approximately 18 percent of the reports cited specific damage claims, which included pool leaks, foundation cracks, sinkholes, and other general damage. The investigator found no violations in these cases, and, as discussed in this document, blast vibrations would not cause these types of events.

3.3.2.3 SOUTHEAST

One investigation report was received and reviewed regarding the Krome Quarry. The investigation states that the resident cited strong vibrations and cracks in the screen door for blasts on March 6, 2017, and March 8, 2017, at 1:00 p.m. However, the mine stated that no blasting occurred on those days. The mine did blast on March 7, 2017; however, that blast report was not provided in the received documentation reviewed for this report. Only the seismograph report was provided in the investigation documentation. The investigator stated that, after interviewing the resident, complaints were regarding truck noise and blast vibrations.

Two investigation reports were received and reviewed for White Rock Quarries. The first was a result of the August 28, 2017, blast, which caused an airblast of 135 decibel (dB) (exceeded regulatory limits). After the investigation, White Rock Quarry stated that the airblast may have been caused by geological anomalies and cracking in the ground that allowed loss of confinement. The second investigation regarded damage claims by a resident in Miramar. The resident had experienced interior water damage from exterior cracking. A water main break in front of the residence was also claimed to be caused by blasting. The resident's water purification system was damaged by the water main break. The investigator found no violations in the 6 months before the visit and also photographed the damage shown by the resident.

3.3.3 CONSTRUCTION MINING PERMITS

RESPEC reviewed the construction mining permits for each of the representative construction materials mining operations. Construction mining permits are provided to an operation that has complied with Florida Statutes and is permitted to engage in construction materials mining and produce construction aggregates, sand, cement, and road base materials. Table 3-25 shows the six construction materials mining permits. All permits are currently active and valid.

Table 3-25. Construction Mining Permit Information for the Six Representative Mines

Mining Operation	Business Name	License/Permit #	Issue Date	Expiration Date
Marianna Mine	North Florida Rock LLC	CMP17-000003	10/12/2017	11/12/2018
Branford Mine	Suwannee American Cement	746718-0001-2002	06/12/2017	06/26/2018
Brooksville Quarry	Cemex Construction Materials	754564-0001-2002	09/14/2017	09/15/2018
West Lakes Mine	Youngquist Brothers	994175-0001-2002	01/04/2018	12/16/2019
White Rock Quarries	White Rock Quarries	758700-0001-2002	03/27/2018	03/26/2019
Krome Quarry	Cemex Construction Materials	765663-0006-2002	04/11/2018	04/10/2019

The business name may not match the FDEP ERO MMR Permit Holder (see Appendix H) because the operator does not have to be the same entity as the permit holder.

3.4 DATA SUMMARY

The Florida ground vibrations have unique characteristics that were not adequately represented by the data used by the USBM when writing RI 8507 and creating the ABLC. RESPEC required a further literature review to determine if the RI 8507 limits apply to Florida ground-vibration characteristics,

such as the long durations and low frequencies experienced in the two southern regions. The data also provided some additional conclusions, which are summarized in the following sections.

3.4.1 DATA ANALYSIS

RESPEC analyzed data from six representative mine sites, including the data supplied by the FSFM and data collected by RESPEC during this project.

- The PPVs that RESPEC measured are significantly below the ABLC limits.
- RESPEC found one instance from the complaint investigation report events where a site was out of compliance because of improper seismograph placement location, which was not identified by the FSFM.
- The FSFM investigators found two airblast exceedance events; however, ground-vibration limits were not exceeded.

3.4.2 COMPLAINTS

Most complaints are likely caused by the long-duration, low-frequency vibrations that occur in the southeastern and southwestern regions, considering that the vibrations that were recorded at the complainant's residences had such low PPVs.

3.4.3 MONITORING

Industry standards only require seismographs to be calibrated down to 2 Hz. Typically, seismographs have a flat response down to 4 Hz and a drop in response below that; however, they must be within 3 dB, or 70 percent of a flat response at 2 Hz. Florida vibrations can have PPVs that correspond to frequencies of less than 2 Hz, which is outside of the typical flat response range of seismographs (flat response range is the range a seismograph reports the input particle velocity values accurately). The permanent seismograph installations may have an issue if the blasting location changes frequently at the mining operation, as RESPEC identified in Section 3.5.2.2.

3.4.4 REPORTING

While reviewing the reports, RESPEC recognized that the various FSFM offices use different forms with varying names (Appendix J). While the content is similar, form names include *Request for Investigation, Complaint Review Form,* and *Request for Review.*

4.0 APPLYING REPORT OF INVESTIGATIONS 8507 TO FLORIDA AND ITS SOILS

In general, the conclusions in RI 8507 were based on a statistical evaluation of a large dataset of damage and nondamage events. The original work in RI 8507 did not necessarily represent some specific characteristics of blasting vibrations in Florida; therefore, RESPEC is also including an analysis of post-RI 8507 studies and research within and outside of the USBM that address these specific details. Namely, the specific areas that include the low-frequency, long-duration vibrations that we have found are characteristic of the blast vibrations created by the southern Florida construction materials mining operations. RESPEC also analyzed the potential impact of those vibrations on soils and other topics.

RESPEC identified the five primary topics relating to the applicability of the ABLC to construction materials mining activities in Florida that are not fully represented by RI 8507. RESPEC conducted further review of each of these five points:

1. **Vibration Duration:** The vibrations that RESPEC recorded in Florida had relatively long durations; one blast vibration event had a duration of approximately 19.5 seconds. RESPEC needed to ensure that the RI 8507 limits apply to vibrations of up to 20 seconds in duration considering that the ABLC was generated by using data from vibrations that had durations of only a few seconds.
2. **Low-Frequency Vibrations**: The USBM only studied vibrations down to 4 Hz in RI 8507. In Florida, RESPEC recorded vibrations down to nearly 1 Hz. The ISEE seismograph standards level is 2 Hz [ISEE, 2017]. RESPEC needed to know the impact of vibrations below 4 Hz on residential structures and how the seismographs respond to vibrations below 2 Hz.
3. **Damage Points Below the ABLC Limits**: Figure 54 in RI 8507 shows seven damage points below the 0.008 in constant displacement line between 10 and 40 Hz. This figure was used to produce the ABLC shown in Appendix B of RI 8507. RESPEC needed to understand why limits would be made with the seven damage points below the limits.
4. **Soil Response:** RI 8507 assumes that structures are sited on a firm foundation. Judging by Google Earth™ imagery, our monitored houses were built on ground at the very edge of areas that were drilled, blasted, and excavated to create lakes, which means that they could be on solid ground or fill material. RESPEC needed to understand whether the blast vibrations in Florida could be causing soil settlement.
5. **Florida Residential Structures**: The USBM studied one- and two-story residential structures but did not study all atypical structures such as mobile homes or apartment buildings. RI 8507 did not include any residential structures in Florida either (Section 2.3.1).

4.1 VIBRATION DURATION

Vibrations can only cause amplification to structures if the motion is continuous, harmonic, and sinusoidal and the driving ground-vibration frequency is continuously equal to the structural frequency [Crum, 1997; Dowding et al., 2018]. Blast vibrations are not a continuous, simple, sinusoidal motion. In

contrast, blast vibrations are complex waveforms that do not display amplification values shown by continuous, harmonic (single-frequency) excitation. Conclusions concerning amplifications should be reached by considering the actual motions themselves.

Stagg et al. [1984] studied continuous vibration in the USBM test home. The first threshold damage was found at over 50,000 cycles of approximately 7 Hz motions (the natural frequency of the test home) at approximately 0.5 in/sec equivalent ground vibration. Therefore, the first structural damage occurred after 7,000 seconds (1.9 hours) of continuous, simple sinusoidal vibrations at the structure's natural frequency. This scenario is worst-case and much more impactful than a blast vibration in southern Florida.

Siskind and Stagg [2000] studied actual quarry blast vibrations in Dade County, Florida (Section 6.3). During this study, the authors monitored the structural response by measuring ground vibration at the base of the residential structures in the study and at corners and midwalls of the structures internally. They found that the high-frequency portion (typically 8–30 Hz, which overlap the structure's natural frequency range) of the ground vibration produces the highest amplification factors in the structure. Amplification factors were approximately 2–4 times the driving ground vibration, which was similar to those found by the USBM when conducting the RI 8507 study. The low-frequency, long-duration portion of the wave (typically 2–4 Hz) had a lower amplification factor of approximately 1–2 times the driving ground vibration. Their results support the conclusions discussed in the previous paragraph by showing that the long-duration, low-frequency component of the waveforms in Florida are not causing a higher structural response than what the USBM found when writing RI 8507 because the vibration frequencies are lower than the structural natural frequency range. Therefore, the RI 8507 ABLC applies to long duration vibrations, such as those that occur in southern Florida.

4.2 LOW-FREQUENCY VIBRATIONS

Ground motions with significant energy lower than 4 Hz were not recorded in the RI 8507 study, so the RI 8507 authors included a conservative constant displacement limit of 0.03 in below 4 Hz, which is shown in Figure 4-1. The following points describe their reasoning for the 0.03 in displacement limit:

- When briefly discussing the ABLC in Appendix B, the USBM states that "an ultimate maximum displacement of 0.03 in is recommended."
- In RI 8507, the USBM states that displacement would only be a concern at low frequencies of less than 4 Hz [Siskind et al., 1980].
- RI 8507 also mentions that the state of Pennsylvania used a 0.03 in displacement as a maximum safe blasting criterion for vibration frequencies below 10 Hz at one point in time [Siskind et al., 1980].
- Crum and Pierce [1995] suggest that the RI 8507 safe level criteria used the 0.03-in constant displacement because ground vibrations of identical particle velocity will have higher displacements as frequency decreases.

Since RI 8507 was published, research has been conducted that has focused on lower frequency vibrations.

In 1987, the USBM researched low-frequency vibrations (4–8 Hz) for over 9 months in Indiana [Siskind et al., 1987]. This study included seven residences, over 500 blast records, five heavily instrumented production blasts, and two heavily instrumented single-charge blasts. The USBM conducted level-loop surveys to understand if the residential structures had any settlement over a 7 month period. The surveys showed that four of the eight structures showed less distortion (difference from base point) after the 7 month survey than they did after the initial survey. Therefore, the USBM stated low-frequency vibrations have no negative effect on the residential structures.

In 1993, the USBM produced RI 9455, *Blast Vibrations and Other Potential Causes of Damage in Homes near a Large Surface Coal Mine in Indiana* [Siskind et al., 1993]. The USBM conducted 1,700 inspections, which occurred before and after every blast and included 6 homes with 45 inspection points inside the 6 homes. Each inspection point was examined 38 times during the study. The USBM used a 7 power optical comparator and side lighting to identify cracks and crack tips and inspected areas of high risk and cracks in wallboard and masonry. Most of the USBM's recordings had frequencies between 4 and 8 Hz. The lowest reported peak particle frequency was 1.75 Hz (at 0.036 in/sec particle velocity), which is similar to the frequencies and particle velocities that RESPEC recorded in Florida. The USBM did not find any cracks that extended during blasting. The USBM also identified foundation responses to soil and water/temperature/humidity interactions as the largest source of structural influence, which is consistent with the recorded cyclic behavior of cracks, rather than blast-induced permanent crack change.

Pierce et al. [1996] produced a study titled *Assessment of Low-Frequency Blast Vibrations and Potential Impacts on Structures*. In the study, one residential structure had a natural frequency range of 3.5–9.4 Hz and averaged 5.3 Hz and 5.1 Hz in two orthogonal, horizontal directions. This dataset included 35 reported blasts with driving ground-vibration frequencies ranging from 2.7 to 22.2 Hz. The authors only observed two crack changes from a single blast, where one crack opened 0.05 millimeters (mm) and one crack closed 0.05 mm. The ground-vibration event was 1.28 in/sec at 5.6 Hz in the transverse direction. Vibrations of up to 6.0 in/sec were recorded, but no other crack changes were noticed.

The 1996 work by Pierce et al. was continued after the closure of the USBM by Crum [1997] as part of a contract with the US Office of Surface Mining. In total, the USBM-originated study included monitoring 46 blasts with over 350 pre- and postblast inspections that involved ten residential structures. The data that the authors collected showed vibration particle velocity amplitudes that ranged from 0.04 to 6.0 in/sec with frequencies between 2.5 and 80 Hz. The study included one residential structure that was located in the Arvida neighborhood outside of Miami, Florida. Damage was only observed on two occasions, both of which were cosmetic cracking and located in Indiana. In both cases, driving ground vibrations were higher than the minimum RI 8507 safe level criteria.

The Pierce et al. [1996] and Crum [1997] studies support the claim that residential structures do not amplify low-frequency vibrations (below 4 Hz), so vibrations are safer below structural resonance than if they were at structural resonance (4–12 Hz). The studies further support that the limits described in RI 8507 ABLC are conservative

This last point, that structural response is not amplified below their resonant frequencies, was also shown in the Dade County Report [Siskind and Stagg, 2000]. The authors showed that structures in Dade County, Florida, have reduced amplification factors below the structural natural frequencies of the 4 to 12 Hz range found in RI 8507. The authors recorded amplification factors of 1–2 between 2 and 4 Hz rather than the 2–4 amplification factor range found by the USBM above 4 Hz in RI 8507. Crum and Siskind [1993] also support this point by using low-frequency laboratory tests from 3–6 Hz. The tests did not generate structure responses with amplification. Their laboratory tests were consistent with historical data from the USBM.

The 0.03 in constant displacement line in the ABLC unnecessarily reduces the particle velocity limits below 4 Hz because of the following factors:

- As shown earlier in this section, structures respond less to frequencies below 4 Hz than they do at their natural frequency (between 4 and 12 Hz). In other words, ground-vibration frequencies less than 4 Hz do not cause structural amplification.
- The 0.75 and 0.5 in/sec limits described in RI 8507 were for higher amplification factors in the natural frequency range of residential structures (4–12 Hz); in other words, residential structures could theoretically withstand higher than 0.75 and 0.5 in particle velocities below 4 Hz.

Therefore, the USBM applied an overly conservative 0.03 in displacement limit below 4 Hz. The 0.75 in/sec (for drywall) and 0.5 in/sec (for older plaster-on-lath) limits that were produced by the USBM probability analyses in RI 8507 are more than sufficient to ensure that vibration levels will not impact residential structures.

4.3 DAMAGE POINTS BELOW ALTERNATIVE BLASTING LEVEL CRITERIA LINE

When reviewing RI 8507, RESPEC noticed the differences between the safe levels determined from the probability analyses (Figure 2-6) and the safe limits shown in the ABLC (Figure 2-8). The USBM wished to connect the low-frequency limits of 0.75 and 0.5 in/sec to the high-frequency limits of 2.0 in/sec, so they used a 0.008 in constant displacement line [Dowding et al., 2018]. The RI 8507 authors used the following logic:

1. Response spectrum analysis showed that residential structures respond on displacement bounds (meaning residential structure response can be described by constant displacement, rather than constant particle velocity, as frequency content changes) in the 20 to 40 Hz range [Dowding, 1996; Dowding et al., 2018]. Therefore, the USBM decided to use a constant displacement line to connect the low-frequency limit to the high-frequency limit.
2. At a 2 in/sec particle velocity and 40 Hz, the constant displacement is equivalent to 0.008 in. The USBM used this rather than the constant displacement line that intersects 0.75 in/sec at 40 Hz for two reasons:
    a. If the USBM used the limit of 0.75 in/sec at 40 Hz to select the constant displacement line, the line would have been at 0.003 in.
        i. A 0.003 in constant displacement line would have intersected 2 in/sec at approximately 100 Hz.

ii. A 0.003 in constant displacement above 40 Hz would essentially make the particle velocity limit set at a constant displacement with particle velocity limits that are less than 2 in/sec.

iii. This limit would have been overprotective after the USBM showed that 2 in/sec is already restrictive above 40 Hz.

b. Structural response frequencies are 4–12 Hz for structural response (racking) and 10–25 Hz for midwall response, so a limit of 0.75 in/sec (and 0.5 in/sec for old plaster-on-lath) between 15 and 40 Hz was considered overly conservative. Therefore, the particle velocity limit above 15 Hz could be gradually increased so that the USBM could connect the limit line from 0.75 to 2 in/sec at 40 Hz.

3. The constant displacement line of 0.008 in intersects 0.75 in/sec at approximately 15 Hz and 0.5 in/sec at approximately 10 Hz, so this line fits relatively well with the residential natural frequencies identified by the USBM.

The derivation of the 0.008 in constant displacement portion of the limit line caused seven threshold damage points to lie within the safe limits under the 0.008 in constant displacement line of the ABLC; these damage points are shown in Figure 4-1. RI 8507 indicates that the damage points shown in the image are a compilation of all of the damage points from the studies used in RI 8507. Figure 4-1 (without the point identifiers) is taken from RI 8507's Figure 54.

Two of those points (S) in Figure 4-1 are from shaker tests from Bulletin 442 [Siskind, 1981]. Shaker data from artificially shaking single walls are not as reliable of a method for judging cosmetic cracking as using blast vibration excitation to strain an entire structure, so these points are suspect. Point D is the 0.56 in/sec at 12 Hz threshold damage point from Dvorak described in RI 8507. Dvorak data were identified as suspect because of the old instrumentation that the author used and the reliability or accuracy of the old studies. Few of Dvorak's data were published, and original time histories were lost. The four numbered points were from houses studied during the RI 8507 tests with plaster-on-lath (19, 27) and plaster-on-brick-on-lath (51).

RESPEC replotted the RI 8507 threshold data provided by Siskind [1981] in Figure 4-2 without the one anomalous point from Bulletin 442 on the ABLC. When plotted with modern computers, the replotted points under the ABLC (shown in Figure 4-3) look slightly different than the points plotted by the USBM in RI 8507. The four USBM damage points from old plaster-on-lath threshold damage observations appear in slightly different locations; however, these points are still below the 0.008 in constant displacement limit.

The literature review described in this section shows that the USBM had instances of threshold damage to old plaster-on-lath below the 0.008 in constant displacement line in the ABLC. The instances were either suspect data from shaker studies, old instrumentation studies with minimal confidence in the data, or from three older houses that the USBM studied that had plaster-on-lath construction. Therefore, the ABLC is an acceptable criteria to use when evaluating the potential impact blast vibrations could have on modern residential structures. If older pre-1950s plaster-on-lath (i.e., the structure has been subjected to long time periods of weathering and distortion) is in a residence in Florida, Table 2-6 (Table 13 of RI 8507) may be more preferable to use for particle velocity and frequency limits. The safe level limits in Table 2-6 are less restrictive for vibrations with frequencies less than 4 Hz, such as those encountered in southern Florida.

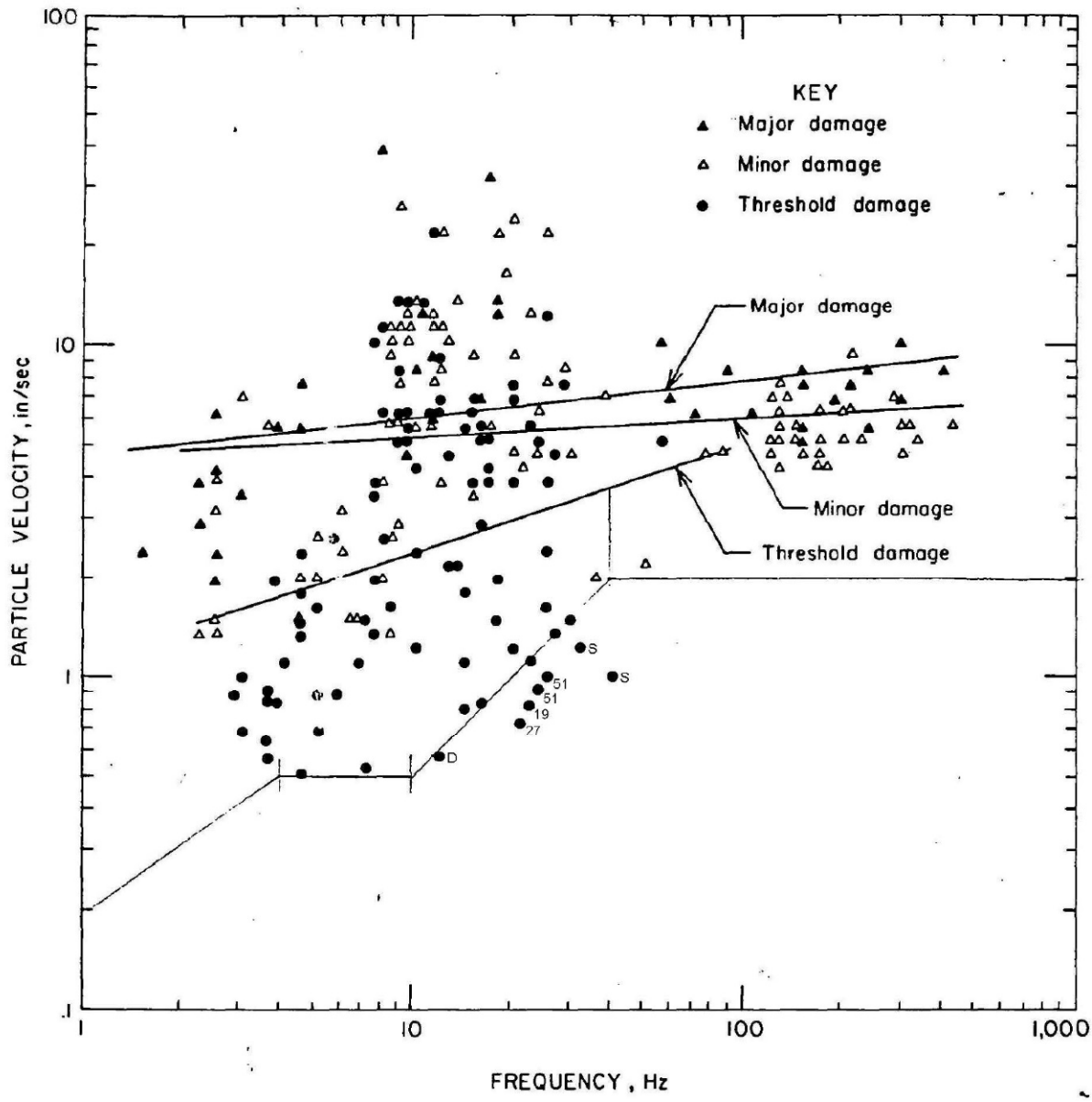

Figure 4-1. Report of Investigations 8507 Figure 54 With Threshold Damage Points Below the 0.008 Inch Constant Displacement Line Identified [Siskind et al., 1980].

Another point to discuss is the amount of nondamage vibration events that were recorded by the USBM during the RI 8507 study [Siskind et al., 1980]. RESPEC plotted each data point used in the RI 8507 analysis [Siskind, 1981] in Figure 4-3. Note the many nondamaged points above the ABLC.

4.4 SOIL RESPONSE

The USBM stated that "additional work on fatigue and special soil and foundation types may later justify stricter criteria" in RI 8507 [Siskind et al., 1980]. RESPEC worked to understand ground vibrations that can cause permanent ground strain, which is the limit where soils have permanent volume change or settlement. Primarily of interest are the minimum ground vibrations that can cause permanent ground strain.

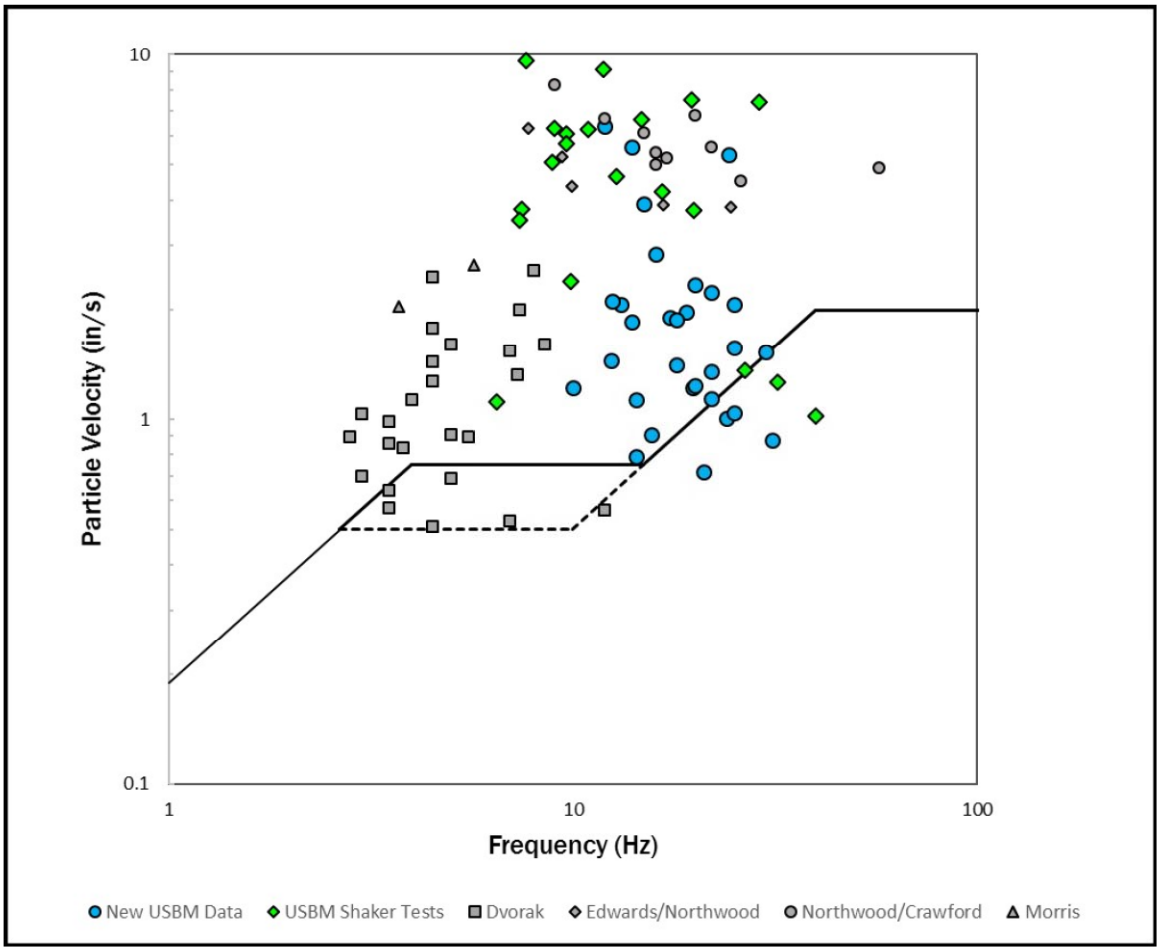

Figure 4-2. Report of Investigations 8507 Threshold Data Plotted on the Alternative Blasting Limit Criteria.

Past research has found that at least all of the following four conditions must be met for blast vibrations to cause soil to settle [Dowding et al., 2018]:

1. Ground vibrations must be over 0.5 in/sec
2. Soil must be clean, round-grained sand
3. Soil must be loose sand
4. Soil must be located below the water table.

The final three requirements for soil conditions describe the requirements for the weakest known soil or fill. Any other soils that do not fall under all three of the soil conditions (Conditions 2 through 4) would have greater strength than the weakest soils and, therefore, would require vibratory motions greater than 0.5 in/sec (Condition 1) to cause changes to the soil volume.

Borden et al. [1994] agrees with these conditions and states that settlement is not controlled by frequency and the degree of saturation of soil specimens. Settlement is controlled by vibration amplitude, soil properties, and confining pressure. Borden et al. observed minimum shear strain amplitude at 0.01 percent (100 µin/in) for the lowest possible confining pressure in the weakest soil. He used 1,000 cycles to arrive at this conclusion and show that soil must be subjected to many more vibratory cycles than could exist in a blast vibration.

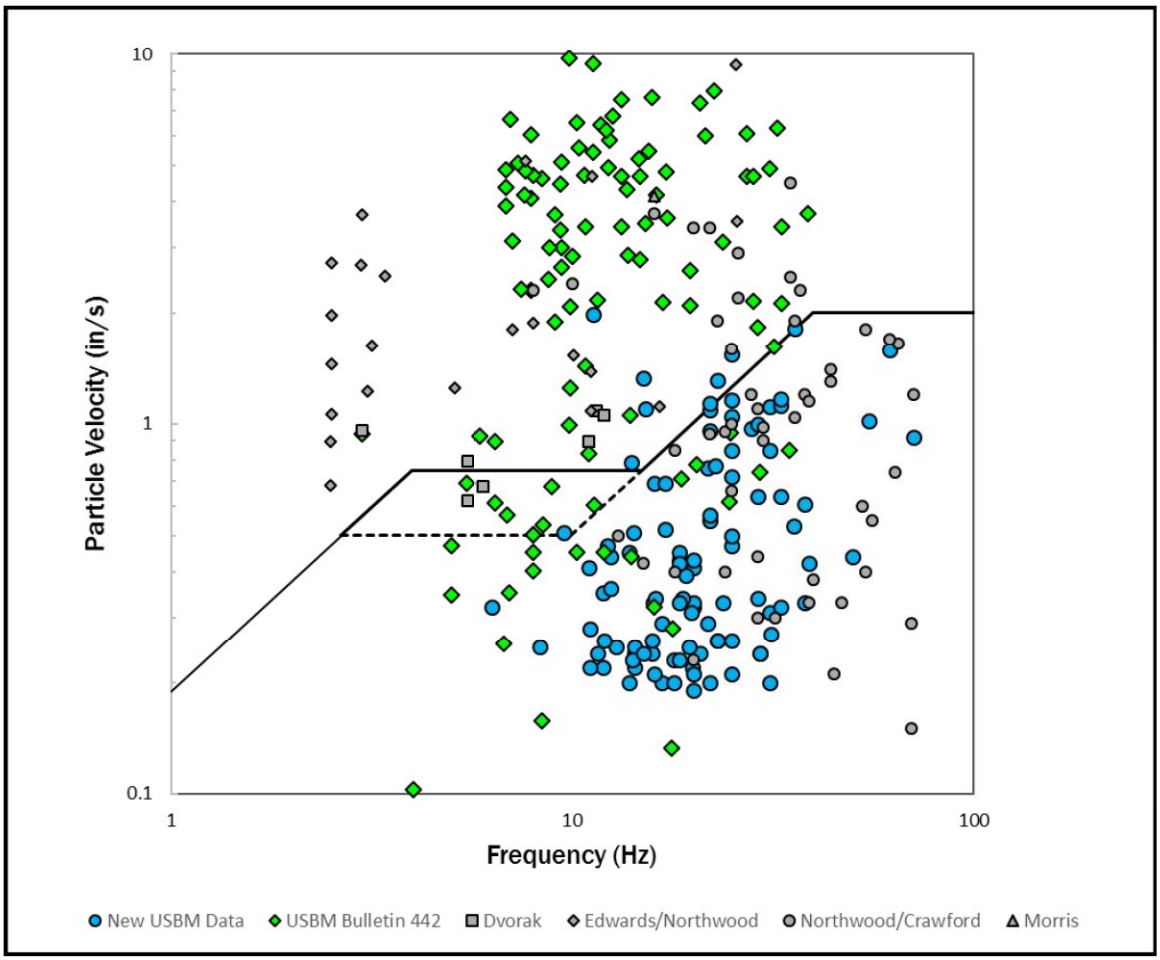

Figure 4-3. Nondamage Points Collected by the US Bureau of Mines During the Report of Investigations 8507 Study.

Diaz-Rodriguez and Lopez-Molina [2008] completed a literature review of research from previous studies on the strain thresholds for volumetric material change. Essentially, materials exhibit a minor reaction to stress where the soil does not experience any long-term effects; this reaction occurs because of strains of approximately 0.001 to 0.005 percent. Materials begin to experience volumetric changes to strains at levels of 0.01 percent [Stokoe and Lodde, 1978; Anderson and Richart, 1976; Kim and Novak, 1981], and this value agrees with the limits found by Borden et al. [1994].

The weakest (least dense) soils have a 0.75 void ratio (ratio of volume of voids to volume of solids), which is the lowest density that a soil can have [Holtz and Kovacs, 2010; Dowding et al., 2018]. Approximately 3 ft of cover is the lowest confining stress, which, at 120 pounds per cubic foot (lb/ft^3) (typical soil weight), is 2.5 pounds per square inch (psi) [Stokoe and Cox, 2014]. At this point, shear wave velocity is approximately 400 feet per second (ft/sec) for Ottawa sand, which is the weakest, most round-grained sand [Shin and Santamarina, 2013]. This shear wave velocity cannot be less in soil [Hardin and Richart, 1963]. Note that Ottawa sand is the most round-grained uniform sand and is used by many organizations for calibration purposes.

We can estimate the minimum shear wave PPV that would be required to overcome 0.01 percent shear strain in the weakest soils, meaning the minimum PPV that can cause movement in the weakest soils, by using the following equation:

$$\gamma = \frac{\dot{u}_s}{c_s} \tag{4-1}$$

where γ is shear strain, $\dot{u}_s$ is the shear wave particle velocity, and c_s is the shear wave propagation velocity (or compressive or longitudinal propagation velocity). The equation can be rewritten to solve for minimum shear particle velocity that can settle the weakest soil as follows [Dowding, 1996]:

$$\dot{u}_s = \gamma \times c_s \tag{4-2}$$

$$\dot{u}_s = 0.0001 \times 400 \text{ ft/sec} \times 12 \text{ in/ft} \tag{4-3}$$

$$\dot{u}_s = 0.5 \text{ in/sec} \tag{4-4}$$

Therefore, as a theoretical approximation, 0.5 in/sec longitudinal particle velocity is the minimum particle velocity that can cause the weakest soil material to have volumetric change (i.e., settlement), where the weakest soil is clean, loose sand located below the water table. Fill and soil material cannot be weaker or have less vibratory resistance than clean, loose, round sand grains [Shin and Santamarina, 2013; Dowding et al., 2018]. This type of soil highlights a worst-case scenario. If the grain size distribution of the soil shows that clay or silt-sized fines are present in the sandy soil, the soil's resistance to densification increases.

Siskind [2000] cites studies where the lowest known examples of vibration-induced settling occurred in saturated, cohesionless sand at equivalently 2.5 in/sec at 4 Hz after 80 cycles, which is nowhere near the amplitude or number of cycles experienced during blast vibration events in Florida. The geology report provided in Appendix H describes the soil types found in Florida. None of those soil types are weaker than the clean loose sands discussed in this section.

In another study, Hadala and Peterson [1993] conducted a soil analysis in Indiana to determine if blast vibrations affect soil settlement at three different sites. Hadala and Peterson measured vibrations with 0.1 in/sec particle velocity and estimated a 0.002 percent strain; the particle velocity levels in their study are similar to those RESPEC measured in Florida. Hadala and Peterson tested the strain levels at 5 and 20 times those measured levels. The authors could find no evidence to demonstrate that the vibrations were causing settlement.

As shown in Chapter 3.0, RESPEC calculated the transverse seismic propagation velocity to be 13,200 ft/sec. Using the transverse component propagation velocity as an estimate for the shear wave propagation velocity and the seismic propagation velocity measured at the residence in Florida, the minimum PPV needed to settle the weakest soil is 15.8 in/sec. The vibrations that RESPEC recorded in Florida is nowhere near this value, so settling or accelerated settling of the soil are likely not caused by blast vibrations based on this analysis.

This analysis does not mean that vibration limits should be set at 0.5 in/sec in Florida, only that the vibrations experienced in Florida are so low and have so few cycles that even the weakest soil would not be settled because of the vibrations that RESPEC recorded. In Florida, any lime material may recement itself and thereby further increase shear strength [Dowding et al., 2018]. Additionally, if the grain size distribution of the soil shows that clay or silt-sized fines are present in the sandy soil, the resistance to soil densification increases. This scenario can also be true of fill material after placement. In summary, the vibration data provided by the FSFM and the vibrations that RESPEC recorded in Florida are much lower than the minimum vibration that can cause soil settlement.

4.5 FLORIDA RESIDENTIAL STRUCTURES

This section addresses the following three points. First, RESPEC needed to determine if residential structures in Florida are well represented on a square-footage basis. RESPEC then needed to understand if the ABLC applies to atypical structures. Third, RESPEC presents two studies that specifically detail blast vibrations measured at Florida residential structures.

4.5.1 STRUCTURE DIMENSIONS

The majority of structures that RESPEC saw during site visits to Florida were one or two stories, so the RI 8507 data support these structures from a height standpoint. Further study was needed to identify if the RI 8507 study represents Florida residences on a square-footage basis. RESPEC summarized the dimensions of the structures that were represented by the RI 8507 data in Section 2.3.1. RESPEC conducted a geographic information system (GIS) review of the neighborhoods surrounding the representative construction materials mining operations to ensure that the residences were represented by RI 8507 on a square-footage basis.

1. The average home square footage for residences in Florida was determined by using Zillow's publicly available data [Zillow, 2018]. The metrics for the average home price, and average price per square foot were used to back-calculate an average square footage.
2. The average square footage was then joined to zip code data that were obtained from the US Census Bureau online clearinghouse to achieve average home square footage by zip code [US Census Bureau Geography, 2018]. The zip codes within an arbitrary 3 mile radius of each site were selected for use in this study.
3. The construction material mine site boundaries were downloaded from the 2014 Florida Department of Environmental Protection (DEP) mandatory nonphosphate mining sites [Florida DEP, 2014]. These data are the most recent available.
4. Finally, the average square footage for houses within the arbitrary 3 mile radius of each mine site was calculated. Table 4-1 details the findings of this brief study and Figure 4-4 is an example of the GIS work.

The average square footage for each zip code ranged from 1,430 to 2,850 square feet (ft^2), with an average of 1,900 ft^2. The structures that were used in RI 8507 ranged from 150 to 8,600 ft^2 and averaged 1,600 ft^2, so the Florida residences were well represented by RI 8507 on an average square-footage basis. Note that areas with low population densities are not tracked in Zillow's datasets. For sites within these low-density areas, the average home square footage for the entire state of Florida (1,731 ft^2) was used.

Table 4-1. Average Square Footage of Residential Structures in Zip Codes Within a 3 Mile Radius of Each Representative Mine Site

Site Name	Zip Code	County	Average Square Feet
Branford Quarry	32024	Columbia	1,968
Branford Quarry	32038	Columbia	1,748
Brooksville Quarry	34609	Hernando	1,941
Brooksville Quarry	34608	Hernando	1,604
Brooksville Quarry	34601	Hernando	1,840
Brooksville Quarry	34613	Hernando	1,999
Brooksville Quarry	34604	Hernando	1,801
Brooksville Quarry	34614	Citrus	1,962
Krome Quarry	33186	Miami-Dade	1,700
Krome Quarry	33196	Miami-Dade	1,903
Krome Quarry	33193	Miami-Dade	1,459
Krome Quarry	33185	Miami-Dade	2,348
Krome Quarry	33182	Miami-Dade	2,081
White Rock Quarries	33027	Broward	1,874
White Rock Quarries	33015	Miami-Dade	1,430
White Rock Quarries	33178	Miami-Dade	1,887
White Rock Quarries	33014	Miami-Dade	1,525
White Rock Quarries	33018	Miami-Dade	1,854
White Rock Quarries	33029	Broward	2,288
White Rock Quarries	33332	Broward	2,849
West Lakes/University Lakes Mines	33928	Lee	1,841
West Lakes/University Lakes Mines	33913	Lee	2,044
Marianna Mine	32448	Jackson	1,731

4.5.2 ATYPICAL STRUCTURES

Aimone-Martin et al. [2003] studied structural response to ground vibration from surface coal mines. As part of the study, the authors instrumented atypical structures to understand the response of residences of unusual character. Included in the response were log structures, stone structures, mine camp structures, wood frames with diagonally sheathed walls and CMU-perimeter foundations, and premanufactured trailer homes. All of these atypical structures were represented by the vibration limits developed by RI 8507. The study found that only two structures had slightly higher amplification factors (5.0 and 4.6) because ground vibrations were at or near the structural frequencies of 4–7 Hz, and one of the structures did not have an upper bond beam along the top of the walls, so it was free to respond without typical wall constraints. Aimone-Martin et al. showed that the RI 8507 vibration limits apply to most atypical structures; therefore, RI 8507 can be applied to the majority of atypical residential structures that were not studied in RI 8507.

Siskind [2000], Aimone-Martin et al. [2003], and Mann [2003] discuss the impact of blast vibrations on trailer homes. The trailer homes are unique, in part, because the two longitudinal walls are typically much longer than the perpendicular walls [Aimone-Martin et al., 2003]. These structures were not well

represented in the RI 8507 data but reacted similarly to the homes that were used to develop RI 8507, except for their vertical response, which can be strong because of the lack of founding walls beneath the exterior walls [Aimone-Martin et al., 2003 and Mann, 2003]. Trailer homes are also transported on the road, where vibrations are typically higher than most residences would experience next to even a large, active mine [Siskind, 2000]. Siskind [2000] states that vibrations on the road (caused by driving) were measured and shown to exceed 6 in/sec. Vibration strains were equivalent to 2 in/sec particle velocities at low frequencies.

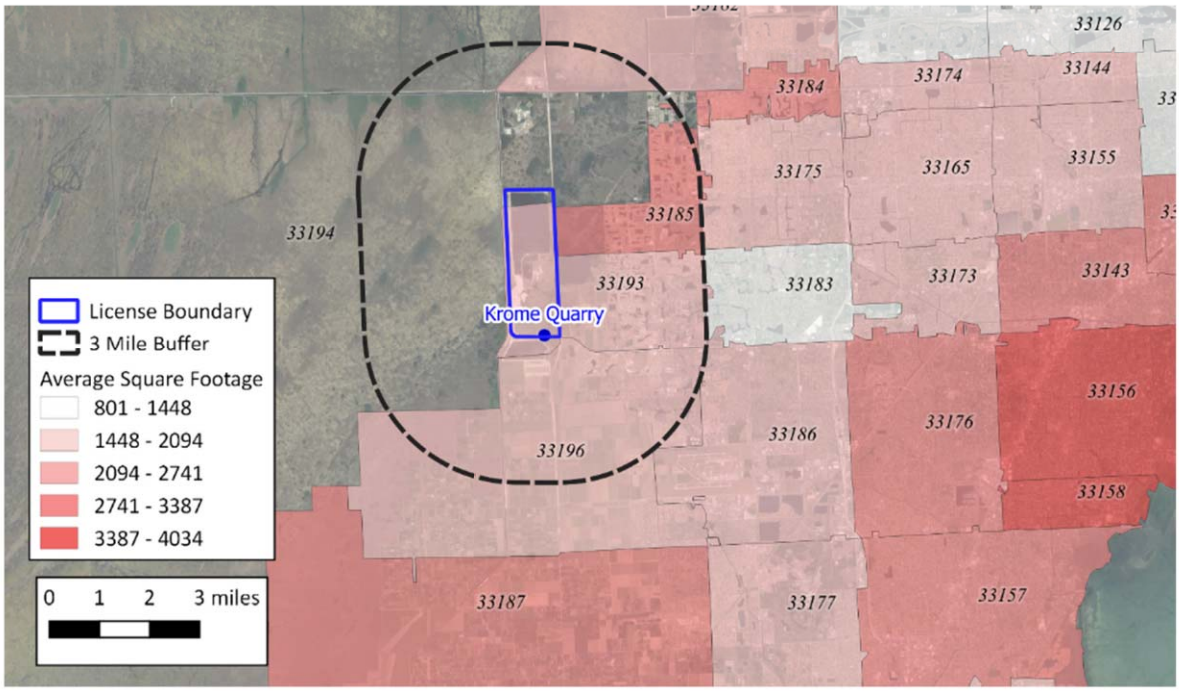

Figure 4-4. Image Showing Florida Department of Environmental Protection Construction Materials Mine Boundaries, 3 Mile Radius Delineations, and Average Residential Square Footage by Zip Code for Southeastern Florida Representative Construction Materials Mines.

4.5.3 FLORIDA RESIDENCES

Crum [1997] verified that the natural frequency ranges (4–12 Hz) that were used to develop the RI 8507 ABLC apply to Florida residences when he studied a block and concrete home in Florida. The residence had higher damping and was stiffer than wood-frame homes; however, the natural frequency was still in the typical range of residential structural frequencies at 11 Hz [Crum, 1997], because masonry adds mass to structures. However, the added mass is partially compensated for by the added stiffness [Siskind, 2000].

The second study was the Miami-Dade County study by Siskind and Stagg [2000]. The authors showed that the structures in Dade County, Florida, have typical amplification factors of those found in the RI 8507 study (2–4 amplification factor in 4 to 12 Hz range). Florida residences do not amplify blast vibrations below the structural natural frequencies of the 4 to 12 Hz range found in RI 8507.
The houses that were studied by the USBM were old, degraded structures with years of previous nonblasting damage [Dowding et al., 2018]. These structures were significantly compromised and already highly strained. Because the quality of plaster and wallboard materials has improved since the 1940s and 1950s, the USBM-studied houses were weaker than the newer Florida structures with

coatings of plaster on CMUs. Therefore, Florida residences are more resistant to structural flexure, which is the mechanism that causes drywall or plaster cracking. RI 8507's ABLC is, from this perspective, overprotective of Florida residential structures.

4.6 SUMMARY OF THE ALTERNATIVE BLASTING LIMIT CRITERIA LIMITS AND ITS APPLICATION TO FLORIDA

This study found that the ABLC that was presented by the USBM in RI 8507 represents Florida well, even though a handful of factors make Florida blast vibrations unique from other areas of the US. The following points summarize RESPEC's findings with respect to the development of the ABLC and its application in Florida.

- Duration and Frequency
  - Florida blast vibrations have uniquely long-duration, low-frequency waveforms with PPVs that are significantly below the ABLC levels. Structures are not affected by the long duration at these frequencies for two reasons:
    - Structures can only be affected by repeated sinusoidal pulses at residential structure natural frequencies.
    - Blast vibrations are complex, transient waveforms and do not repeat cycles at uniform frequencies for extended periods of time.
  - Below 4 Hz, residential structures do not amplify blast vibration signals; therefore, the 0.03 in constant displacement line in the ABLC is overly conservative.
- Points Below the 0.008 In Constant Displacement Line
  - The USBM found threshold damage points below the 0.008 in constant displacement line in the ABLC.
  - These threshold damage points were attributed to two causes: two old studies that cannot be defended (antiquated equipment and analysis methods) and old plaster-on-lath damage observations collected during the RI 8507 study.
  - The ABLC, therefore, applies to all modern construction homes.
- Soil Response
  - The weakest soil can settle under the following conditions:
    - Ground vibrations must be over 0.5 in/sec
    - Soil must be clean round-grained sand
    - Soil must be loose sand
    - Soil must be located below the water table.
  - These conditions do not exist in Florida; however, these conditions show that the vibrations that RESPEC recorded at the six representative mines cannot cause settlement of the residences.
- Florida Residential Structures
  - Florida structures are represented by the RI 8507 data from multiple standpoints.
  - Recent studies have shown that Florida residences have similar structural natural frequencies to those found in RI 8507.
  - House sizes in Florida are similar to those studied by the USBM in RI 8507.
  - Atypical structures have a similar response to blast vibrations as those studied by the USBM in RI 8507.
  - Neither Florida study found cracking that could be attributed directly to blast vibrations.

5.0 BLAST VIBRATION LIMITS AND REGULATIONS IN FLORIDA

RESPEC reviewed the Florida blast vibration codes and regulations, including regional regulations and statewide regulations. We also reviewed federal regulations that govern blast vibrations through the US Office of Surface Mining, Reclamation, and Enforcement (OSMRE) because the OSMRE is the only federal regulatory agency that governs blast vibrations in the mining (coal) industry. The codes and regulations are included below:

- Florida Statutes
- Florida Administrative Code (FAC)
- Florida Department of Transportation Standards
- Miami-Dade County Code of Ordinances
- Lee County Development Code
- OSMRE.

5.1 2017 FLORIDA STATUTES

RESPEC reviewed the 2017 Florida Statutes [Florida Statutes, 2017] with respect to the blast vibration requirements because the Contract FM410 requires RESPEC to review the "current blast vibration limits set by statute." Florida Statutes Chapter 552, *the Manufacture, Distribution, and Use of Explosives*, applies to any operation that uses explosives to extract limestone and sand for the commercial sales of construction aggregates, sand, cement, and road-base materials. Florida Statutes Chapter 552 covers the maintenance of records, the FSFM duties with respect to construction material mining activities, and legislative findings. RESPEC's review focused on ground-vibration limits. Other subjects in the Florida Statutes are not discussed.

5.1.1 552.112 MAINTENANCE OF RECORDS BY USERS: INSPECTION

Chapter 552.112 states:

> *(2) Such records shall include, but not be limited to, invoices or sales tickets from purchases, location of blasting sites, dates and times of firing, the amount of explosives used for each blast or delay series, the name of the person in charge of loading and firing, and the license or permit number and name of the person making such entry into the records. Such records shall be maintained by users for a period of 5 years.*

This statute requires permit holders to record some information concerning the blast and retain those records for 5 years. The statute does not require any information concerning the ground vibrations, such as seismograph location, ground-vibration particle velocity amplitudes and frequencies, recording time, seismograph technician, and calibration certificate.

5.1.2 552.25 MUNICIPAL AND COUNTY ORDINANCES, RULES, AND REGULATIONS

Chapter 552.25 states:

> *Nothing contained in this chapter shall affect any existing ordinance, rule or regulation pertaining to explosives of any incorporated city, town, county, or other local governmental*

entity in this state not less restrictive than the provisions of this chapter and rules promulgated pursuant thereto, or affect, modify or limit the power of such incorporated cities, towns, counties, or other local governmental entities to make ordinances, rules or regulations hereunder pertaining to explosives within their respective corporate limits.

This statute allows cities, towns, and counties to have ordinances that limit blasting vibrations. Florida cities, towns, and counties may have different ordinances than what the FSFM enforces.

5.1.3 552.30 CONSTRUCTION MATERIAL MINING ACTIVITIES

Chapter 552.30 states:

The State Fire Marshal shall establish statewide ground vibration limits for construction materials mining activities which conform to those limits established in the United States Bureau of Mines, Report of Investigations 8507, Appendix B - Alternative Blasting Level Criteria (Figure B-1). The State Fire Marshal may, at his or her sole discretion, by rule or formal agreement, delegate to the applicable municipality or county, the monitoring and enforcement components of regulations governing the use of explosives, as recognized in this section, by construction materials mining activities. Such delegation may include the assessment and collection of reasonable fees by the municipality or county for the purpose of carrying out the delegated activities.

This statute implies that all of the construction materials mining activities must conform to the RI 8507 ABLC; however, FAC 69A-2.024 restricts ground-vibration limits more than the ABLC (see Section 5.2.2.5), which means that two documents with differing vibration limits could apply to construction materials mining activity in Florida.

5.1.4 552.34 LEGISLATIVE FINDINGS: PUBLIC PURPOSE

Chapter 552.34 states:

Construction materials mining activities require the use of explosives to fracture the material prior to excavation.

The statement implies that banning explosives use for mining construction materials is against the Florida Statutes.

5.2 FLORIDA ADMINISTRATIVE CODE

RESPEC reviewed FAC 69A-2.024 *Construction Materials Mining Activities Vibration Regulations* [FAC, 2010]. This code applies to any operation that uses explosives to extract limestone and sand for the commercial sales of construction aggregates, sand, cement, and road-base materials. This regulation is in addition to the Florida Statutes Chapter 552 *Manufacture, Distribution, and Use of Explosives*. Other subjects in FAC 69A-2.024 will not be discussed.

The FAC references the following external documents:

- RI 8507
- National Fire Protection Association Standard 495 (NFPA 495), 1996 Edition [National Fire Protection Association, 1996]

- International Society of Explosives Engineers *17th Edition Blaster's Handbook* [ISEE, 1998]
  - Appendix K Seismograph Field Practice Guidelines
  - Pages 541–544 *Seismograph Components*.

5.2.1 GROUND-VIBRATION LIMITS

FAC 69A-2.024 (4) (a) 2. states:

> *The U.S. Bureau of Mines Report of Investigations No. 8507, Appendix B – Alternative Blasting Level Criteria (Figure B-1) and Table 8-1.3, established in Section 8-1 of the National Fire Protection Association Standard 495, 1996 Edition are hereby adopted and incorporated by reference.*

The ground-vibration limits in FAC 69A-2.024 are dictated by RI 8507, *Appendix B – Alternative Blasting Level Criteria (ABLC)* and Table 8-1.3 in Section 8-1 of the NFPA 495, 1996 Edition. RESPEC's review of the FAC and the referenced documents highlights the following points with respect to these two documents:

- In Section (4)(a)2 of the FAC 69A-2.024, the ABLC (Figure 2-8) and Table 8-1.3 of the NFPA 495 1996 Edition are adopted and incorporated by reference; however, the NFPA 495 1996 Edition does not include Table 8-1.3. The NFPA 495 1996 Edition does have Subsection 8-1.3 that references Tables 8A and 8B, which are shown in Figures 5-1 and 5-2 of this document. Of the two tables, the FAC is likely referencing Table 8A. Sections (4)(b)1 and (4)(b)2 of the FAC requires at least one seismograph to be used for every blast, and Table 8A identifies PPV limits by distance from the blasting site. Table 8B is likely not the table that the FAC is referencing because this table is only used if an operation is not monitoring with a seismograph or can be used to determine if an operation needs to use a seismograph.
- Table 8A from the NFPA 495 1996 Edition and the RI 8507 ABLC are two separate criteria. Table 8A simplifies the vibration limits as a function of distance but restricts vibration amplitudes more than the ABLC. The FAC citation implies that both standards are used to limit vibrations. A better requirement would be for an operation to have an option of using one or the other if both criteria are to be cited in the Florida rules.
- Under FAC 69A-2.024 *Construction Materials Mining Activities Ruling Section (7) Blasting Activities Reporting*, mines are only required to report, at a minimum, the seismograph location and the PPV and sound decibels, with respect to blast vibrations, during a blast event. The ABLC requires particle velocity and associated frequency, so the minimum amount of seismograph information that is required to be reported in the FAC is not enough to determine if a mine is in compliance by using the ABLC.

Table 8-A Peak Particle Velocity Limits

Distance from blasting site	Maximum allowable peak particle velocity[1]
0 to 300 ft (91.4 m)	1.25 in./sec (31.75 mm/sec)
301 to 5000 ft (91.5 m to 1524 m)	1.00 in./sec (25.4 mm/sec)
5001 ft (1525 m) and beyond	0.75 in./sec (19 mm/sec)

[1] Peak particle velocity shall be measured in three (3) mutually perpendicular directions, and the maximum allowable limits shall apply to each of these measurements.

Figure 5-1. Table 8A From the National Fire Protection Association 495 1996 Edition [National Fire Protection Association, 1996].

Table 8-B Scaled Distance Equations

Distance from blasting site	Scaled Distance* Equation
0 to 300 ft (91.4 m)	W (lb) = (D (ft)/50)^2 or W (kg) = (D (m)/22.6)^2
301 to 5000 ft (92 m to 1524 m)	W (lb) = (D (ft)/55)^2 or W (kg) = (D (m)/24.9)^2
5001 ft (1524 m) and beyond	W (lb) = (D (ft)/65)^2 or W (kg) = (D (m)/29.4)^2

W = The maximum weight of explosives in pounds (or kilograms) that can be detonated per delay interval of 8 milliseconds or greater.

D = The distance in feet (or meters from the blast to the nearest dwelling, public building, school, church, commercial, or institutional building not owned, leased, or contracted by the blasting operation, or on property on which the owner has not given a written waiver to the blasting operation.

* To convert English Units of scaled distances (ft/16^2) to Metric units (m/kg^2) divide by a factor of 2.21.

Figure 5-2. Table 8B From the National Fire Protection Association 495 1996 Edition [National Fire Protection Association, 1996].

5.2.2 SEISMOGRAPH MONITORING REQUIREMENTS

5.2.2.1 FLORIDA ADMINISTRATIVE CODE

FAC 69A-2.024 (4)(b) states:

1. *Ground vibration shall be measured for every blast at the location of the nearest building that is not owned, leased, or contracted by the blasting or mining operation, or on property for which the owner has not provided a written waiver to the blasting operations, up to a maximum of one mile.*
2. *If there are no such buildings within one mile, measurement shall be made at one mile in the direction of the nearest such building.*
3. *If there is a building that is not owned, leased, or contracted by the blasting or mining operation, or on property for which the owner has not provided a written waiver to the blasting operations in a direction 90 to 270 degrees from the direction of the nearest building specified in subparagraph (4)(b)1., above, and that building is no more than*

500 feet farther than the nearest building, measurement shall also be made at the nearest of those buildings.

Section (4)(b) determines the distance at which monitoring is required. The rule states that the mine is required to set up at least one seismograph for every blast that needs to be at the nearest building that is not owned by the mine site if the house is a maximum of 1 mile away. If the nearest building is beyond 1 mile, the seismograph must be placed 1 mile from the blast. Requiring that a seismograph be placed at a maximum distance of 1 mile does not appear to have any scientific backing.

5.2.2.2 FLORIDA ADMINISTRATIVE CODE 69A-2.024 (4)(C)2

Measurements shall be taken and equipment shall meet specifications of and be installed in accordance with the International Society of Explosives Engineers Blaster's Handbook, 17th Edition, Copyright 1998.

The ISEE *17th Edition Blaster's Handbook* is no longer in print. The 17th edition also only provides specifications on how to install a seismograph [ISEE, 1998] but does not give seismograph specifications.

5.2.2.3 FLORIDA ADMINISTRATIVE CODE 69A-2.024 (4)(C)4

When the use of explosives occurs within 2 miles of an urban development, measurements shall be collected and reported by an independent seismologist.

An urban development is defined as "a residential subdivision containing 25 or more occupied residences within the local urban development boundary." No science supports requiring an independent seismologist only when an urban development is 2 miles away from the use of explosives. Currently, no scientific reasons exist to restrict blasting operations because of a residential subdivision that contains 25 or more occupied residences from a structural analysis standpoint.

5.2.2.4 FLORIDA ADMINISTRATIVE CODE 69A-2.024 (7)

FAC 69A-2.024 (7) contains a list of minimum required information that needs to be reported when blasting at a construction materials mine. The only seismograph information required in this list is the location of each seismograph (*s*), PPV (*t*) in in/sec, and Sound decibels (*u*). The RI 8507 ABLC can only be used with particle velocity and associated frequency, and frequency is not required to be recorded in the FAC.

5.2.2.5 FLORIDA ADMINISTRATIVE CODE 69A-2.024 (15)

(a) Based upon the safe level of blasting vibrations for houses as shown in Figure B-1, United States Bureau of Mines, Report of Investigations 8507, notwithstanding the limits in subsection (4), above, the use of explosives within two miles of an urban development, as defined in paragraph (2)(e), above, shall not exceed a peak particle velocity of more than 0.5 inches per second due to the potential existence of plaster on lath construction.
(b) Measurement of such ground vibration levels shall be made consistent with subparagraph (4)(c)2., above, at the nearest occupied residential structure within the urban development, which structure is not owned, leased, or contracted with the blasting or mining operation.

RI 8507 does not suggest using a limit of 0.5 in/sec with no frequency component for plaster-on-lath construction or for housing developments with 25 or more houses. For old plaster-on-lath, RI 8507

suggests that ground vibrations should be limited to 0.5 in/sec at frequencies of 40 Hz or lower and limited to 2.0 in/sec at frequencies of 40 Hz or higher because these limits have a very low probability of damaging old plaster-on-lath construction. For any other construction, even newer residences with plaster, RI 8507 increases the limit to 0.75 in/sec at frequency of 40 Hz or lower and 2.0 in/sec at frequencies of 40 Hz or higher (or the ABLC).

Figure 5-3 highlights another side effect of FAC 69.2.024(15). The urban development requirement of a blanket 0.5 in/sec limit means that any particle velocity pulse with frequencies below around 2.5 Hz (within red dash triangle) is restricted less than under the ABLC limits

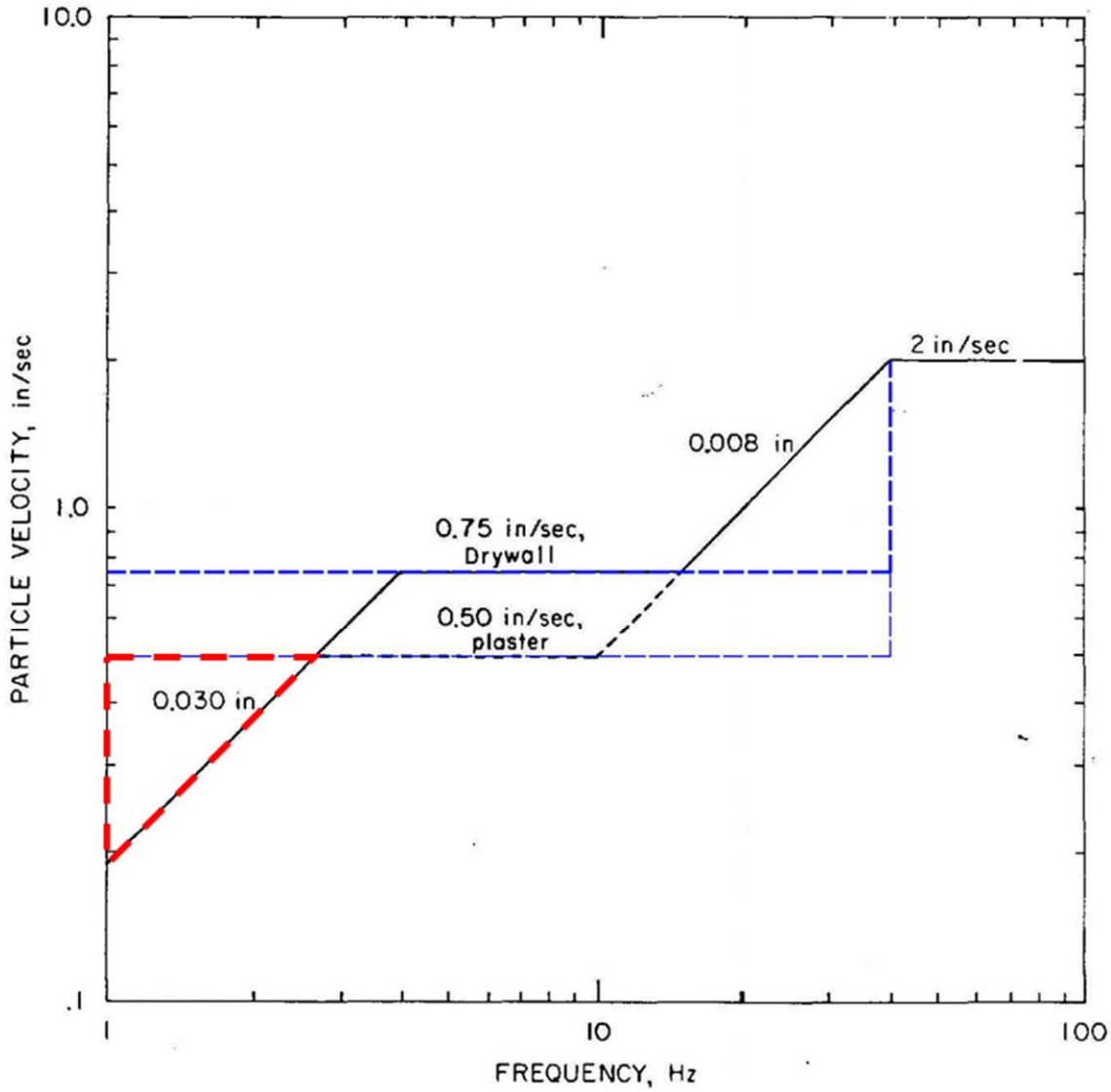

Figure 5-3. Alternative Blasting Level Criteria and Safe Levels of Blasting Table Combined With the Region Under 0.5 Inches Per Second Highlighted.

5.3 FLORIDA DEPARTMENT OF TRANSPORTATION STANDARD SPECIFICATIONS FOR ROAD AND BRIDGE, JANUARY 2016

RESPEC reviewed the Florida Department of Transportation (FDOT) standard specifications for roads and bridges, January 2016 [FDOT, 2016], which govern the blasting for FDOT projects. RESPEC reviewed this document to determine if Florida construction mining regulations are still current with respect to other governing bodies in Florida. The document was only reviewed for ground-vibration limits.

5.3.1 108-2.1.5 SETTLEMENT SURVEY AND MONITORING REQUIREMENTS

This standard requires settlement monitoring during the blast. An engineer is required to approve the number and location of blast vibration monitoring points. The survey records elevations to 0.001 ft. If a movement of 0.005 ft occurs or the structure is damaged, the construction operation that is affecting the structure is stopped. Once the operation is stopped, the operations must immediately backfill open excavations and notify the engineer. An engineer-accepted correction plan is also required if movement is detected.

Settlement monitoring could be a reasonable practice for close-in blasting; however, this practice would not apply to any scenario that RESPEC encountered during this study. This requirement only applies to close-in highway excavations where the ground could move into the opening, which causes settling of nearby structures to settle. Settling discussed in this standard could only occur very close to the excavation. Additionally, monitoring would need to be done during the blast at a high enough sample rate to capture the movement of the blast. The survey should not occur only before or after the blast. Finally, a requirement such as backfilling open excavations would not be feasible if it were applied to Florida construction mining activities.

5.3.2 108-2.2 VIBRATION MONITORING

A qualified specialty engineer is required to continuously monitor and record vibration levels at structures during blasting operations. Monitoring equipment must be capable of detecting velocities of 0.01 in/sec or less. The operation must obtain the engineer's approval for the amount and location of the seismographs. The vibration limit is set at 0.5 in/s or damage to the structure. If the limit is reached, the standard states, "immediately stop the source of vibrations, backfill any open excavations, notify the Engineer and provide a corrective action plan for acceptance by the Engineer."

These requirements are stricter than those in the FAC; however, no frequency component to the limit is set. Additionally, damage to the structure or how damage to the structure is measured is not defined. RESPEC believes that requiring a qualified specialty engineer is overly restrictive; however, some oversight to ensure that monitoring is performed to best practices and standards is a reasonable requirement.

5.4 MIAMI-DADE COUNTY, FLORIDA – CODE OF ORDINANCES

The Miami-Dade County Code of Ordinances, Chapter 13 *Explosives* governs blasting for the use of explosives in Miami-Dade County [Miami-Dade County, 2017]. RESPEC only reviewed the code for

ground-vibration limits. Key points in the Miami-Dade County Code of Ordinances that differ from the FAC include the following:

- Sets blanket limit of 0.75 in/s, regardless of frequency
- Requires monitoring three mutually perpendicular directions at one location 1 mile away from the blast if no houses are within 1 mile of the blast
- Implies that the operator is required to report ground-vibration wave forms and raw data files.

5.4.1 SECTION 13-8 VIOLATIONS OF STATE LAWS DEEMED VIOLATION OF THIS CHAPTER, REVOCATION OF COUNTY LICENSE, AND/OR USER PERMIT

This section requires permit holders to abide by regulations of Florida Statutes Chapter 552, the FSFM, and any other state regulation. The ordinance also requires the permit holder to abide by federal, state, and local law.

5.4.2 SECTION 13-14 ADVERSE EFFECTS

Miami-Dade Ordinance Section 13-14 states:

> *Ground vibration shall be measured as particle velocity. The maximum allowable peak particle velocity shall not exceed 0.75 inch per second measured at the nearest building or structure not owned by the user or when measured at a distance of five thousand two hundred eighty (5,280) feet from the blast when the nearest structure not owned by the user is more distant than one (1) mile from the blast. Particle velocity shall be recorded in three (3) mutually perpendicular directions. The maximum allowable peak particle velocity shall apply to each of the three (3) measurements.*
>
> *Whenever blasting in the vicinity of a utility as set forth in Section 13-11(f) the user shall protect said utility from damage by establishment of a maximum allowable vibration level submitted by the user and agreed to in writing by the person from the utility who has authority to enter into said agreement. If there is a dispute between the user and the utility, the Director shall determine the maximum allowable vibration level.*

The ground vibrations are limited to 0.75 in/sec with no frequency component to the ordinance. Using a blanket limit without a frequency component does not agree with current scientific standards for protecting drywall from cracking.

The section allows alternative limits to utilities. The limit of 0.75 in/sec is a common limit for drywall at frequencies below 40 Hz, and drywall is typically much weaker than any utility; therefore, 0.75 in/sec is an overly protective limit for typical utilities.

5.4.3 SECTION 13-20 BLASTING RECORDS

Miami-Dade Ordinance Section 13-20 states:

> *(a) All users of explosives shall keep daily records for a period of three (3) years of all blasting performed on a form or forms prescribed by the Director of the Public Works Department which shall be made available at reasonable times and hours at a location approved by the Director for inspection by him or her or his or her designee and signed*

copies of such records shall be furnished to the Director within seven (7) days from the date of the actual blast.

(b) The minimum data to be shown on such record shall be:
(1) Name and location of blasting site.
(2) Date and time of firing.
(3) Arrangements and spacing of charges.
(4) The amount of explosive for each blast or delay series.
(5) Delay interval.
(6) Name of person in charge of loading and firing.
(7) County user permit number, and signature and title of person making report.
(c) (1) Records of instrument readings taken as required by Section 13-18 shall be analyzed by an independent recognized seismologist or vibration engineer and shall be reported by him or her to the Director of Public Works with full and complete details within thirty (30) days from the date of the actual blast or upon demand. This seismologist or vibration engineer shall be qualified in blast monitoring and shall have documented prior experience within this field.
(2) All original records will be the property of the blasting company with a copy certified by a seismologist or vibration engineer furnished to the Director of Public Works
(d) Unless otherwise authorized by the Director, all instruments used for compliance with this chapter shall meet the following minimum specifications:
(1) Seismic frequency range: 2 to 200HZ (3HZ)
(2) Acoustic frequency range: 2 to 200HZ (1db)
(3) Velocity range: 0.02 to 4.0 inches/second
(4) Sound range: 110 to 140 dB linear
(5) Transducers: Three mutually perpendicular axis
(6) Recording: Provide time history of waveform.
(7) Each instrument shall be calibrated annually, preferably on a shake table, and such calibration certified except for instruments which are certified as self-calibrating.
(e) A copy of preblast inspection documentation as required by Section 13-15(b) and (c) shall be forwarded, in its entirety, to the Director upon demand.

The section requires records to be kept for a period of 3 years, which is 2 years less than the FAC requirements. The primary difference between the FAC and the Miami-Dade County Ordinance is that "full and complete details" (Section 13-20 [c][1]) are required to be reported by the seismologist or vibration engineer, which requires the full waveform.

The Miami-Dade County Ordinance states the seismograph equipment requirements in the document, in contrast to the FAC, which references an external document. Listing the requirements in the code is reasonable because the requirements are easy to find; however, best practices in the industry can change, so the code would need to be amended as new industry best practices are developed.

5.5 LEE COUNTY DEVELOPMENT CODE

The Lee County Development Code, Chapter 3. *Explosives and Blasting Regulations* governs the use of explosives when developing property in unincorporated Lee County [Lee County, 2018]. Construction

materials mining does not have to comply with this regulation; however, the regulations provide RESPEC with additional methods that are used to regulate blast vibrations in part of Florida. RESPEC reviewed this code with a focus on ground-vibration monitoring, limits, and reporting. Key points in the Lee County Development Code that differ from the FAC include the following:

- 0.3 in/sec limit for habitable structures
- Limits that vary for different types of structures
- Seismograph monitoring required in all four compass directions
- Operations that must report the full ground-vibration waveform
- Operations that must report digital data generated by the seismograph.

5.5.1 SECTION 3-8 LIMITATIONS ON BLASTING INTENSITY

Lee County Development Code Section 3-8 states:

> *(a) Blast intensity will be measured in all four compass directions at the nearest structure not owned by the Developer, as measured from the boundary of the blast site. If no structure exists within one mile of the blast site, then the measurement will be taken at the one mile mark in the direction of the nearest structure or at an alternative location specifically identified by the approved blasting permit. Subsequent to the issuance of the blasting permit, the Director has the discretion to require monitoring of intensity levels at alternate locations not under the ownership or control of the developer, user or blaster if such is warranted based upon complaints received by the County after the blasting activity begins. These alternate locations may be inside or outside the overall development project boundary.*
>
> *(b) Blast intensity may not exceed any of the following limits:*
> *Peak Particle Velocity (PPV):*
> *Calculating PPV using the Peak Vector Sum is prohibited for purposes of compliance with this code.*
> *Habitable Structure 0.30 inches per second*
> *Utility 5.0 inches per second*
> *Bridge 5.0 inches per second*
> *Roadway 10 inches per second for roadway outside the known fracture zone of the blast.*
> *Airblast overpressure: 134 peak dBL (linear) at a habitable structure*

Monitoring in multiple directions can be beneficial, because, depending on geology and blast parameters, vibrations can propagate uniquely in different directions. Differential propagation means that frequencies and particle velocity levels could be different at monitoring locations that are equally distant from the blast but in different directions.

The Lee County Development Code arbitrarily requires monitors at 1 mile from the blast if habitable structures are no closer to the blast than 1 mile. No scientific basis supports this requirement.
One major difference in this regulation compared to the FAC is that this regulation separates the types of structures and assigns limits accordingly. While the limits used may or may not be appropriate, identifying different limits for different structures is a sound approach because the limits are used to protect the weakest part of the structure. The weakest part of a habitable structure is not the same as

the weakest parts of a bridge or utility. Utilities and other infrastructure also respond to vibrations differently than habitable structures.

5.5.2 SECTION 3-13 RECORD KEEPING

Lee County Development Code Section 3-3 requires the following recordkeeping for seismograph monitoring:

> *(c) Date, time and location of the blast;...*
> *(v) Location of each seismograph; set up procedure used;*
> *(w) The PPV, airblast overpressure and frequency measurements for the blast;*
> *(x) Global position system direction and distance in feet to the nearest building in each compass direction;*
> *(y) Copy of strip tape from seismograph showing readings, marked with date, time and machine location, and signed by seismograph operator.*

The Lee County Development Code requires setup procedures, both particle velocity and ground-vibration measurements, the location of each seismograph, setup procedures used, and the vibration report produced by the seismograph. The code requires all of the information that the seismograph records, which is a best practice.

The requirement for a copy of the strip tape is outdated because modern seismographs do not use strip tape printers. This requirement should be updated to require the waveform report from the seismograph.

Requiring the GPS location of the blast and the GPS location of each seismograph is important so that the operation and regulatory authority have records that the seismograph is placed at the nearest structure for every blast.

5.5.3 SECTION 3-15 BLAST VIBRATION MONITORING

This section gives requirements for the seismograph monitoring equipment, seismograph installation, and the data that are reported. The section also outlines the required specifications of the seismograph.

The section references two different documents for seismograph installation. One document is referenced as "accepted industry standards as identified by the International Society of Explosives Engineers" (no specific document referenced), and the other includes standards identified by RI 8508 [Stachura et al., 1981]. Assuming that the Lee County Development Code is referencing the ISEE Field Practice Guidelines [ISEE, 2015], ISEE updates their standards periodically, while RI 8508 is not updated.

RESPEC recommends that the most current version of the ISEE standards be used for seismograph requirements and monitoring practices. These standards are updated periodically and are considered best practices in the industry. With respect to reporting requirements, Lee County Development Code Section 3-15 also requires that digital data be included with the required report. This requirement is important if an operation or the regulatory authority wishes to analyze the recorded ground vibration in detail.

5.6 OFFICE OF SURFACE MINING, RECLAMATION, AND ENFORCEMENT

The OSMRE is the only federal agency that regulates blasting vibrations; however, the OSMRE blasting regulations only apply to surface coal mining and do not apply to any of the construction materials mining conducted in Florida. RESPEC reviewed OSMRE blast vibration regulations [Government Publishing Office, 2018] because many Florida state and local laws require the blasting operation to adhere to any federal laws.

In addition to the above, some surface coal mining-generated blast vibrations are the only other blast vibrations in the US that have been studied and have similar characteristics to the blast vibrations generated by Florida construction materials mining operations.

Note that the Code of Federal Regulations (CFR) that governs blasting is used as a guide for states to determine their own regulatory guidelines with the approval of the OSMRE. Individual states are allowed to regulate surface coal mining if they choose. 30 CFR gives each state guidelines to develop a program/regulations that must be approved by the OSMRE. 30 CFR 25.955 states that the OSMRE oversees state coal mining regulations if the state chooses not to regulate coal mining internally.

5.6.1 30 CFR 850: PERMANENT REGULATORY PROGRAM REQUIREMENTS – STANDARDS FOR CERTIFICATION OF BLASTERS

30 CFR 850 states:

> *This part establishes the requirements and the procedures applicable to the development of regulatory programs for training, examination, and certification of persons engaging in or directly responsible for the use of explosives in surface coal mining operations.*

30 CFR 850 was reviewed because it requires training for blaster certification. The FAC does not require construction materials mining blasters to have an FSFM-approved training for license renewal. The FAC also does not license individual seismologists or require them to get FSFM-approved training.

30 CFR 850.13 establishes training requirements and requires the following information to be included in the blaster training:

1. *Explosives, including—*
    - I. *Selection of the type of explosive to be used;*
    - II. *Determination of the properties of explosives which will produce desired results at an acceptable level of risk; and*
    - III. *Handling, transportation, and storage;*
2. *Blast designs, including—*
    - I. *Geologic and topographic considerations;*
    - II. *Design of a blast hole, with critical dimensions;*
    - III. *Pattern design, field layout, and timing of blast holes; and*
    - IV. *Field applications;*
3. *Loading blastholes, including priming and boostering;*
4. *Initiation systems and blasting machines;*
5. *Blasting vibrations, airblast, and flyrock, including—*
    - I. *Monitoring techniques, and*
    - II. *Methods to control adverse affects;*

6. *Secondary blasting applications;*
7. *Current Federal and State rules applicable to the use of explosives;*
8. *Blast records;*
9. *Schedules;*
10. *Preblasting surveys, including—*
    I. *Availability,*
    II. *Coverage, and*
    III. *Use of in-blast design;*
11. *Blast-plan requirements;*
12. *Certification and training;*
13. *Signs, warning signals, and site control;*
14. *Unpredictable hazards, including—*
    I. *Lightning,*
    II. *Stray currents,*
    III. *Radio waves, and*
    IV. *Misfires.*

This regulation requires blasters to receive formal training. The training must include important topics that are related to the public and safety. For example: OSM-certified blasters are trained on blasting vibrations, airblast, and flyrock (including monitoring techniques) and methods to control adverse effects.

If the FSFM required approved training for blasters and seismologists, blasters and seismologists would be knowledgeable of the latest rules, regulations, methodologies, and technologies. RESPEC feels that a training and retraining program for blasters and seismologists is beneficial. Government-approved training is important because the approval process ensures that the training content is appropriate and occurs on a set schedule.

5.6.2 30 CFR 816.67: USE OF EXPLOSIVES

30 CFR 816.67 states:

> *(d) Ground vibration—(1) General. In all blasting operations, except as otherwise authorized in paragraph (e) of this section, the maximum ground vibration shall not exceed the values approved in the blasting plan required under §780.13 of this chapter. The maximum ground vibration for protected structures listed in paragraph (d)(2)(i) of this section shall be established in accordance with either the maximum peak-particle-velocity limits of paragraph (d)(2), the scaled-distance equation of paragraph (d)(3), the blastinglevel chart of paragraph (d)(4) of this section, or by the regulatory authority under paragraph (d)(5) of this section. All structures in the vicinity of the blasting area, not listed in paragraph (d)(2)(i) of this section, such as water towers, pipelines and other utilities, tunnels, dams, impoundments, and underground mines, shall be protected from damage by establishment of a maximum allowable limit on the ground vibration, submitted by the operator in the blasting plan and approved by the regulatory authority.*
>
> *(2) Maximum peak particle velocity. (i) The maximum ground vibration shall not exceed the following limits at the location of any dwelling, public building, school, church, or community or institutional building outside the permit area:*

Distance (*D*), from the blasting site, in feet	Maximum allowable peak particle velocity (*V* max) for ground vibration, in inches/second [1]	Scaled-distance factor to be applied without seismic monitoring [2] (*Ds*)
0 to 300	1.25	50
301 to 5,000	1.00	55
5,001 and beyond	0.75	65

[1] Ground vibration shall be measured as the particle velocity. Particle velocity shall be recorded in three mutually perpendicular directions. The maximum allowable peak particle velocity shall apply to each of the three measurements.

[2] Applicable to the scaled-distance equation of paragraph (d)(3)(i) of this section.

(ii) A seismographic record shall be provided for each blast.

(3) Scale-distance equation. (i) An operator may use the scaled-distance equation, W=(D/Ds) 2, to determine the allowable charge weight of explosives to be detonated in any 8-millisecond period, without seismic monitoring; where W=the maximum weight of explosives, in pounds; D=the distance, in feet, from the blasting site to the nearest protected structure; and Ds=the scaled-distance factor, which may initially be approved by the regulatory authority using the values for scaleddistance factor listed in paragraph (d)(2)(i) of this section. (ii) The development of a modified scaled-distance factor may be authorized by the regulatory authority on receipt of a written request by the operator, supported by seismographic records of blasting at the minesite. The modified scale-distance factor shall be determined such that the particle velocity of the predicted ground vibration will not exceed the prescribed maximum allowable peak particle velocity of paragraph (d)(2)(i) of this section, at a 95-percent confidence level.

(4) Blasting-level chart. (i) An operator may use the ground-vibration limits in Figure 1 to determine the maximum allowable ground vibration.

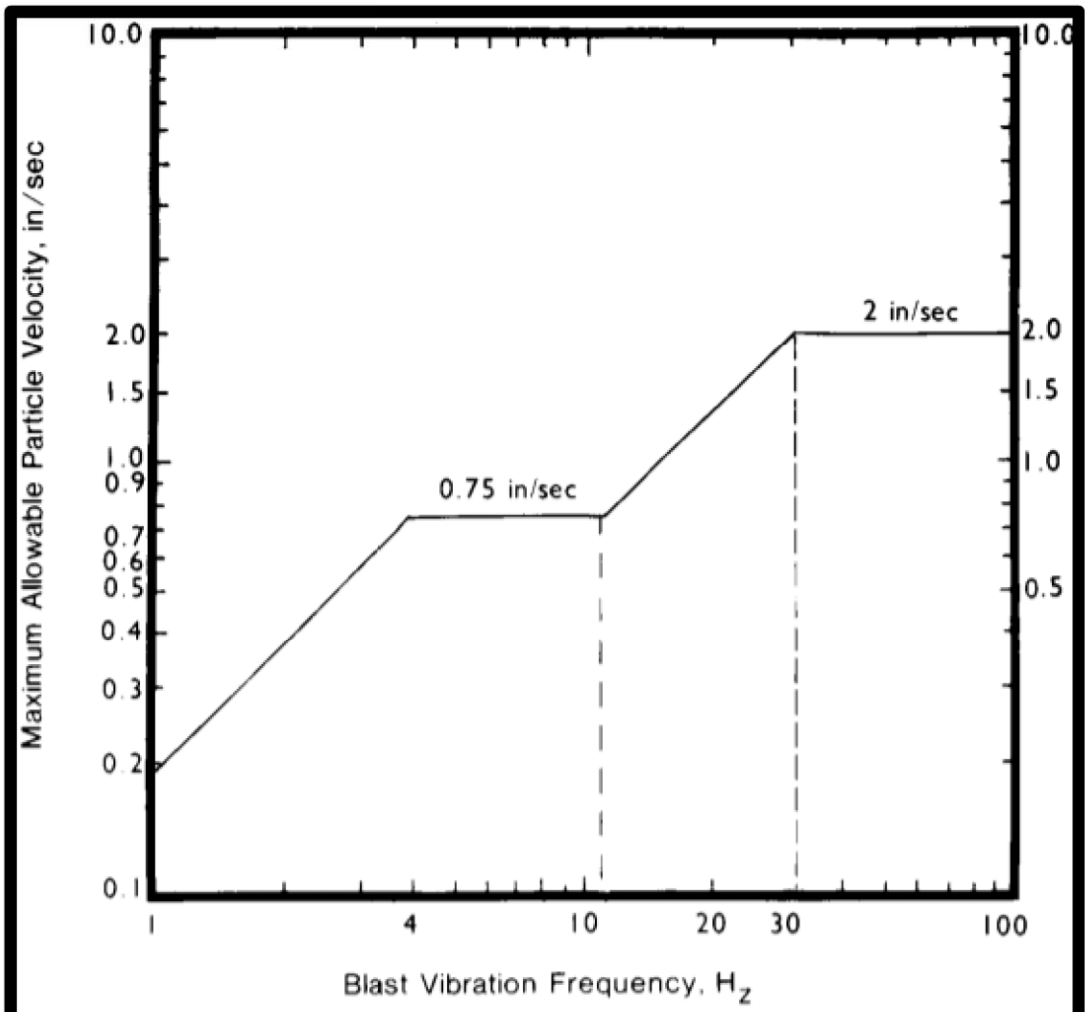

Figure 1. Alternative blasting level criteria.
(Source Modified from figure B-1, Bureau of Mines RI8507)

(ii) If the Figure 1 limits are used, a seismographic record including both particle velocity and vibration-frequency levels shall be provided for each blast. The method for the analysis of the predominant frequency contained in the blasting records shall be approved by the regulatory authority before application of this alternative blasting criterion.

(5) The maximum allowable ground vibration shall be reduced by the regulatory authority beyond the limits otherwise provided by this section, if determined necessary to provide damage protection.

(6) The regulatory authority may require an operator to conduct seismic monitoring of any or all blasts or may specify the location at which the measurements are taken and the degree of detail necessary in the measurement. (e) The maximum airblast and ground-vibration standards of paragraphs (b) and (d) of this section shall not apply at the following locations: (1) At structures owned by the permittee and not leased to another person. (2)

At structures owned by the permittee and leased to another person, if a written waiver by the lessee is submitted to the regulatory authority before blasting.

The OSMRE outlines the following options for ground-vibration limits:

1. Maximum PPV – requires seismograph, limits PPV by distance as a means of incorporating frequency because frequency decreases with distance [Dowding et al., 2018]
2. Scaled-Distance Equation – requires no seismograph, limits maximum charge weight per 8 millisecond delay
3. Blasting Level Chart – requires seismograph, limits PPV and frequency. This chart was modified from the ABLC and is less restrictive than the ABLC. Also, the method of determining frequency must be approved by the OSMRE.

5.6.2.1 MAXIMUM PEAK PARTICLE VELOCITY

The maximum PPV option was developed to limit only the PPV while accounting for the typical frequencies found at various distances in surface coal mining [Dowding et al., 2018]. This option is based on the limits in the blasting level chart but simplified to accommodate the monitoring equipment available in the early 1980s, when frequency could not be easily obtained in the field because the equipment was analogue [Dowding et al., 2018]. RESPEC does not recommend this method because it only applies to surface coal mining, oversimplifies the ABLC limits, is based on antiquated equipment, and is outdated because seismograph technology could not report frequencies with particle velocities easily until the 1990s.

5.6.2.2 SCALED-DISTANCE EQUATION

The scaled-distance equation option allows blasting operations to occur without seismograph monitoring. The OSMRE developed the scaled-distance equation by using surface coal mine blast vibration data because, at the time, seismographs were expensive and difficult to use. Operators needed extra equipment to decipher tape recordings and could not use personal computers to obtain these data.

The scaled-distance equation limited the charge weight per 8 millisecond delay to ensure that maximum particle velocity would be under a certain PPV with a 95 percent confidence interval. The various distances are used to account for frequency variations with distance. This option is restrictive, so most blasting operations choose to use a seismograph to monitor the ground vibrations under one of the other two methods.

This option could apply to Florida, but the following items would need addressed:

1. The FSFM would need to develop region-specific, scaled distance equations. The OSMRE scaled distance limits were generated from surface coal mining data.
2. Each region in Florida has different blast vibration characteristics, so scaled distance equations would need to be developed for all of the regions.
3. Florida requires seismographs for every blast. This method would negate the need to use seismographs if mining operations limit charge weight per delay using a regulatory-approved, regional-specific, scaled distance equation.

5.6.2.3 BLASTING LEVEL CHART

The blasting level chart option is modified from the RI 8507 ABLC. This limit required using PPV and frequency to regulate blast vibrations similar to the ABLC; however, this limit is less restrictive than the ABLC between approximately 12 and 40 Hz.

5.6.2.4 SUMMARY OF 30 CFR 816.67

30 CFR 816.67 shows the importance of accounting for frequency in all of its ground-vibration limit options. The frequency content of a blast vibration associated with a particle velocity should be reported; however, reporting is not required by the FAC.

30 CFR 816.67 mentions that allowable ground-vibration limits may be reduced by the regulatory authority if the authority determines that the limits should be reduced to protect historic and other sensitive structures. This point of 30 CFR 816.67 allows the OSMRE to protect historic and other sensitive structures [Dowding et al., 2018].

Note that 30 CFR 816.67 also requires federal approval on "the method for the analysis of the predominant frequency contained in the blasting records." Multiple methods can be used to determine frequency, so the methodology needs to be approved by the regulatory agency.

5.6.3 30 CFR 955: CERTIFICATION OF BLASTERS IN FEDERAL PROGRAM STATES AND ON INDIAN LANDS

30 CFR 955 is OSMRE's program for certifying blasters. The OSMRE federal certification has reciprocity in most states within the United States.

5.6.3.1 955.11 GENERAL REQUIREMENTS

30 CFR 955.11 states:

> *To qualify for an OSM blaster certificate, a person shall:*
> *(a) Be at least 20 years old prior to submitting an application, and at least 21 years old prior to the grant of a certificate;*
> *(b) In the 3 years prior to submitting an application have been qualified and worked as a blaster or the equivalent, or have worked under the direction of a blaster or the equivalent, for the following cumulative length of time:*
> *(1) Certificate issuance—2 years; or*
> *(2) Certificate renewal or reissuance—1 year;*
> *(c) For certificate issuance or reissuance, have received on-the-job training, completed a training course, and obtained satisfactory evidence of having completed training, as provided in §955.12;*
> *(d) Be competent, possess practical knowledge of blasting techniques, understand the hazards involved in the use of explosives, and exhibit a pattern of conduct consistent with the acceptance of responsibility for blasting operations;*
> *(e) Submit an application as provided in §955.13;*
> *(f) For certificate issuance or reissuance, pass a written examination as provided in §955.14;*
> *(g) For a certificate through reciprocity, meet the requirements of §955.16; and*
> *(h) Not be subject to suspension, revocation or other action under §955.17.*

The general requirements for the OSMRE's certifications are unique because they require the applicant to retake the test to reissue their license every 6 years. The OSMRE certification requirements also necessitate training and retraining for first-time applications and renewals, respectively.

Most regulatory agencies require retraining before renewing a blaster's license to keep blasters current with best practices, new methods, and new technologies and reduce the adverse impacts of blasting. Regulatory-approved training courses and retraining courses are important because training oversight is needed. Regulatory agencies control training to ensure that the trainees are present during the entire course and that the content of the course is appropriate; kept up-to-date; and adequately teaches new technologies, methodologies, and best practices.

5.6.3.2 955.13 TRAINING

30 CFR 955.13 states:

> *(a) On-the-job training. Except as provided in §955.14(c) for reexamination, each applicant for the issuance of an OSM blaster certificate who does not qualify as a blaster or the equivalent shall:*
>
> *(1) Have received on-the-job training, including practical field experience in blasting operations, from a blaster or the equivalent for 2 out of the 3 years preceding the submission of his or her application; and*
>
> *(2) Have obtained from the blaster or the equivalent, the relevant employer, or other knowledgeable source, satisfactory evidence of having received on-the-job training in accordance with paragraph (a)(1) of this section.*
>
> *(b) Training course. Except as provided in §955.14(c) for reexamination, each applicant for the issuance or reissuance of an OSM blaster certificate shall:*
>
> *(1) Within 2 years prior to submitting an application, have completed a training course as follows:*
>
> *(i) For certificate issuance the course shall cover the technical aspects of blasting operations and State and Federal laws governing the storage, transportation and use of explosives, including the topics specified in §850.13(b) of this chapter; or*
>
> *(ii) For certificate reissuance the course shall cover any significant changes that have occurred in the topics specified in §850.13(b) of this chapter since the applicant last completed a course that was accepted by OSM for the issuance or reissuance of an OSM blaster certificate. If OSM determines that no significant changes have occurred, OSM may waive this requirement; and*
>
> *(2) Have obtained from the training provider satisfactory evidence that he or she has completed training in accordance with paragraph (b)(1) of this section.*
>
> *(c) Availability. OSM shall ensure that courses are available as provided in §850.13(b) of this chapter to train persons subject to this part who are responsible for the use of explosives in surface coal mining operations.*

The OSMRE requires on-the-job training (i.e., experience under a licensed blaster) and a training course for initial certification. The on-the-job training requirement ensures that the blaster-in-training knows how to safely use all of the equipment and the products specific to the job. The training course ensures

that the blaster knows about all of the laws that regulate blasting and how to design blasts with minimal adverse effects to the public.

5.7 SUMMARY

RESPEC has thoroughly reviewed the FAC, Florida Statutes, FDOT standards, Miami-Dade and Lee County Codes, and federal regulations of the OSMRE with respect to blast vibration limits. The scope of this project limits RESPEC's recommendations to outlining whether current blasting vibration limits set by statutes are still appropriate. Therefore, the following conclusions for RESPEC's initial findings are limited to the Florida Statutes and FAC, which is directed by the Florida Statutes:

- Florida Statutes Chapter 552
  - This statute implies that explosives must be used for construction materials mining activities.
  - The FSFM should establish ground-vibration limits that conform to RI 8507.
  - Local governments may regulate more strictly than statewide codes.
  - Chapter 552 does not require blast vibrations to be reported.
- FAC
  - The FAC governs the FSFM.
  - The FAC does not correctly identify which table it is referring to in the NFPA.
  - The FAC references an old version of the NFPA.
  - The FAC references RI 8507 and Table 8A from the NFPA 495 1996 Edition. Table 8A is derived from RI 8507 and the OSMRE but conflicts with the ABLC because the table does not account for frequency.
  - The FAC does not require frequency to be reported, but vibration frequencies should be reported in some form.
  - Monitoring requirements based on distance from the mine site (i.e., 1 mile) do not have scientific justification.
  - The FAC has vibration limits for urban development, but these use an incorrect justification. Vibration limits should be specific to individual residences.
  - The FAC does not have requirements for training or retraining of seismograph operators to ensure that they are knowledgeable and use best practices.
  - The FAC has specific requirements for seismograph operators but does not require licenses for seismograph operators.

6.0 OTHER FLORIDA BLAST VIBRATION STUDIES

The FSFM, Lee County, Miami-Dade County and the Lee County Port Authority had previously contracted consultants to evaluate the blast vibration limits in those respective counties. Additional private studies may exist, but these are the only additional blast vibration studies known to RESPEC. This section provides brief reviews and select conclusions of each document.

6.1 FLORIDA STATE FIRE MARSHAL REPORT IN MIAMI-DADE COUNTY

In 2017, the FSFM contracted with Lampl Herbert Consultants, Inc. (Lampl Herbert) to evaluate blast vibrations produced by White Rock Quarries [Lampl Herbert, 2017]. Lampl Herbert was contracted to assess the accuracy of individual seismographs and identify operational issues that could lead to inconsistencies in seismograph readings. Lampl Herbert also studied blasting activities reports, waveform analysis reports, and seismograph reports for 135 blast events in 2016. None of the blast events exceeded 0.5 in/sec at any of the seismographs that Lampl Herbert reviewed.

Lampl Herbert reviewed complaints, vibration levels, and discrepancies and provided recommendations on data collection and reporting. The Lampl Herbert recommendations focused more on regulatory practices than requirements, such as a ground-vibration minimization plan and quarry commission to improve communication between the quarry, communities, and governments. Lampl Herbert did not comment on the applicability of the vibration amplitude limits.

6.2 LEE COUNTY BLASTING STUDY

In 2004, Lee County contracted Terra Dinamica to determine if land development blasting could be completed without damage or other impacts to residences, other structures, utilities, and groundwater resources [Lucca and Williams, 2005]. The authors evaluated the limit of 0.3 in/sec PPV and used various instrumentation setups to evaluate control houses in the Fort Myers and Estero areas of Lee County. The authors showed that human activity and weather events can impact residential structures at levels over an equivalency of 0.3 in/sec and that the limit of 0.3 in/sec is conservative. Additionally, 0.3 in/sec was described as being the lowest that the authors have seen in the US. Despite these points, the authors recommended that the maximum limit of 0.3 in/sec be retained because local operations showed that they could blast under that level.

The 0.3 in/sec limit is not an appropriate limit for Florida, as has been described in this document. Apart from being overly restrictive from a structural standpoint, with no scientific backing, this limit does not have any frequency requirements. Lucca and Williams [2005] stated that the vibration amplitude limit should be set, regardless of the distance from the blast. Lucca and Williams are correct that the limits should not be distance-specific. The authors also suggested that a requirement be placed for the local regulations to require 8 hours of continuing education per year. RESPEC believes that continuing education is a beneficial requirement.

6.3 MIAMI-DADE COUNTY BLASTING STUDY

Miami-Dade County contracted with D. E. Siskind & Associates, LLC to examine blasting in Miami-Dade County in 2000 [Siskind and Stagg, 2000]. The authors measured vibrations and structural responses at 11 locations for 3 months in early 2000 and inspected 10 homes to study the characteristics of cracking and other damages.

In general, Siskind and Stagg [2000] concluded that quarry blasting did not appear to be responsible for cracking and other damage in the residential structures that they analyzed; however, they did propose a temporary reduction of the county's limit from 0.75 to 0.5 in/sec until an additional study was completed to further evaluate the structural response to blast vibrations in Florida.

The authors made their conclusion for reducing the limit based on basic theoretical calculations and the response of a single structure that had two vibration recordings, after which, the equipment failed.

- The single structure, Structure 6, had a structural amplification calculation of 6.1 from a driving particle velocity of 0.041 in/sec measured in the ground next to the house. The 6.1 amplification is higher than the 2–4 amplification factor for whole-structural response found by the USBM in RI 8507 and in other additional studies; however, this amplification factor is questionable because of the following:
  - The reading came from only one of two blasts before the instrumentation at that location failed.
  - The monitoring equipment was placed in the ceiling of the second floor of the structure, rather than a structural corner, which means that the amplification factor is likely not representative of the structural response of Residence 6. The sensor would need to be placed at a structural corner to measure the whole-structure response.
  - Additionally, the ceiling response is more likely to be similar to the midwall response, and the midwalls were shown by the USBM to have amplifications of up to 8 for midwalls in RI 8507, so this reading is representative of expected midwall response.
- In the perpendicular direction of the monitoring equipment that measured the 6.1 amplification reading at Structure 6, the amplification factor was at the expected level of 3.8.

All other amplification factors that describe structural responses from this study are within the expected range (Table 6-1). Siskind and Stagg [2000] only measured the structural response in two other residential structures: House 13 and House 45. Table 6-1 shows the structural amplification factors for high-frequency and low-frequency portions of each blast vibration. Amplification factors were all typical of those expected (2–4 times amplification) based on the RI 8507 work. Siskind and Stagg [2000] state that the House 6 monitor was on a second-floor ceiling truss in a closet, the House 13 monitoring location was on a roof rafter at the house's southwestern corner, and the House 45 monitoring location was on a second-floor ceiling truss in the attic, floor-centered. Without photographic evidence of the monitor placement and actual monitor location, RESPEC had difficulty verifying that each structural response monitor was placed in a structural corner and, therefore, monitoring the whole-structure response.

Table 6-1. Low- and High-Frequency Amplification Factor Ranges in Horizontal Plane Recorded in Miami-Dade County Study [Siskind and Stagg, 2000]

House Number	Low Frequency		High Frequency		Number of Events Reported
	Minimum Amplitude	Maximum Amplitude	Minimum Amplitude	Maximum Amplitude	
6	1.3	1.9	2.5	4.2[a]	4[b]
13	0.9	2.2	1.2	2.2	4
42/45[c]	1.6	3.6	0.9	3.6	5

(a) This number excludes the anomalous 6.1 amplification.
(b) Only two events were recorded inside the structure before the sensor went down.
(c) A 42/45 amplification factor was calculated from the ground vibration at House 42 and structural response at House 45. Another two readings were recorded 2 months later.
High frequency is the early part of the ground-vibration waveform (anywhere from 8 to 30 Hz).
Low frequency is the later part of the ground-vibration waveform (anywhere from 2 to 4 Hz).

The authors of this study estimated a maximum vibration limit that could be allowed by using the questionable amplification factor. They assumed that a 0.75 in/sec vibration could produce the maximum amplification factor of 6.1 found in this study; however, the 6.1 maximum amplification factor came from a driving ground particle velocity of 0.041 in/sec. Amplification factors decrease as ground particle velocity increases because frequency typically increases [Dowding et al., 2018]. To estimate the amplification factor at 0.75 in/sec, the authors should have used amplification data from records with a driving ground particle velocity of approximately 0.75 in/sec.

The data in this study were used to determine a site-specific, scaled-distance equation to relate the charge weight and distance from the blast to the maximum particle velocities that the authors recorded. The authors used this equation to predict the maximum particle velocities that residences would experience as the quarry progressed closer to the residences. The authors estimated that the maximum particle velocities that the quarry blasting would generate was 0.35 in/sec, which the authors stated would not damage the residential structures. The authors then assumed that the 0.75 in/sec limit at the residences would be too high because of the questionable 6.1 amplification factor, which is higher than the 2–4 amplification factor range that the USBM used to develop the 0.75 in/sec limit (at frequencies below 40 Hz). The authors used the questionable 6.1 amplification factor to back-calculate a temporary PPV limit of 0.5 in/sec. The authors realized that all of the calculations were based on theoretical numbers, so they proposed that further work was needed to study the limit of 0.75 in/sec to determine if blasting at the limit could potentially damage the residential structures. The further work was never conducted.

Siskind and Stagg [2000] also instrumented cracking to identify responses from blast vibrations versus responses to weather. They stated that many of the cracks experienced closure over a 2 month period, which suggests that the warming of the season caused the crack shrinkage. The one structural crack that the authors monitored was shown to be more sensitive to temperature effects than blasting vibrations.

6.4 LEE COUNTY PORT AUTHORITY VIBRATION STUDY

The authors of the Lee County Port Authority vibration study looked into the effects of blast vibrations caused by nearby quarries on the airport terminal, a new control tower, and a retention lake. The study found that current vibration levels were low (0.0425 in/sec and lower) with dominant frequencies between 1 and 5 Hz. The study concluded that current blasting was not damaging to infrastructure at the Lee County Airport. However, the authors predicted vibrations from a new expansion of the quarry would be of concern to the airport. The authors' prediction used a scaled distance regression equation with data collected at the airport (thousands of feet away from the blast) to estimate blast vibration levels for blasting events that would be within a couple hundred feet of the airport. Regression equations are not accurate for modeling vibrations at distances significantly shorter than distances used to collect data in the field.

The Lee County Port Authority vibration study authors focused on the three-story airport terminal and determined an amplification factor for the three-story airport building. The authors determined the amplification factor by using two seismographs and one accelerometer. The seismographs were installed on the ground with one on the east corner of the terminal building and one on the west corner of the terminal building. The accelerometer was installed on the third floor of the terminal building. The contractor used an accelerometer because, "This accelerometer-based monitoring system provided for more accurate vibration measurement of low-frequency vibrations typical of earthborn vibrations". Since current industry standards for geophones do not require geophones to be calibrated to accurately record frequencies below 2 Hz, using geophones and accelerometers together to determine an amplification factor from blast vibrations with under 2 Hz frequencies could provide false results. Because of the equipment limitations and the airport terminal an engineered structure, the amplification factor in this study could not be used for validation of the use of the ABLC.

The Lee County Airport structures are engineered and require special engineered limits because the ABLC limits only apply to residential structures. Therefore, the Lee County Port Authority vibration study does not apply to the action items under contract FM410. A site-specific engineered limit using site-specific data should be developed for the Lee County Airport.

The study also discusses the social impact (annoyance) of blast vibrations. While this is an important topic, the social impact of blast vibrations was out of scope for the contract FM410; therefore, the social impact discussion in the Lee County Port Authority vibration study was not used for the FM410 contract study.

7.0 CONCLUSIONS

This document provides a comprehensive review of RI 8507 and its conclusions, historical blast and blast vibration data in Florida, blast vibration data collected by RESPEC during the study, and blast vibration regulations in Florida. Throughout the study, RESPEC completed the following groupings of Action Items as required by Contract FM410:

- **Action Item 1:** An analysis of the current ground-vibration limits set by RI 8507, with respect to Florida and its soil conditions, particularly in areas that surround construction materials mines.
- **Action Item 2:** Analysis of reports, regulatory permits, and related correspondence produced by a representative sample of construction materials mines in Florida, including a summary of all documentation provided by the FSFM that documents blasting activities at the same representative sample of construction materials mines in Florida and complaints by residents who are located near those same mines. The dataset included all of the following reports that are required by a statute and/or administrative rule:
  - Blasting activities reports
  - Complaint reports (i.e., requests for investigation, preliminary report, and letters)
  - Regulatory permits issued by federal, state, and local governmental agencies applicable to construction materials mines.
- **Action Item 3:** The effects of current ground-vibration limits in the communities surrounding Florida's construction material mines and whether the current blasting vibration limits set by statutes are still appropriate, including a review of measured vibration amplitudes and frequencies, structure responses, and theoretical analyses of material strength and strains.

7.1 ACTION ITEM 1

The primary goal of this study was to conduct an analysis of the current ground-vibration limits set by the RI 8507, with respect to Florida and its soil conditions, particularly in areas surrounding construction materials mines. In Florida, blast vibrations tend to have long-duration wavetrains with low-frequency components. The vibrations can be up to almost 20 seconds in duration with frequencies below 2 Hz. The vibrations are typically low-amplitude vibrations (less than 0.1 in/sec PPV) and vibrations have long durations and low-frequency characteristics because of the Florida geology and water table.

RESPEC used multiple literature sources to evaluate the applicability of the RI 8507 vibration limits with respect to Florida and its soil conductions based on the following unique factors in Florida.

7.1.1 DURATION AND FREQUENCY

- Structures can only be affected by repeated sinusoidal pulses at residential structures' natural frequencies.
- Blast vibrations are complex, transient waveforms and do not repeat cycles at uniform frequencies for extended periods of time.
- The long-duration, low-frequency tails of the blast vibration waveforms in southern Florida do not create a high enough strain level because of the normally low amplitude of the particle velocities. Additionally, the low frequencies do not occur at the natural frequency of residential

structures in Florida. The operations have recorded PPV values that exceed the ABLC; however, they exceed the ABLC below 4 Hz, so the structures do not amplify these ground vibrations.

- Below 4 Hz (and above 12 Hz), residential structures do not amplify blast vibration signals; therefore, the 0.03 in constant displacement line in the ABLC is overly conservative.
- Residential structures in Florida amplify blast vibrations by 2–4 times at the natural frequency (4–12 Hz), which is consistent with the USBM's analysis in RI 8507; therefore, the ABLC vibration limits apply to Florida residential structures.

7.1.2 POINTS BELOW THE 0.008 INCH CONSTANT DISPLACEMENT LINE

- The USBM had seven threshold damage observations below the 0.008 in constant displacement line (between 14 and 40 Hz) in the ABLC.
- These threshold damage points were attributed to two causes: two old studies that cannot be defended and old plaster-on-lath damage observations that were collected during the RI 8507 study.
- The ABLC applies to all modern construction homes, including CMU construction with plaster.
- The ABLC is only questionable when applied to old plaster-on-lath homes that were constructed before the 1950s; in this case, Table 2-6 may be more applicable because it applies a 0.5 in/sec limit below 40 Hz for old plaster-on-lath structures.

7.1.3 SOIL RESPONSE

- The weakest soil can settle under the following conditions (all four must occur), at minimum:
  - Ground vibrations must be over 0.5 in/sec
  - Soil must be clean, round-grained sand
  - Soil must be loose sand
  - Soil must be located below the water table.
- These conditions do not exist in Florida; however, these conditions show that the data provided by the FSFM and the vibrations that RESPEC recorded at the six representative mines cannot cause settlement of the residences.
- Any settlement is caused by natural events, such as variations in temperature, humidity, and weather.

7.1.4 FLORIDA RESIDENTIAL STRUCTURES

- Florida structures are represented by the RI 8507 data from multiple standpoints.
- More recent studies have shown that atypical residences and Florida residences have similar natural frequencies and amplification factors to those found in RI 8507.
- RESPEC found that no previous research or documentation in Florida showed cracking that could be directly attributed to blast vibrations.

7.2 ACTION ITEM 2

The second action item concerned the data provided by the FSFM, which included blasting activity reports and complaint reports for six representative sample mines in Florida.

7.2.1 REPRESENTATIVE CONSTRUCTION MATERIALS MINING OPERATIONS

RESPEC reviewed the blasting activities reports, seismograph reports, and blasting reports from six representative mining sites in three regions in Florida. RESPEC also collected blast vibration waveforms during this study. The data was tabulated into spreadsheet format and analyzed for minimum, maximum, and median values. Both the data provided by the FSFM and the data collected by RESPEC show that Florida vibrations have uniquely long duration, low frequency characteristics.

The data values in Florida were analyzed for unique characteristics from the data collected by the USBM in RI 8507. This process showed that Florida blast vibrations can have much longer durations and lower frequencies than the vibrations that were used to create the ABLC.

7.2.2 COMPLAINTS, COMPLAINT INVESTIGATION REPORTS, AND CONSTRUCTION MINING PERMITS

RESPEC reviewed complaints, complaint investigation reports, and construction mining permits that were provided by the FSFM. RESPEC developed a Public Outreach Plan for the FSFM to follow up on after completing this document (Appendix K). Complaints reports will be used to tailor the public outreach plan as the FSFM conducts public outreach. None of the complaint data were associated with cases in which the DOAH awarded damages.

Note that some of the complaints that RESPEC reviewed from Florida were associated with the social impacts of blasting vibrations and what the residents feel when a blast occurs. The social impact of the blast vibrations produced by construction materials mining operations was beyond the Scope of Work for the RESPEC study.

RESPEC found that the FSFM conducts investigation reports after receiving complaints. The FSFM does not necessarily receive enough information from the blasting activities reports to conduct complete investigations.

All six of the representative mines' construction mining permits are compliant.

7.3 ACTION ITEM 3

The final action item focuses on the effects of current ground-vibration limits in the communities that surround Florida's construction material mines and whether the current blasting vibration limits set by the statutes are still appropriate, including a review of measured vibration amplitudes and frequencies, structure responses, and theoretical analyses of material strength and strains.

7.3.1 CURRENT BLAST VIBRATION LIMITS

Currently, Florida blast vibration regulations require using the ABLC from RI 8507 and a table (RESPEC assumes Table 8A) from the NFPA 495 1996 Edition. The ABLC accounts for both particle velocity and frequency; however, Table 8-A from the NFPA only limits PPV by distance, which accounts for

frequency changes with distance; however, the table does not apply to the Florida blasting vibrations because the table was developed by using blast vibrations and vibration propagation characteristics from other industries.

If more than 25 residential structures are within 2 miles of a construction materials mine, the blast vibration limit is 0.5 in/sec, regardless of the frequency content of the blast vibration.

Vibration limits should include two variables: PPV and frequency. Therefore, only the ABLC should be used (or Figure 11.2.1 in the NFPA 495, 2018 edition, which is the same as the ABLC). The USBM proved that residential structures have a variable response to blast vibrations, depending on the ground-vibration frequency. Residential structures have a multiplied response to input ground vibrations between 4 and 12 Hz, where the house can amplify ground-vibration particle velocity amplitudes by 2–4 times. For ground vibrations under 4 Hz and over 12 Hz, structures do not respond with an amplification. Therefore, the USBM proved that vibrations should be more restrictive in the lower frequency range between 4 and 12 Hz.

7.3.2 REVIEW OF MEASURED VIBRATIONS, STRUCTURAL RESPONSES, AND MATERIAL STRENGTHS

According to the USBM data that RESPEC analyzed, cracking caused by blast vibrations below the RI 8507 ABLC could only occur to older, mature, wood-frame homes with plaster-on-lath that were constructed before the 1950s in a very specific range of frequencies between 10 and 20 Hz and at PPVs above 0.5 in/sec. For this type of structure, the limits in Table 13 of RI 8507 (Table 2-6) would apply (those limits being 0.5 in/sec below 40 Hz and 2 in/sec above 40 Hz for old plaster-on-lath).

Drywall joints and plaster are the weakest building materials in residential structures. For modern homes, even those with modern CMU construction and plaster such as those built in Florida around the construction materials mines, the RI 8507 ABLC limits apply. Any more restrictive limits or limits that are not frequency-dependent are overly restrictive from a structural response and theoretical analysis of material strengths and strains perspective. This conclusion was specifically shown in the data collected by Crum [1997] and Siskind and Stagg [2000], which showed that Florida residential structures respond at amplification factors of 2–4 times the structural frequency range. Because of the CMU construction in Florida residences, Florida residences are also more resistant to structural flexure, which is the mechanism that causes drywall or plaster to crack.

Fluctuations in the high water table around the construction materials mining sites, high rainfall, temperature and humidity changes, and winds are likely the leading causes of cracking for the residences in Florida. Weather variability caused crack expansion at strains significantly higher than those generated by the vibrations that RESPEC measured in Florida, which is supported by one of the conclusions of RI 8507:

> *All homes eventually crack because of a variety of environmental stresses, including humidity and temperature changes, settlement from consolidation and variations in ground moisture, wind, and even water absorption from tree roots. Consequently, there may be no absolute minimum vibration damage threshold when the vibration (from any cause, for instance slamming a door) could in some case precipitate a crack about to occur.*

This statement means that all homes experience cracking from environmental causes and age.

7.4 PROPOSED RECOMMENDATIONS

While conducting this study, RESPEC has identified the following recommendations:

- Florida Administrative Code
  - RESPEC recommends changing the FAC to reference the latest version of the *ISEE Field Practice Guidelines for Blasting Seismographs* [2015]. The latest version can be downloaded from the ISEE website's digital downloads portal.
  - The FAC should state minimum seismograph specifications. The ISEE's *Performance Specifications for Blasting Seismographs* was published in 2017; however, this document only requires seismographs to have a range of 2–250 Hz and would not apply to the range of ground-vibration frequencies that occur in Florida. RESPEC recommends a follow-up study to evaluate this point.
  - RESPEC recommends that vibration limits should include frequency as well as particle velocity because frequency is just as important to evaluate as particle velocity. The FAC should not use a blanket particle velocity limit with no frequency component. The FSFM could reference the 2018 edition of the NFPA 495, which limits vibrations based on frequency and particle velocity (by using the ABLC from RI 8507) [NFPA, 2018].
  - RESPEC also recommends that the FAC state that frequencies should be determined by using either zero crossing or Fast Fourier Transform (FFT) during compliance monitoring. The FSFM should require an operation to report which method was used.
  - Currently, limiting vibrations to 0.5 in/sec based on the low chance that a pre-1950s plaster-on-lath home is overly restrictive. The FAC assumes that an urban development has the potential existence of plaster-on-lath construction and that a development with 25 or more houses should have a different limit, but this approach does not have scientific justification. RESPEC recommends changing the ruling to address plaster-on-lath construction and drywall construction. Each house's construction should dictate the limit rather than the number of houses in a development area.
  - The 2-mile urban development distance requirement from blasting does not have any scientific justification with respect to structural damage, so RESPEC recommends eliminating the requirements for blasting 2 miles or less from an urban development and replacing with requirements that have scientific backing.
  - RESPEC recommends that the FAC require an electronic report of each vibration record and the raw seismograph file to be available so that the waveform can be analyzed. Seismograph software can create PDF documents of the waveform and the waveform plotted on the ABLC graph. At times, the image quality of a PDF can be an issue, so the FSFM should have the option of reviewing either file.
- Operating Reports
  - GPS coordinates of the seismograph location are needed.
  - GPS coordinates of the blast location are needed. Another option that the FSFM could require is the corner points of a polygon boundary that includes all blastholes in each blast, which would help the FSFM identify the nearest point of the blast to each nearby residential structure.
  - Frequency and particle velocity are needed to use the ABLC as a limit.

- Complaint Report Formatting
  - A standard form template should be used for complaints to the FSFM to ensure that all of the required information for a complaint is collected.
  - RESPEC recommends that each form has a unique number for tracking; the date and time; the name of the investigator; the complainant's contact information, including their name, address, phone, and email; the subject of review information (i.e., the construction materials mining operation), including their name, address, phone, and license number; a written summary of the complaint; the mining activities report for the specific blast event; and any applicable photographs. All data should be stored in a georeferenced electronic database that can accessed and queried by the FSFM from any location in the state with internet access.
- Training
  - The FSFM should require training (continuing education) for blasters and seismograph operators. The FSFM currently does not require training, even though blasters are licensed. In many other states, blasters are required to obtain continuing education/retraining. Typically, seismograph operators are not required to undergo training unless they do so internally to each monitoring company; however, no oversight over the quality of that training is currently being conducted.
  - The FSFM inspectors could also attend an OSMRE blaster training course to better understand the nature and effect of blast vibrations so they can better inform the public.
- Seismograph capabilities
  - RESPEC recorded a high percentage of vibration events with frequency content below 2 Hz (74 percent). Seismographs are typically only calibrated to 2 Hz; therefore, below 2 Hz, particle velocity amplitudes could be higher than those reported. This point was also identified by the USBM in RI 8506 and RI 9455 [Stagg and Engler, 1980; Siskind et al., 1993]. The USBM mentioned that the peak velocities were close to the low-frequency roll-offs of seismographs, so amplitudes could be higher than reported.
  - Under-2-Hz-capable seismographs are available but not currently commonly commercially available.
  - The FSFM should sponsor a study to determine seismographs specifications that apply to the unique blast vibration characteristics that occur in Florida.
- Public Outreach Plan (Appendix K)
  - The Public Outreach Plan that RESPEC developed will be used to help educate the community so that the community understands the content of this document and RESPEC's conclusions.

7.5 LIMITS OF THE STUDY

This study had the following limitations:

- **Time Frame:** The actual monitoring portion of this study lasted 3 months because of the contract timeline. The contract was signed on February 1, 2018, and the draft summary report was due April 12, 2018. The data acquisition phase was extended beyond the draft summary report deadline to collect the maximum amount of data possible before the proposed final report due date, which was June 19, 2018.

- **Monitoring Locations:** RESPEC was limited to contacting recent complainants to request seismograph monitoring locations. Therefore, the team was unable to monitor at the nearest residential structures to each representative mine site.
- **Crack Monitors:** The crack monitors have a low sample rate. With more time and money, high sample rate crack monitors could have been deployed to study potential crack movement during a blast vibration event.
- **Structural monitoring:** RESPEC was unable to monitor corner response (whole-structure response) at the sampling locations because of time and budget constraints.
- **Crack observations:** RESPEC was limited by time and budget constraints, so the team was unable to recreate some of the practices used in previous studies, such as having personnel on site for extended periods to monitor and inspect cracks immediately before and after every blast.

7.6 NEXT STEPS

This report was comprehensive in the data and research documents that were studied. Several options could be addressed in the future:

- Seismograph Study
  - RESPEC was unable to complete a full evaluation of blasting seismographs and their accuracy in measuring vibrations with frequencies under 2 Hz.
  - ISEE seismograph standards call for accuracy within ±5 percent from 4 to 125 Hz and +5 percent to –3 dB of an ideal flat response (geophone response typically decreases under 4 Hz, so the amplitude at 2 Hz could be 70–80 percent of the input value).
  - A high percentage of Florida blast vibrations have frequencies below 2 Hz, so the standard blasting seismograph response could be less than 70 percent or 80 percent at frequencies below 2 Hz.
  - Therefore, a study needs to be completed to determine if standard blasting seismographs that meet ISEE standard performance specifications accurately report blast vibration amplitudes below 2 Hz. If standard calibration seismographs cannot correctly report particle velocity amplitudes at frequencies below 2 Hz, can the industry internally adjust seismographs that are currently in use to accurately report vibrations with frequencies below 2 Hz, or do the monitoring companies need to supply seismographs that operate at a lower frequency range?
- Detailed structural response studies in Florida
  - This study did not require instrumentation. A thorough structural response study would need significantly more instrumentation and duration.
  - Relatively few studies have been conducted in Florida, so conducting additional structural response instrumentation measurements during blast vibration events at residences in Florida could be taken to further support the conclusions in this document.
  - A study such as this would need to be done by experts with experience in this type of instrumentation because this type of work is difficult to conduct correctly.
  - This study could be used to further prove that structures respond at amplification factors of 2–4 times by using seismographs that can respond below 2 Hz.

- Florida structure damage study
  - Currently, no supporting documentation links exist between ground vibrations from blasting to residential structure damage in Florida.
  - The FSFM could sponsor a study that purposefully induces structural damage to a residential structure near a construction materials mine site in Florida to identify the level of vibrations that would damage a Florida residential structure.
  - The study would be similar to RI 8896 but would be conducted in Florida and modern instrumentation would be used.
  - As Appendix A discusses, the instrumentation that was used to collect the data and that the USBM used to create the ABLC was not calibrated to a uniform specification, so the ABLC could be studied in more detail with modern instrumentation.
  - This type of project would likely cost more than $5 million dollars to complete, which is the present-day cost of the RI 8896 study.
- Florida mining region-specific, scaled-distance equation for determining seismograph placement
  - The FSFM could work with construction materials mining operations and seismograph operators to collect regional construction materials mines blast vibration waveforms throughout the state.
  - This information could be used to generate Florida mining region-specific, scaled distance equations to determine maximum seismograph placement.
  - Completing this process would replace the nonscientific monitoring requirements for 1 and 2 mile distances from the mine sites.
- Social impact of blasting
  - The social impact of blast vibrations on residents around construction materials mining operations in Florida is not an action item under Contract FM410 with the FSFM.
  - The social impact of blast vibrations in the southeastern and southwestern regions is the focus of many blasting complaints.
  - The blast vibration characteristics in southern Florida (long duration, low frequency) are likely why the vibrations are noticeable, even though the vibrations have low amplitudes.
  - While the vibration levels are low, the social impact of the blast vibrations produced by construction materials mining operations was beyond the scope of work for the RESPEC study; any future study could include this topic.

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APPENDIX A

SENSOR OVERVIEW

APPENDIX A: SENSOR OVERVIEW

A.1 OVERVIEW

The US Bureau of Mines (USBM) Report of Investigations (RI) 8507 was written in 1981. The data used in USBM RI 8507 are mostly from the 1970s and earlier; most of the data is more than 50 years old. Technology has come a long way in the last 50 years. This appendix summarizes the differences between seismographs used in the 1960s and 1970s and seismographs used today.

A.2 REPORT OF INVESTIGATIONS 8507 SENSORS

RI 8507 does not specify the types of sensors that were used during the RI 8507 study. At the time, the authors of RI 8507 could have used geophones, accelerometers, or some sort of displacement seismograph, so the specific instrumentation that the authors used is not obvious. RESPEC relied on interviews with RI 8507 authors and seismograph manufacturers to understand the equipment that was used at the time.

Mr. Bob Turnbull, of Instantel, states that the primary sensors that were used in all of the RI 8507 research were accelerometers [Turnbull, 2018]. RI 8506 confirms that the USBM used accelerometers and geophones but did not specify the sensors that were used during each test [Stagg and Engler, 1980]. A problem with accelerometers was that the output must be integrated to find velocity. If the datalogging equipment did not have a high enough sample rate and bit rate, the integration could cause large errors in the generated velocity wave form.

The RI 8507 authors did not have a standard for seismograph construction or calibration during the time of the study; therefore, the equipment that was used during the RI 8507 study and earlier studies were not calibrated or constructed similarly. To combat the variance in seismograph calibration and manufacturing, the USBM tried to use as many brands and types of seismographs to average out the data [Wheeler, 2018].

In the 1970s, personal computers were not available. Computers were the size of conference rooms and cost more than a fleet of vehicles [Worsey, 2018]. Because computers were very expensive and impractical during the 1970s, the seismograph industry used velocity gauges (geophones) that reported the peak particle velocity (PPV) value. At the time, vibration signals were recorded on tapes and then played back to obtain the waveform. A significant amount of labor went into obtaining vibration waveforms [Dowding et al., 2018].

None of the studies that RESPEC reviewed stated how strain values were calculated. The available technologies in the 1970s have caused questions to arise regarding the USBM's comparisons of strain to PPV. Therefore, all PPV-strain comparisons cannot be confirmed.

A.3 CURRENT SENSORS

The only sensors that are used for compliance monitoring today, including in Florida, are geophones and microphones. A geophone is a mechanical sensor with moving parts that generates a voltage that is proportional to the velocity within a frequency range. Blast vibrations are recorded by an array of

three geophones that measure in three perpendicular directions (i.e., radial, transverse, and vertical). The microphone is used to record air over pressure. A seismograph, which is a common term for the blast vibration monitoring equipment, is a data acquisition box (datalogger) that records output from both the geophones and the microphone.

The geophones used today have not changed since the 1980s [Turnbull, 2018; Cornelius, 2018; and Wheeler, 2018]; however, specialized sensors with different frequency ranges are now available, and the construction of the components have improved.

The primary component in a seismograph that has changed since the time of the study is the computing power and the method used to turn the analog signal (output from the geophones) into an electronic signal. With today's seismographs, the geophone signal is converted in real time by the datalogger and/or internal electrical components.

A.4 OPERATING CHARACTERISTICS OF SENSORS

The USBM likely used accelerometers over geophones because accelerometers are more precise over a larger frequency range. The frequency range of the accelerometers that were used in RI 8506 was 1 to 1,000 Hertz (Hz), and the sensors had a natural frequency greater than 10,000 Hz. Typical geophones have a flatline response for frequencies from 8–10 Hz to 250 Hz with electronic compensation from 8–10 Hz down to 2 Hz. Geophones have a problem with roll-off outside of the linear response range. Today, most manufacturers calibrate geophones to report no more than ±3 decibels (dB) of the particle velocity (+41 percent and –29 percent) at 2 Hz, which means that geophone output is allowed to fall within a larger error range below 2 Hz because of the roll-off.

The roll off can be fairly sharp and can be seen in Figure A-1. This figure represents a typical geophone sensor response curve under current International Society of Explosives Engineers (ISEE) standards [ISEE, 2017]. The figure shows that below 2 Hz, the output particle velocity amplitude is drastically reduced from the input particle velocity amplitude even with a slight frequency change (the input particle velocity is 1 in/s [0 dB] for the full frequency range).

According to the data recorded by RESPEC, 74 percent of blast vibrations displayed frequencies below 2 Hz. Any reported particle velocities with frequencies lower than 2 Hz will likely be reported low, which does not mean that the PPV would be any different, but it could be. In this case, the output waveform could cause false peak particle velocity readings from the seismograph.

RI 8506 states, "at least the frequency range at which significant spectral energy is present should fall within the linear frequency range of the instrumentation used" [Stagg and Engler, 1980]. An instrumentation study should be completed for the FSFM to determine the proper compliance monitoring specifications of seismographs, because of the presence frequencies that are less than 2 Hz.

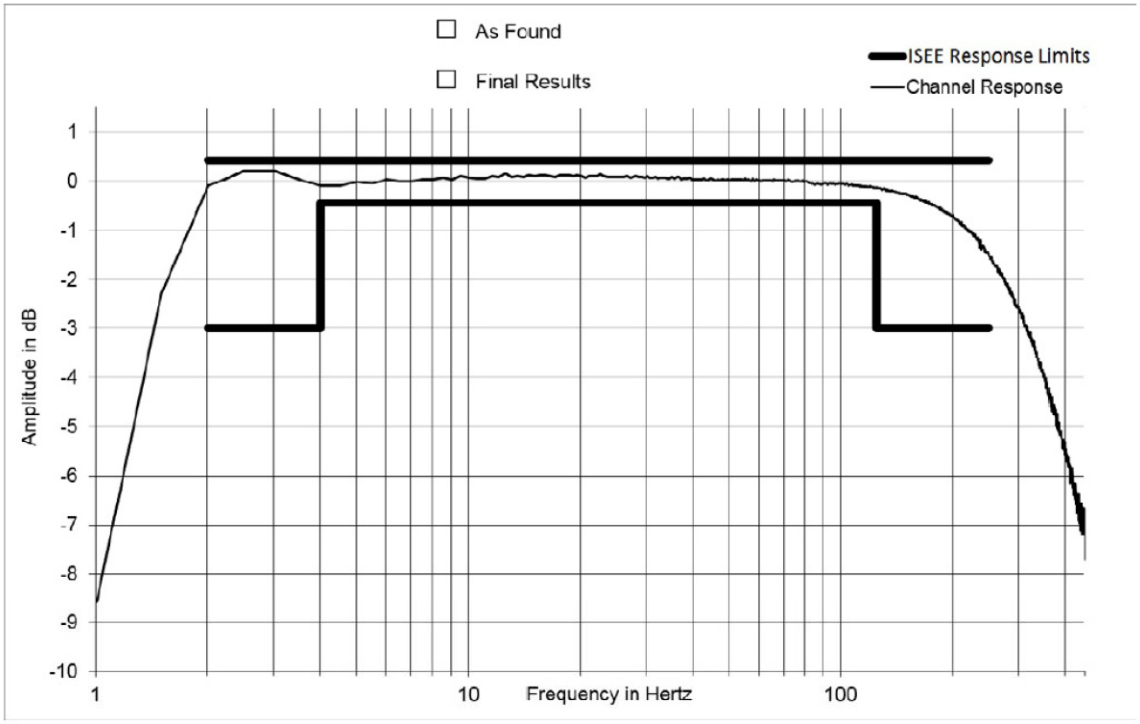

Figure A-1. Sample Amplitude-Versus-Frequency Response Graph (ISEE Seismograph Standard).

A.5 SENSOR IMPACT ON VIBRATION LIMITS

Many current vibration limits (i.e., those under the National Fire Protection Association [NFPA] and the US Office of Surface Mining, Reclamation, and Enforcement [OSMRE]) are written based on old seismograph technology and are influenced because of the cost of instrumentation in the 1970s [Stagg and Engler, 1980; Turnbull, 2018]. Seismographs were relatively expense in the 1970s compared to today's seismographs, and many operations could not afford to own a seismograph or a model from which one could determine frequency from a waveform [Worsey, 2018].

Many affordable seismographs in the 1970s only reported PPV or peak vector sum velocity [Stagg and Engler, 1980]. Because early seismographs could not produce data like current seismographs, the OSMRE created two vibration limits: (1) a table that had vibration limits based on PPV and accounted for frequency changes based on distance from the blast and (2) vibration limits based on charge weight and distance (no seismograph). This is why the OSMRE and NFPA adopted a three-way limit system: (1) PPV where the PPV levels are determined by range of distance from the blast; (2) scaled distance (no seismograph), which is determined by distance from the blast and charge weight per 8 millisecond delay; and (3) the Alternative Blasting Limit Criteria (ABLC) from USBM RI 8507 that uses zero-crossing frequency and frequencies associated with PPV. With today's technology and relative seismograph price in mind, a vibration limit that accounts for particle velocity and frequency (e.g., the ABLC) should be used.

Because of the improvements in modern technology, construction standards, and instrumentation standards, the RI 8507 ABLC should be revisited.

A.6 FLORIDA SPECIFICATIONS

Currently, Florida does not have specifications for seismograph manufacturing, hardware requirements, or seismograph calibration. The Florida Administrative Code (FAC) references the of the ISEE *17th Edition Blaster's Handbook* as a way of specification; however, the *17th Edition Blaster's Handbook* only has a broad overview concerning seismographs [ISEE, 1998]. The *17th Edition Blaster's Handbook* discusses basic information on seismograph components (e.g., a seismograph consists of sensors and a datalogger); however, the reference does not have requirements for the type of sensor, linear frequency response range, measuring capacity of particle velocity, sampling rate, or bit rate, among other requirements.

RI 8506 was conducted to develop recommendations for seismograph build and calibration. Many of the suggestions in RI 8506 were adopted in the current ISEE standards on the use, construction, and calibration of seismographs (updated every 5 years). The current versions of these standards are: *ISEE Performance Specification for Blasting Seismographs 2017* and *ISEE Field Practice Guidelines for Blasting Seismographs* [ISEE, 2017; ISEE, 2015]. The FSFM should cite the ISEE specifications and standards for seismograph requirements because these are the most up-to-date industry best practice guidelines available.

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APPENDIX B

BLASTING ACTIVITIES REPORTS SUMMARY

Marianna Mine

Mine Name	Blast Event ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temp (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes / Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)	Notes
Marianna Mine	MAR1	10:03	4/4/2017	30-38-26.7	85-10-8.76		Partly Cloudy		NE		31	7	60	31	20		20		25	25	1	880	26920	62	non-electric						
Marianna Mine	MAR2	15:34	7/12/2017	30-38-26.7	85-09-59.94		Partly Cloudy		S		75	7	20	75	5-6		9		22	22	1	220	15750	75	non-electric						
Marianna Mine	MAR3	16:26	7/27/2017	30-38-33.9	85-10-2.58		Clear		NE		100	7	20	100	15		10		23	23	1	185	18100	102	non-electric						
Marianna Mine	MAR4	15:05	8/9/2017	30-38-33.66	85-10-3.12		Cloudy		Calm		92	7	20	92			9		23	23	1	247	16960	92	non-electric						
Marianna Mine	MAR5	11:27	8/11/2017	30-38-33.66	85-10-3.12		Clear		SE		4	7					10				1				non-electric						Report copy is poor quality and many values are illegible
Marianna Mine	MAR6	14:00	8/24/2017	30-38-30.72	85-10-4.26		Clear		NE		50	7	20,25,47.48	50	10		9-14		23	23	1	740	19800	50	non-electric						
Marianna Mine	MAR7	15:30	10/16/2017	30-38-34.2	85-10-2.64		Cloudy		NE		76	7	75	76	70		8		25	25	1	302	22980	78	non-electric						
Marianna Mine	MAR8	15:31	11/2/2017	30-38-33.9	85-10-2.76		Clear		E		80	6.75	25	0			8		25	25	1	255	18540	82	non-electric						
Marianna Mine	MAR9	15:35	12/14/2017	30-38-36.54	85-10-2.04		Cloudy		NE		69	6.75	20,30,35	69	10		7, 9, 11		25	25	1	432		71	non-electric						Total Explosives Weight not Provided in Blast Report

Branford Quarry

Mine Name	Blast Event ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temp (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes/ Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)	Notes
Branford Quarry	BRA1	11:51	1/4/2017	29-58-1.0002	82-50-15.30000	Production	Clear	69	NW	6	33	4.25	70	70	65		25		18	18		332	10926	66	electronic					610	
Branford Quarry	BRA2	12:19	1/10/2017	29-57-58.9998	82-50-15.7002	Production	Clear	60	Light & Var	5	36	4.25	70	36	65		23		18	18		689	12392	72	electronic					811	
Branford Quarry	BRA3	13:46	1/18/2017	29-58-1.2798	82-50-23.4402	Cap Rock	Partly Cloudy	77	W	7	114	4.25	26	0	0		12		18	18		138	15694	114	electronic					880	
Branford Quarry	BRA4	12:49	1/20/2017	29-57-49.2798	82-50-19.6602	Cap Rock	Partly Cloudy	80	SW	14	102	4.25	25	0	0		9.5		18	18		138	14062	102	electronic					1827	
Branford Quarry	BRA5	12:46	1/24/2017	29-57-56.70000	82-50-16.09980	Production	Clear	70	Light & Var	5	38	4.25	70	38	65		23		18	18		684	12996	76	electronic					1044	
Branford Quarry	BRA6	11:43	2/9/2017	29-57-54.60000	82-50-16.39020	Production	Clear	72	NW	15	45	4.25	70	45	65		21		18	18		358	16098	90	electronic					1258	
Branford Quarry	BRA7	13:17	2/16/2017	29-57-45.60000	82-50-20.20020	Cap Rock	Clear	70	Light & Var	5	110	4.25	25	0	0		10		18	18		291	14722	110	non-electric					1763	
Branford Quarry	BRA8	11:59	2/22/2017	29-58-1.39020	82-50-23.70000	Cap Rock	Rainy	70	SE	12	92	4.25	25	0	0		10		18	18		139	12772	92	electronic					890	
Branford Quarry	BRA9	12:38	3/1/2017	29-58-1.36980	82-50-24.15000	Cap Rock	Partly Cloudy	84	SW	14	100	4.25	25	0	0		10		18	18		274	13660	100	electronic					922	
Branford Quarry	BRA10	12:19	3/8/2017	29-57-57.94980	82-50-24.84000	Cap Rock	Clear	80	W	10	100	4.25	25	0	0		10		18	18		265	13220	100	electronic					1208	
Branford Quarry	BRA11	12:52	3/14/2017	29-58-1.33020	82-50-25.09020	Cap Rock	Partly Cloudy	54	NW	14	99	4.25	25	0	0		10		18	18		276	13639	99	electronic					991	
Branford Quarry	BRA12	12:55	3/22/2017	29-57-57.85980	82-50-25.38000	Cap Rock	Clear	83	NW	6	99	4.25	25	0	0		10		18	18		271	13379	99	electronic					1246	
Branford Quarry	BRA13	11:49	4/14/2017	29-58-01.00020	82-50-16.00020	Production	Clear	85	Light & Var	5	33	4.25	70	33	65		21		18	18	2	727	11986	66	electronic	27720	35027	22	0.43	603	
Branford Quarry	BRA14	11:22	4/19/2017	29-57-59.10000	82-50-16.30020	Production	Clear	85	Light & Var	4	33	4.25	70	33	65		20		18	18	2	743	12246	66	electronic	27720	35027	29	0.44	801	
Branford Quarry	BRA15	10:57	4/24/2017	29-57-57.19980	82-50-16.69980	Production	Overcast	71	W	10	33	4.25	70	33	65		21		18	18	2	728	12006	66	electronic	27720	35027	36	0.43	993	
Branford Quarry	BRA16	12:03	4/26/2017	29-57-52.27980	82-50-20.37000	Cap Rock	Partly Cloudy	80	S	7	100	4.25	25	0	0		10		18	18	2	285	14220	100	non-electric	30000	25272	91	0.47	1543	
Branford Quarry	BRA17	11:30	5/1/2017	29-57-55.11000	82-50-17.02980	Production	Partly Cloudy	83	SW	15	54	4.25	70	54	65		21		18	18	1	361	19488	108	non-electric	45360	57317	63	0.43	1209	
Branford Quarry	BRA18	12:20	5/5/2017	29-57-48.90000	82-50-20.50020	Cap Rock	Clear	69	SW	22	95	4.25	25	0	0		10		16	16	2	283	13435	95	electronic	22519	18970	111	0.60	1879	
Branford Quarry	BRA19	12:47	5/19/2017	29-57-45.91020	82-50-20.65020	Cap Rock	Partly Cloudy	90	E	8	137	4.25	25	0	0		10		16	16	2	283	19374	274	electronic	32474	27356	129	0.60	2179	
Branford Quarry	BRA20	10:29	6/2/2017	29-57-59.20020	82-50-16.99980	Production	Overcast	85	Calm	1	33	4.25	70	33	65		22		18	18	1	360	11866	66	electronic	27720	35027	41	0.43	796	
Branford Quarry	BRA21	11:36	6/20/2017	29-57-58.60020	82-50-17.10000	Production	Overcast	79	Light & Var	5	36	4.25	70	36	65		21		18	18	1	365	13132	72	electronic	30240	38211	44	0.43	853	
Branford Quarry	BRA22	12:08	7/3/2017	29-57-36.40020	82-50-17.40000	Production	Partly Cloudy	87	S	2	36	4.25	70	36	65		21		18	18	1	357	12852	72	electronic	30240	38211	109	0.43	2063	
Branford Quarry	BRA23	11:08	7/7/2017	29-57-54.10020	82-50-17.80020	Production	Partly Cloudy	90	W	4	36	4.25	70	36	65		20		18	18	1	365	13112	72	electronic	30240	38211	68	0.43	1318	
Branford Quarry	BRA24	11:36	7/11/2017	29-57-53.80020	82-50-25.90020	Cap Rock	Partly Cloudy	88	SW	4	101	4.25	25	0	0		10		16	16	2	267	13481	101	electronic	23941	20168	97	0.56	1601	
Branford Quarry	BRA25	10:55	8/17/2017	29-57-59.10000	82-50-17.80020	Production	Clear	90	Light & Var	2	36	4.25	70	36	65		21		18	18	2	729	13112	72	electronic	30240	38211	30	0.43	818	
Branford Quarry	BRA26	13:07	8/23/2017	29-57-47.92020	82-50-21.40980	Cap Rock	Partly Cloudy	94	N	5	105	4.25	25	0	0		10		12	12	2	244	12785	105	electronic	14000	11794	117	0.91	1833	
Branford Quarry	BRA27	11:37	8/30/2017	29-57-56.94000	82-50-18.06000	Production	Partly Cloudy	78	S	5	36	4.25	70	36	65		22		18	18	2	709	12752	72	electronic	30240	38211	38	0.42	1037	
Branford Quarry	BRA28	12:12	9/20/2017	29-57-45.10020	82-50-20.89980	Cap Rock	Clear	82	NW	3	110	4.25	25	0	0		10		12	12	2	273	14850	110	electronic	14667	12355	112	1.02	1857	
Branford Quarry	BRA29	12:28	9/27/2017	29-57-55.00020	82-50-18.40020	Production	Partly Cloudy	86	N	4	33	4.25	70	33	65		22		18	18	2	704	11606	66	electronic	27720	35027	46	0.42	1236	
Branford Quarry	BRA30	11:16	10/2/2017	29-57-54.90000	82-50-18.60000	Production	Partly Cloudy	74	E	11	41	4.25	70	41	65		20		18	18	1	371	15182	82	non-electric	34440	43518	83	0.44	1617	
Branford Quarry	BRA31	11:06	10/6/2017	29-57-49.14000	82-50-21.78000	Cap Rock	Cloudy	77	NE	9	100	4.25	25	0	0		10		12	12	5	739	14780	100	non-electric	13333	11232	68	1.11	1850	
Branford Quarry	BRA32	11:33	10/18/2017	29-57-53.52000	82-50-21.66000	Cap Rock	Clear	68	NE	11	109	4.25	25	0	0		10		14	14	2	285	15509	109	non-electric	19782	16664		0.78	1850	Scaled distance was reported incorrectly so it was redacted from this summary.
Branford Quarry	BRA33	13:27	10/24/2017	29-57-52.12020	82-50-21.48000	Cap Rock	Clear	76	NW	8	120	4.25	25	0	0		10		14	14	3	421	16840	120	electronic	21778	18346	88	0.77	1821	
Branford Quarry	BRA34	11:30	11/6/2017	29-57-59.40000	82-50-18.19980	Production	Partly Cloudy	73	N	3	33	4.25	70	33	65		21		18	18	1	362	11946	66	electronic	27720	35027	41	0.43	796	
Branford Quarry	BRA35	12:19	11/15/2017	29-57-53.20020	82-50-33.90000	Cap Rock	Clear	63	N	7	120	4.25	25	0	0		9		16	16	2	266	15960	120	electronic	28444	23962	129	0.56	2212	
Branford Quarry	BRA36	11:04	11/16/2017	29-57-57.60000	82-50-18.70020	Production	Clear	66	N	7	33	4.25	70	33	65		20		18	18	2	734	12106	66	electronic	27720	35027	36	0.44	984	

Branford Quarry	BRA37	11:47	11/21/2017	29-57-50.70000	82-50-22.90020	Cap Rock	Cloudy	70	SE	4	108	4.25	25	0	0		9		14	14	2	282	15188	108	non-electric	19600	16511	104	0.77	1763	
Branford Quarry	BRA38	11:55	12/1/2017	29-57-57.40020	82-50-18.79980	Production	Cloudy	77	S	3	33	4.25	70	33	65		23		18	18	2	734	12106	66	electronic	27720	37423	37	0.44	1763	
Branford Quarry	BRA39	10:19	12/7/2017	29-57-55.39980	82-50-19.09980	Production	Rainy	50	N	11	24	4.25	70	24	65		21		18	18	1	362	8688	48	non-electric	20160	27217	63	0.43	1209	
Branford Quarry	BRA40	11:12	12/14/2017	29-57-54.22020	82-50-19.39980	Production	Partly Cloudy	63	W	6	33	4.25	70	33	65		20		18	18	1	372	12246	66	electronic	27720	37423	86	0.44	1669	
Branford Quarry	BRA41	11:09	1/10/2018	29-57-59.20020	82-50-19.30020	Production	Overcast	66	NE	11	33	4.25	70	70	65		21		18	18	2	720	11866	66	electronic	27720	37423	31	0.43	845	
Branford Quarry	BRA42	11:34	1/16/2018	29-57-58.90020	82-50-19.30020	Production	Clear	50	NE	4	33	4.25	70	70	65		21		18	18	2	717	11826	66	electronic	27720	37423	32	0.43	873	
Branford Quarry	BRA43	12:14	1/26/2018	29-57-56.89980	82-50-19.50000	Production	Partly Cloudy	63	E	11	33	4.25	70	70	65		21		18	18	1	358	11786	66	electronic	27720	37423	56	0.43	1071	
Branford Quarry	BRA44	11:35	1/31/2018	29-57-54.90000	82-50-19.90020	Production	Clear	58	E	8	45	4.25	70	70	65		21		18	18	1	363	16330	90	non-electric	37800	51031	66	0.43	1276	
Branford Quarry	BRA45	11:42	2/5/2018	29-58-01.30020	82-50-25.99980	Cap Rock	Clear	63	N	7	105	4.25	25	0			10		16	16	2	260	13645	105	electronic	24889	33601	65	0.55	1059	
Branford Quarry	BRA46	12:00	2/8/2018	29-58-01.30020	82-50-26.89980	Cap Rock	Overcast	64	N	9	105	4.25	25	0			6		14	14	2	278	14545	105	non-electric	19056	25726	67	0.76	1126	
Branford Quarry	BRA47	11:54	2/15/2018	29-58-01.30020	82-50-27.60000	Cap Rock	Clear	75	S	3	105	4.25	25	0			10		14	14	2	239	12525	105	electronic	19056	25726	76	0.66	1179	
Branford Quarry	BRA48	11:40	2/21/2018	29-57-58.39980	82-50-26.29980	Cap Rock	Partly Cloudy	82	SE	10	92	4.25	25	0			10		14	14	2	244	11212	92	electronic	16696	22541	80	0.67	1263	
Branford Quarry	BRA49	11:36	3/8/2018	29-57-58.30020	82-50-27.30000	Cap Rock	Clear	56	NW	13	102	4.25	25	0			10		14	14	2	256	13042	102	non-electric	18511	24991	83	0.7	1334	
Branford Quarry	BRA50	11:21	3/26/2018	29-57-51.79980	82-50-15.70020	Production	Cloudy	62	NE	7	41	4.5	70	70	65		25		20	20	2	764	15662	82	electronic	42519	57401	47	0.37	1312	
Branford Quarry	BRA51	11:15	3/29/2018	29-57-48.90000	82-50-15.60000	Production	Partly Cloudy	76	S	14	28	4.5	70	70	64		25		20	20	1	387	10816	56	electronic	29037	39201	93	0.37	1835	

Brooksville Quarry

Mine Name	Blast Event ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temp (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes / Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)	Comments
Brooksville Quarry	BR01	12:00	1/5/2017	28-34-00.49980	82-27-10.90020	Lykes West	Clear	64	SW	2	21	6.75	39				14		20	20	1	579	12181	42	non-electric						Only hole spacing is given, square pattern assumed
Brooksville Quarry	BR02	11:49	1/12/2017	28-34-00.66000	82-27-21.88980	Lykes Pit	Clear	70	SE	8	25	6.75	40				14		20	20	1	574	14385	50	non-electric						Added primer wt to bulk wt for total
Brooksville Quarry	BR03	10:29	1/23/2017	28-37-07.96980	82-26-32.80020	North New Bench	Partly Cloudy	62	W	24	20	6.75	39				14		20	20	1	553	11092	38	non-electric						
Brooksville Quarry	BR04	12:52	2/1/2017	28-34-01.50000	82-27-13.00020	Lykes Pit	Clear	75	S	4	28	6.75	40				14		20	20	2	1194	16779	77	non-electric						
Brooksville Quarry	BR05	10:50	2/3/2017	28-37-08.20020	82-26-33.10020	North New Bench	Clear	73	NW	3	38	6.75	31				14		20	20	2	756	14392	38	non-electric						
Brooksville Quarry	BR06	11:15	2/14/2017	28-34-01.50000	82-27-13.00020	Lykes Pit	Clear	75	Light & Var.	5	19	6.75	41				14		20	20	1	580	11045	38	non-electric						
Brooksville Quarry	BR07	13:12	2/14/2017	28-33-37.0020	82-25-55.20000	North	Clear	75	Light & Var.	5	23	6.75	40				14		18	18	1	577	13299	46	non-electric						
Brooksville Quarry	BR08	11:13	2/21/2017	28-34-01.42980	82-27-14.74020	North Lykes West	Partly Cloudy	73	SW	11	23	6.75	50				14		18	20	1	768	17659	47	non-electric						
Brooksville Quarry	BR09	11:39	2/28/2017	28-33-59.65020	82-27-14.61000	Lykes Pit	Partly Cloudy	81	SE	7	27	6.75	35				14		20	20	2	768	10419	54	non-electric						
Brooksville Quarry	BR010	11:19	3/9/2017	28-33-36.19980	82-25-57.19980	North Shep Pit	Clear	80	W	3	27	6.75	36				14		18	20	1	484	13050	54	non-electric						
Brooksville Quarry	BR011	9:01	3/10/2017	28-37-08.08020	82-26-32.08980	North Butch Pit	Clear	70	W	0	19	6.75	43				14		18	18	1	658	12537	38	non-electric						
Brooksville Quarry	BR012	12:18	3/10/2017	28-34-01.74000	82-27-16.21020	North Lykes Pit	Clear	75	W	11	22	6.75	51				14		20	20	1	742	16353	44	non-electric						
Brooksville Quarry	BR013	16:15	3/20/2017	28-35-44.50020	82-25-15.10020	Railroad Pit	Clear	78	NW	7	24	6.75	50				14		20	20	1	760	18275	48	non-electric						
Brooksville Quarry	BR014	10:38	3/23/2017	28-37-08.52000	82-26-32.92980	North Butch Pit	Partly Cloudy	75	NE	13	35	6.75	30				12		20	20	2	825	14458	35	non-electric						
Brooksville Quarry	BR015	10:42	3/29/2017	28-37-04.84020	82-26-29.85000	North Butch Pit	Clear	82	SE	4	31	6.75	39				14		18	18	1	505	15694	62	non-electric						report says 63 electric caps but sum of actual dets adds up to 62
Brooksville Quarry	BR016	12:42	4/4/2017	28-34-00.10020	82-27-18.04980	North Butch Pit	Partly Cloudy	81	SW	8	32	6.75	50				14		20	20	1	726	23276	64	non-electric						
Brooksville Quarry	BR017	11:39	4/12/2017	28-37-08.44020	82-26-32.44980	North Butch Pit	Partly Cloudy	80	NE	7	37	6.75	40				14		18	18	1	492	18268	74	non-electric						
Brooksville Quarry	BR018	12:42	4/12/2017	28-37-02.50020	82-27-10.60020	North Butch Pit	Partly Cloudy	80	NE	7	1	6.75	50				14		20	20	1	840	842	2	non-electric						
Brooksville Quarry	BR019	10:44	4/13/2017	28-37-04.90020	82-26.30.19980	North Butch Pit	Partly Cloudy	80	NE	10	28	6.75	35				14		18	18	1	469	13187	56	non-electric						
Brooksville Quarry	BR020	11:30	4/20/2017	28-37-02.56980	82-26-27.24000	North Butch Pit	Clear	83	N	2	30	6.75	40				14		18	18	1	591	17783	60	non-electric						electric caps says 60 but only 56 when added up
Brooksville Quarry	BR021	11:02	5/3/2017	28-33-58.30020	82-27-18.30000	North Lykes West Pit	Clear	86	NE	11	34	6.75	35				12		18	18	2	846	14450	68	non-electric						
Brooksville Quarry	BR022	11:28	5/8/2017	28-37-05.70000	82-26-28.60020	North Butch Pit	Partly Cloudy	84	NW	3	34	6.75	38				14		18	18	1	533	18172	68	non-electric						
Brooksville Quarry	BR023	11:28	5/17/2017	28-33-45.52020	82-27-19.99020	North Lykes West Pit	Partly Cloudy	86	SE	10	33	6.75	39				14		18	18	1	508	16804	66	non-electric						
Brooksville Quarry	BR024	09:46	5/24/2017	28-37-09.37020	82-26-32.41980	North Butch Pit	Partly Cloudy	83	S	18	34	6.75	35				14		18	18	1	444	15131	57	non-electric						
Brooksville Quarry	BR025	11:27	5/31/2017	28-37-07.50000	82-26-29.70000	East Butch Pit	Clear	90	Light & Var.	3	36	6.75	37				14		18	18	1	468	17848	76	non-electric						
Brooksville Quarry	BR026	9:29	6/6/2017	28-37-07.50000	82-26-29.70000	West Lykes Pit	Rainy	77	SE	10	24	6.75	38				14		18	18	1	468	11731	48	non-electric						

Brooksville Quarry	BRO27	11:37	6/16/2017	28-37-06.49980	82-26-29.80020	Butch Pit	Rainy	79	W	6	31	6.75	38				14		18	20	1	481	14895	62	non-electric						
Brooksville Quarry	BRO28	12:03	6/23/2017	28-36-59.31000	82-26-28.60980	Butch Pit	Clear	89	SE	8	47	6.75	40				14		18	18	2	1038	23869	92	non-electric						
Brooksville Quarry	BRO29	9:30	6/28/2017	28-33-45.07980	82-27-15.76020	West Lykes Pit	Partly Cloudy	82	NE	7	20	6.75	40				14		18	18	1	542	10831	40	non-electric						
Brooksville Quarry	BRO30	10:18	6/30/2017	28-34-29.50020	82-25-43.80000	New Bench	Partly Cloudy	88	SE	5	52	6.75	15				8		20	20	2	265	6882	52	non-electric						
Brooksville Quarry	BRO31	11:15	7/5/2015	28-37-06.00000	82-26-28.99980	North Butch Pit	Partly Cloudy	88	Calm	0	43	6.75	39				12		20	20	2	993	21378	75	non-electric						
Brooksville Quarry	BRO32	11:14	7/12/2017	28-33-44.80020	82-27-13.50000	South Lykes West	Partly Cloudy	86	E	7	39	6.75	39				14		18	18	1	549	21399	78	non-electric						
Brooksville Quarry	BRO33	11:38	7/20/2017	28-33-46.20000	82-27-17.50020	North Lykes West	Partly Cloudy	92	NE	4	22	6.75	41				14		18	18	1	546	12011	44	non-electric						
Brooksville Quarry	BRO34	10:15	7/27/2017	28-33-44.70000	82-27-13.20000	South North Pit	Partly Cloudy	81	S	5	21	6.75	40				14		18	18	1	539	11284	43	non-electric						
Brooksville Quarry	BRO35	11:52	8/9/2017	28-37-04.98000	82-26-26.88000	South Butch Pit	Partly Cloudy	90	S	4	40	6.75	30				14		18	18	2	709	14167	80	non-electric						
Brooksville Quarry	BRO36	13:47	8/15/2017	28-36-58.99980	82-26-27.40020	North Butch Pit	Rainy	80	SW	9	30	6.75	40				14		18	18	1	650	19537	61	non-electric						
Brooksville Quarry	BRO37	11:03	8/22/2017	28-33-44.38020	82-27-13.96020	North Lykes West	Clear	90	NE	7	23	6.75	41				12		18	18	1	587	13492	46	non-electric						
Brooksville Quarry	BRO38	10:45	8/31/2017	28-36-58.92000	82-26-26.70000	South Butch Pit	Clear	89	S	10	41	6.75	30				12		18	18	2	741	15182	41	non-electric						
Brooksville Quarry	BRO39	10:03	9/6/2017	28-33-44.08980	82-27-13.60980	North Lykes West	Rainy	74	N	4	23	6.75	43				14		18	18	1	587	13497	46	non-electric						
Brooksville Quarry	BRO40	12:00	9/21/2017	28-33-43.80000	82-27-11.40000	North Lykes West	Clear	85	NE	6	24	6.75	45				12		18	18	1	680	16314	48	non-electric						
Brooksville Quarry	BRO41	10:14	9/28/2017	28-33-43.39980	82-27-11.29980	North Lykes West	Clear	88	SE	2	17	6.75	44				12		18	18	1	636	10784	34	non-electric						
Brooksville Quarry	BRO42	10:09	10/4/2017	28-33-44.89980	82-27-09.90000	North Lykes West	Clear	80	NE	14	32	6.75	38				14		18	18	1	486	15526	64	non-electric						
Brooksville Quarry	BRO43	11:18	10/13/2017	28-33-46.39980	82-27-10.30020	South Lykes West	Clear	80	NE	9	22	6.75	40				14		18	18	1	482	10598	44	non-electric						
Brooksville Quarry	BRO44	11:17	10/19/2017	28-33-45.66000	82-27-10.78020	North Lykes West	Partly Cloudy	78	NE	9	28	6.75	40				14		18	18	1	482	15530	56	non-electric						
Brooksville Quarry	BRO45	11:11	10/27/2017	28-33-44.86980	82-27-10.95000	North Lykes West	Clear	73	NE	9	32	6.75	40				14		18	18	1	554	17699	64	non-electric						
Brooksville Quarry	BRO46	10:12	11/3/2017	28-33-43.00020	82-27-11.40000	South North Pit	Clear	73	N	7	18	6.75	42				14		18	18	1	588	10583	36	non-electric						
Brooksville Quarry	BRO47	10:31	11/7/2017	28-36-53.10000	82-26-55.30020	South North Pit	Clear	78	W	2	22	6.75	42				14		18	18	1	609	13397	44	non-electric						
Brooksville Quarry	BRO48	13:27	11/7/2017	28-36-53.10000	82-26-55.30020	South New Bench	Clear	82	N	2	34	6.75	10				6		18	18	1	101	3436	36	non-electric						
Brooksville Quarry	BRO49	10:33	11/8/2017	28-37-00.34980	82-27-10.54980	West Bench 1	Cloudy	76	N	2	28	6.75	40				14		18	18	1	617	17253	56	non-electric						
Brooksville Quarry	BRO50	8:52	11/13/2017	28-37-00.34980	82-27-10.54980	South New Bench	Clear	73	N	9	30	6.75	10				6		18	18	1	105	3144	30	non-electric						
Brooksville Quarry	BRO51	10:49	11/17/2017	28-37-02.20020	82-27-10.50000	West Bench 1	Clear	63	N	4	21	6.75	40				16		18	18	1	499	10464	42	non-electric						
Brooksville Quarry	BRO52	11:13	11/20/2017	28-33-43.60020	82-27-10.99980	South Lykes West	Clear	61	N	7	30	6.75	42				14		18	18	1	603	18082	60	non-electric						
Brooksville Quarry	BRO53	12:22	11/30/2017	28-33-44.40000	82-27-16.69980	South Lykes West	Cloudy	79	N	7	40	6.75	43				14		18	18	1	608	24316	80	non-electric						
Brooksville Quarry	BRO54	11:09	12/8/2017	28-33-42.49980	82-27-11.40000	Lykes West	Overcast	73	S	14	23	6.75	44				14		18	18	1	610	14028	46	non-electric						
Brooksville Quarry	BRO55	12:05	12/12/2017	28-33-43.09980	82-27-07.69980	North Lykes West	Partly Cloudy	70	W	16	39	6.75	43				14		18	18	1	609	23746	78	non-electric						
Brooksville Quarry	BRO56	10:29	12/21/2017	28-37-00.19980	82-27-16.99980	South Bench 1	Clear	74	N	10	26	6.75	40				14		18	18	1	1107	14381	52	non-electric						

Brooksville Quarry	BRO57	11:29	1/8/2018	28-36-47.70000	82-25-08.70000	North Jones Pit	Partly Cloudy	64	E	7	48	6.75	17				8		18	18	1	192	9201	48	non-electric						
Brooksville Quarry	BRO58	10:28	1/9/2018	28-34-25.20000	82-25-30.40020	East Pond 13	Overcast	68	E	9	57	6.75	10				6		18	18	1	161	4569	57	non-electric						
Brooksville Quarry	BRO59	10:34	1/12/2018	28-34-25.20000	82-25-30.40020	West Pond 13	Overcast	73	S	12	55	6.75	10				6		18	18	1	157	4295	55	non-electric						
Brooksville Quarry	BRO60	10:28	1/17/2018	28-33-42.30000	82-27-08.89980	North Lykes West	Clear	64	NW	7	23	6.75	43				14		18	18	1	589	13540	46	non-electric						
Brooksville Quarry	BRO61	13:35	1/24/2018	28-33-32.61000	82-25-53.11980	North Shot Pattern Shep Pit	Clear	67	NW	6	54	6.75	18				9		20	20	1	359	9668	54	non-electric						
Brooksville Quarry	BRO62	12:39	2/1/2018	28-33-42.04020	82-27-10.18980	North Lykes West	Clear	71	S	6	31	6.75	43				14		18	18	1	616	19093	62	non-electric						
Brooksville Quarry	BRO63	11:16	2/9/2018	28-34-22.20000	82-25-30.10020	North TG Hughes	Clear	77	SE	9	80	6.75	12				7.5		20	20	3	288	7674	80	non-electric						
Brooksville Quarry	BRO64	10:35	2/14/2018	28-33-41.6400	82-27-11.11980	North Lykes West	Partly Cloudy	70	NE	6	26	6.75	43				14		18	18	1	598	15529	52	non-electric						
Brooksville Quarry	BRO65	11:17	2/20/2018	28-34-20.89980	82-25-29.10000	North Bench 1	Partly Cloudy	83	SE	10	80	6.75	12				7.5		22	22	2	216	8640	80	non-electric						
Brooksville Quarry	BRO66	11:19	2/22/2018	28-34-00.00000	82-27-10.50000	North Lykes West	Partly Cloudy	80	SE	10	31	6.75	43				15		18	18	2	1066	16521	62	non-electric						
Brooksville Quarry	BRO67	11:53	3/2/2018	28-33-41.50020	82-27-10.00020	North Lykes West	Partly Cloudy	80	N	7	34	6.75	43				14		18	18	1	643	21855	68	non-electric						
Brooksville Quarry	BRO68	12:57	3/2/2018	28-34-20.20020	82-25-27.49980	West Bench 1	Partly Cloudy	80	N	12	57	6.75	13				7		21	21	1	102	5867	57	non-electric						
Brooksville Quarry	BRO69	10:17	3/12/2018	28-33-38.29980	82-27-12.40020	North Lykes West	Clear	64	NW	16	30	6.75	43				14		18	18	2	1179	17682	60	non-electric						
Brooksville Quarry	BRO70	12:31	3/12/2018	28-33-39.00000	82-25-51.79980	East Shot Pattern Shep Pit	Rainy	65	NW	18	34	6.75	13				7		18	18	1	104	3588	34	non-electric						
Brooksville Quarry	BRO71	12:26	3/21/2018	28-33-44.97000	82-27-18.81000	North Lykes West	Partly Cloudy	64	NW	17	39	6.75	43				14		18	18	1	602	23454	78	non-electric						
Brooksville Quarry	BRO72	11:54	3/28/2018	28-33-43.39980	82-25-42.00000	South Shot Pattern McClung	Clear	73	SE	11	51	6.75	10				6		20	20	2	137	3422	50	non-electric						
Brooksville Quarry	BRO73	2:12	3/28/2018	28-33-42.10020	82-27-07.20000	North Lykes West	Clear	82	SE	8	26	6.75	43				14		18	18	2	1218	15820	50	non-electric						

West Lakes and University Lakes Mines

Mine Name	BastEvent ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temperature (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes / Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)	Comments
West Lakes Mine	WES1	11:00	1/9/2017	26-28-51.40020	81-41-37.99980	University Lakes (N)	Partly Cloudy	68	N	6	10	4.5	62			water	22		20	20	1	344	3440	20	non-electric	9185	20483	63	0.37	1181	
West Lakes Mine	WES2	11:12	1/9/2017	26-28-51.00000	81-41-41.29980	University Lakes (N)	Partly Cloudy	62	N	4	9	4.5	62			water	22		20	20	1	344	3096	18	non-electric	8267	18435	47	0.37	886	
West Lakes Mine	WES3	11:22	1/9/2017	26-28-50.29980	81-41-46.00020	University Lakes (N)	Partly Cloudy	56	N	5	8	4.5	62			water	22		20	20	1	344	2408	14	non-electric	7348	16386	26	0.33	485	
West Lakes Mine	WES4	11:13	1/12/2017	26-28-51.10020	81-41-37.60020	University Lakes (N)	Partly Cloudy	78	N	3	15	4.5	62			water	20.533		20	20	1	362	5068	28	non-electric	13778	30724	64	0.37	1220	report shows 280 primers
West Lakes Mine	WES5	11:20	1/12/2017	26-28-51.00000	81-41-41.10000	University Lakes (N)	Partly Cloudy	78	N	4	16	4.5	62			water	22		20	20	1	344	5504	32	non-electric	14696	32773	48	0.37	904	
West Lakes Mine	WES6	11:28	1/12/2017	26-28-51.19980	81-41-45.19980	University Lakes (N)	Partly Cloudy	78	N	5	11	4.5	62			water	22		20	20	1	282	3100	22	non-electric	10104	22531	31	0.31	532	
West Lakes Mine	WES7	10:32	1/18/2017	26-28-51.00000	81-41-37.00020	University Lakes (N)	Partly Cloudy	79	N	3	16	4.5	62			water	19.25		20	20	1	344	4816	28	non-electric	14696	32773	68	0.33	1275	
West Lakes Mine	WES8	10:39	1/18/2017	26-28-51.00000	81-41-40.30020	University Lakes (N)	Partly Cloudy	79	N	3	11	4.5	62			water	20		20	20	1	344	3440	20	non-electric	10104	22531	52	0.34	976	
West Lakes Mine	WES9	10:47	1/18/2017	26-28-51.00000	81-41-44.70000	University Lakes (N)	Partly Cloudy	79	N	2	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	31	0.37	580	
West Lakes Mine	WES10	11:31	1/23/2017	26-28-51.10020	81-41-36.40020	University Lakes (N)	Partly Cloudy	74	N	9	21	4.5	62			water	19.905		20	20	1	344	6536	38	non-electric	19289	43014	71	0.34	1328	
West Lakes Mine	WES11	11:39	1/23/2017	26-28-51.00000	81-41-40.30020	University Lakes (N)	Partly Cloudy	74	N	10	14	4.5	62			water	20.429		20	20	1	344	4472	26	non-electric	12859	28676	52	0.35	976	
West Lakes Mine	WES12	11:47	1/23/2017	26-28-51.10020	81-41-44.29980	University Lakes (N)	Partly Cloudy	75	N	9	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	33	0.37	615	
West Lakes Mine	WES13	11:01	1/26/2017	26-28-51.30000	81-41-35.50020	University Lakes (N)	Partly Cloudy	77	N	5	19	4.5	62			water	22		20	20	1	336	6376	38	non-electric	17452	38918	76	0.37	1409	
West Lakes Mine	WES14	11:08	1/26/2017	26-28-51.10020	81-41-33.30000	University Lakes (N)	Partly Cloudy	77	N	4	11	4.5	62			water	22		20	20	1	344	3784	22	non-electric	10104	22531	86	0.37	1609	
West Lakes Mine	WES15	11:16	1/26/2017	26-28-50.40000	81-41-44.80020	University Lakes (N)	Partly Cloudy	77	N	3	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	31	0.37	585	
West Lakes Mine	WES16	9:13	2/2/2017	26-28-51.19980	81-41-43.90020	University Lakes (N)	Partly Cloudy	76	N	2	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	34	0.37	649	
West Lakes Mine	WES17	11:51	2/2/2017	26-28-51.19980	81-41-22.69980	University Lakes (N)	Partly Cloudy	76	N	2	15	4.5	62			water	22		20	20	1	344	5160	30	non-electric	13778	30724	138	0.37	2570	
West Lakes Mine	WES18	12:02	2/2/2017	26-28-51.30000	81-41-34.60020	University Lakes (N)	Partly Cloudy	76	N	2	19	4.5	62			water	22		20	20	1	344	6536	38	non-electric	17452	38918	80	0.37	1490	
West Lakes Mine	WES19	12:13	2/2/2017	26-28-51.10020	81-41-38.80020	University Lakes (N)	Partly Cloudy	76	N	2	15	4.5	62			water	22		20	20	1	344	5160	30	non-electric	13778	30724	59	0.37	1111	
West Lakes Mine	WES20	12:22	2/2/2017	26-28-50.59980	81-41-44.10000	University Lakes (N)	Partly Cloudy	76	N	2	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	34	0.37	642	
West Lakes Mine	WES21	14:22	2/8/2017	26-28-51.19980	81-41-23.40000	University Lakes (N)	Partly Cloudy	78	N	6	15	4.5	62			water	23		20	20	1	344	5160	30	non-electric	13778	30724	135	0.37	2507	
West Lakes Mine	WES22	14:34	2/8/2017	26-28-51.30000	81-41-33.70020	University Lakes (N)	Partly Cloudy	78	N	6	25	4.5	62			water	20.24		20	20	1	344	7568	44	non-electric	22963	51207	84	0.33	1572	
West Lakes Mine	WES23	14:44	2/8/2017	26-28-51.19980	81-41-43.39980	University Lakes (N)	Partly Cloudy	78	N	6	8	4.5	62			water	22		20	20	1	344	2065	13	non-electric	7348	16386	37	0.28	694	
West Lakes Mine	WES24	13:34	2/14/2017	26-28-50.59980	81-41-43.30020	University Lakes (N)	Partly Cloudy	77	N	3	6	4.5	62			water	22		20	20	1	344	2064	12	non-electric	5511	12290	38	0.37	713	
West Lakes Mine	WES25	12:41	2/16/2017	26-28-21.40020	81-42-50.89980	West Lakes (N)	Partly Cloudy	74	N	7	39	4.5	55			water	18		26	26	1	318	12402	78	non-electric	53704	45241	194	0.23	3472	
West Lakes Mine	WES26	10:50	3/3/2017	26-28-32.08022	81-42-54.22085	West Lakes (N)	Overcast & Windy		NNE		56	4.5	56	56			18		26	26		312	17444	112	non-electric					2433	
West Lakes Mine	WES27	14:53	3/6/2017	26-28-31.33333	81-42-56.81953	West Lakes (N)	Overcast & Windy		E		64	4.5	56	64			19		26	26		300	19268	124	non-electric					2346	
West Lakes Mine	WES28	12:48	3/8/2017	26-28-31.28135	81-43-01.11067	West Lakes (N)	Mostly Cloudy		ESE		64	4.5	56	64			19		26	26		306	19268	128	non-electric					2293	

West Lakes Mine	WES29	10:13	3/10/2017	26-28-31.26322	81-43-02.54091	West Lakes (N)	Clear		NNW		40	4.5	56	40			19		26	26		306	12230	80	non-electric					2289	
West Lakes Mine	WES30	11:58	3/14/2017	26-28-31.25241	81-43-03.97512	West Lakes (N)	Scattered Clouds		WNW		40	4.5	56	40			19		26	26		307	11349	74	non-electric					2294	
West Lakes Mine	WES31	13:03	3/16/2017	26-28-31.22175	81-43-05.97399	West Lakes (N)	Mostly Cloudy		E		48	4.5	56	48			19		26	26		294	14399	98	non-electric					2312	
West Lakes Mine	WES32	11:04	3/20/2017	26-28-31.20045	81-43-07.68956	West Lakes (N)	Clear		NE		48	4.5	56	48			19		26	26		287	13489	94	non-electric					2338	
West Lakes Mine	WES33	13:44	3/22/2017	26-28-31.17304	81-43-09.97909	West Lakes (N)	Clear		WNW		64	4.5	56	64			19		26	26		287	18368	128	non-electric					2389	
West Lakes Mine	WES34	11:22	3/24/2017	26-28-31.15165	81-43-11.69641	West Lakes (N)	Partly Cloudy		E		48	4.5	56	48			19		26	26		281	13491	96	non-electric					2438	
West Lakes Mine	WES35	10:24	3/27/2017	26-28-31.13166	81-43-13.41163	West Lakes (N)	Clear		Calm		48	4.5	56	48			19		26	26		273	12547	92	non-electric					2497	
West Lakes Mine	WES36	10:48	3/30/2017	26-28-31.10947	81-43-15.12960	West Lakes (N)	Scattered Clouds		S		48	4.5	56	48			19		26	26		277	13019	94	non-electric					2563	
West Lakes Mine	WES37	10:44	3/31/2017	26-28-31.08595	81-43-17.13172	West Lakes (N)	Partly Cloudy		S		53	4.5	56	53			19		26	26		237	14420	120	non-electric					2650	
West Lakes Mine	WES38	10:34	4/3/2017	26-28-31.06008	81-43-19.13413	West Lakes (N)	Clear		SSE		59	4.5	56	59			19		26	26		277	15512	112	non-electric					2756	
West Lakes Mine	WES39	10:07	4/6/2017	26-28-12.46829	81-43-20.85699	West Lakes (N)	Mostly Cloudy		WSW		33	4.5	56	33			19		26	26		284	9372	66	non-electric					4497	
West Lakes Mine	WES40	9:50	4/13/2017	26-28-10.62799	81-42-41.77291	West Lakes (N)	Clear		E		33	4.5	56	33			19		26	26		291	9603	66	non-electric					3005	
West Lakes Mine	WES41	12:21	4/14/2017	26-28-09.03442	81-42-45.75498	West Lakes (N)	Partly Cloudy		NE		45	4.5	56	45			19		26	26		267	12015	90	non-electric					3199	
West Lakes Mine	WES42	12:01	4/18/2017	26-28-09.78043	81-42-47.91195	West Lakes (N)	Overcast		SE		30	4.5	56	30			19		26	26		286	8585	60	non-electric					3404	
West Lakes Mine	WES43	10:19	4/19/2017	26-28-08.75063	81-42-47.89649	West Lakes (N)	Partly Cloudy		E		30	4.5	56	30			19		26	26		277	8310	60	non-electric					3347	
West Lakes Mine	WES44	9:26	4/20/2017	26-28-08.73713	81-42-49.04027	West Lakes (N)	Clear		E		32	4.5	56	32			19		26	26		277	8864	3	non-electric					3436	
West Lakes Mine	WES45	9:40	4/21/2017	26-28-08.72262	81-42-50.18550	West Lakes (N)	Partly Cloudy		E		32	4.5	56	32			19		26	26		277	8310	0	non-electric					3525	
West Lakes Mine	WES46	10:03	4/27/2017	26-28-08.70446	81-42-51.61573	West Lakes (N)	Partly Cloudy		SSE		40	4.5	56	40			19		26	26		277	10803	0	non-electric					3637	
West Lakes Mine	WES47	9:42	4/28/2017	26-28-08.70142	81-42-51.90154	West Lakes (N)	Scattered Clouds		SE		32	4.5	56	32			19		26	26		277	8864	0	non-electric					3360	
West Lakes Mine	WES48	9:02	5/4/2017	26-28-08.68835	81-42-53.04606	West Lakes (N)	Clear		SSE		27	4.5	56	27			19		26	26		287	7462	0	non-electric					3751	
West Lakes Mine	WES49	10:06	5/5/2017	26-28-09.71703	81-42-53.06100	West Lakes (N)	Overcast		NNW		32	4.5	56	32			19		26	26		286	9144	0	non-electric					3802	
West Lakes Mine	WES50	11:14	5/9/2017	26-28-08.91938	81-42-55.19493	West Lakes (N)	Clear		Calm		42	4.5	56	42			19		26	26		287	11767	0	non-electric					3936	
West Lakes Mine	WES51	9:14	5/18/2017	26-28-09.17171	81-43-16.65919	West Lakes (N)	Mostly Cloudy		E		25	4.5	56	25			19		26	26		253	6323	0	non-electric					4692	
West Lakes Mine	WES52	10:01	5/19/2017	26-28-09.40931	81-43-18.23545	West Lakes (N)	Scattered Clouds		SE		23	4.5	56	23			19		26	26		292	5548	0	non-electric					4710	
West Lakes Mine	WES53	8:45	6/2/2017	26-28-51.22804	81-41-24.19632	West Lakes (N)	Clear		Calm		20	4.5	55	20			25		20	20		258	5160	40	non-electric					2719	
West Lakes Mine	WES54	9:58	6/5/2017	26-28-51.21490	81-41-25.29686	West Lakes (N)	Clear		S		25	4.5	55	25			25		20	20		258	6450	50	non-electric					2619	
West Lakes Mine	WES55	12:47	6/6/2017	26-28-51.19980	81-41-26.40000	University Lakes (N)	Rainy	77	S	4	25	4.5	55			water	25		20	20	1	258	6450	50	non-electric	20370	45426	139	0.32	2235	
West Lakes Mine	WES56	10:20	6/8/2017	26-28-51.19980	81-41-27.49980	University Lakes (N)	Partly Cloudy	80	SE	4	25	4.5	55			water	25		20	20	1	258	6450	50	non-electric	20370	45426	132	0.32	2135	
West Lakes Mine	WES57	12:16	8/31/2017	26-28-33.00000	81-42-53.10000	West Lakes (N)	Partly Cloudy	90	SE	2	53	4.5	55			water	21		26	26	2	584	15476	106	non-electric	72983	61481	95	0.21	2299	
West Lakes Mine	WES58	13:17	9/1/2017	26-28-32.89980	81-42-54.79980	West Lakes (N)	Partly Cloudy	90	SE	2	29	4.5	55			water	21		26	26	1	292	8468	58	non-electric	39934	33641	131	0.21	2254	
West Lakes Mine	WES59	10:15	9/7/2017	26-28-09.79980	81-43-22.90020	West Lakes (S)	Clear	90	Light and Variable	5	41	4.5	55			water	21		26	26	1	292	11972	82	non-electric	51326	43237	282	0.23	4835	
West Lakes Mine	WES60	13:20	10/2/2017	26-28-32.89980	81-42-57.70020	West Lakes (N)	Overcast	88	Light and Variable	7	49	4.5	55			water	21		26	26	2	584	14308	98	non-electric	67475	56841	90	0.21	2183	

West Lakes Mine	WES61	13:24	10/5/2017	26-28-32.80020	81-43-00.40020	West Lakes (N)	Rainy	77	E	10	50	4.5	55			water	21		26	26	3	876	14600	100	non-electric	68852	58001	72	0.21	2155	
West Lakes Mine	WES62	10:28	10/10/2017	26-28-32.89980	81-43-03.30000	West Lakes (N)	Clear	90	Light and Variable	8	50	4.5	55			water	21		26	26	2	584	14600	100	non-electric	68852	58001	88	0.21	2134	
West Lakes Mine	WES63	12:14	10/11/2017	26-28-33.10020	81-43-00.19980	West Lakes (N)	Partly Cloudy	88	SE	6	50	4.5	55			water	21		26	26	2	584	14600	100	non-electric	68852	58001	87	0.21	2126	
West Lakes Mine	WES64	10:21	10/16/2017	26-28-33.00000	81-43-08.50020	West Lakes (N)	Partly Cloudy	90	SE	1	40	4.5	55			water	21		26	26	2	584	11680	80	non-electric	55082	46401	90	0.21	2185	
West Lakes Mine	WES65	9:30	11/13/2017	26-28-32.89980	81-43-10.50000	West Lakes (N)	Cloudy	78	E	10	35	4.5	55			water	21		26	26	2	584	10220	70	non-electric	48196	40601	92	0.21	2245	
West Lakes Mine	WES66	9:03	11/14/2017	26-28-32.59980	81-43-14.50020	West Lakes (N)	Clear	78	N	8	30	4.5	55			water	21		26	26	2	584	8760	60	non-electric	41311	34801	99	0.21	2411	
West Lakes Mine	WES67	9:30	11/15/2017	26-28-33.00000	81-43-12.49980	West Lakes (N)	Partly Cloudy	80	SE	3	35	4.5	55			water	21		26	26	2	584	10220	70	non-electric	48196	40601	95	0.21	2299	
West Lakes Mine	WES68	11:07	11/17/2017	26-28-40.00020	81-43-16.00020	West Lakes (N)	Partly Cloudy	81	S	4	30	4.5	55			water	21		26	26	2	584	8760	60	non-electric	41311	34801	76	0.21	1853	
West Lakes Mine	WES69	9:08	11/22/2017	26-28-33.00000	81-43-17.70000	West Lakes (N)	Clear	75	Calm	3	30	4.5	55			water	21		26	26	2	584	8760	60	non-electric	41311	34801	104	0.21	2518	
West Lakes Mine	WES70	12:43	11/27/2017	26-28-32.89980	81-43-18.79980	West Lakes (N)	Partly Cloudy	81	SE	2	27	4.5	55			water	21		26	26	1	292	7884	54	non-electric	37180	31320	151	0.21	2581	
West Lakes Mine	WES71	10:00	12/12/2017	26-28-10.39980	81-42-34.30020	West Lakes (SE)	Clear	55	NE	6	18	4.5	55			water	21		26	26	1	276	4966	36	non-electric	24787	20880	151	0.20	2513	
West Lakes Mine	WES72	11:12	12/21/2017	26-28-10.30020	81-42-35.80020	West Lakes E	Partly Cloudy	80	Light and Variable	5	33	4.5	55			water	21		26	26	2	584	9636	66	non-electric	45442	38281	107	0.21	2595	
West Lakes Mine	WES73	9:00	12/22/2017	26-28-11.50020	81-42-34.60020	West Lakes (N)	Partly Cloudy	80	S	2	33	4.5	55			water	21		26	26	1	292	9636	66	non-electric	45442	38281	153	0.21	2616	
West Lakes Mine	WES74	9:40	12/26/2017	26-28-12.49980	81-42-35.10000	West Lakes (N)	Clear	75	Light and Variable	5	30	4.5	55			water	21		26	26	2	584	8760	60	non-electric	41311	34801	112	0.21	2724	
West Lakes Mine	WES75	14:01	12/27/2017	26-28-11.29980	81-42-37.99980	West Lakes (N)	Clear	80	Light and Variable	5	38	4.5	55			water	21		26	26	2	569	10806	76	non-electric	52327	44081	117	0.21	2806	
West Lakes Mine	WES76	9:52	12/29/2017	26-28-10.39980	81-42-39.60000	West Lakes (N)	Foggy	65	N	3	37	4.5	55			water	21		26	26	2	584	10804	74	non-electric	50950	42921	117	0.21	2847	
West Lakes Mine	WES77	9:32	1/2/2018				Partly Cloudy	50	N	20	35	4.5	55				21		26	26	2	292	10220	70	non-electric					2725	
West Lakes Mine	WES78	9:30	1/3/2018				Rainy	56	NW	8	37	4.5	55				20.125		26	26	1	285	10804	74	non-electric					2814	
West Lakes Mine	WES79	10:03	1/5/2018				Clear	45	N	5	39	4.5	55				21		26	26	2	292	11388	78	non-electric					2960	
West Lakes Mine	WES80	9:01	1/8/2018				Clear	63	Light and Variable	5	21	4.5	55				21		26	26	2	292	6090	42	non-electric					3194	
West Lakes Mine	WES81	9:07	1/9/2018				Partly Cloudy	77	NE	3	21	4.5	55				21		26	26	1	292	6132	42	non-electric					3336	
West Lakes Mine	WES82	9:19	1/11/2018				Partly Cloudy	77	N	2	20	4.5	55				21		26	26	1	292	5840	40	non-electric					3577	
West Lakes Mine	WES83	9:19	1/12/2018				Partly Cloudy	77	SE	3	20	4.5	55				21		26	26	1	292	5840	40	non-electric					3687	
West Lakes Mine	WES84	9:12	1/16/2018				Partly Cloudy	66	SE	2	21	4.5	55				21		26	26	1	292	6090	42	non-electric					3867	
West Lakes Mine	WES85	12:56	1/17/2018				Partly Cloudy	77	N	3	20	4.5	55				21		26	26	1	292	5840	40	non-electric					4135	
West Lakes Mine	WES86	9:18	2/13/2018				Partly Cloudy	77	SE	2	1	4.5	55				21		26	26	1	294	294	2	electronic					4830	
West Lakes Mine	WES87	9:39	2/13/2018				Clear	77	SE	2	32	4.5	55				21		26	26	2	292	9344	64	non-electric					4857	
West Lakes Mine	WES88	9:18	2/14/2018				Partly Cloudy	80	SE	3	35	4.5	55				21		26	26	2	292	10220	70	non-electric					4886	
West Lakes Mine	WES89	9:17	2/15/2018				Partly Cloudy	77	SE	2	30	4.5	55				21		26	26	2	292	8700	60	non-electric					4910	
West Lakes Mine	WES90	9:43	2/16/2018				Partly Cloudy	85	S	3	35	4.5	55				21		26	26	2	292	10220	70	non-electric					4956	
West Lakes Mine	WES91	9:32	2/19/2018				Partly Cloudy	76	S	2	28	4.5	55				21		26	26	1	292	8120	70	non-electric					4862	
West Lakes Mine	WES92	12:13	2/23/2018				Cloudy	77	NE	5	1	4.5	72				47		26	26	1	222	222	2	electronic					3218	

West Lakes Mine	WES93	10:53	2/26/2018				Clear	83	Light and Variable	5	36	4.5	72				23		26	26	2	429	15336	72	electronic					2601	
West Lakes Mine	WES94	15:20	2/27/2018				Partly Cloudy	83	Light and Variable	8	40	4.5	72				30		26	26	2	387	15456	80	electronic					1778	
West Lakes Mine	WES95	11:10	3/6/2018				Partly Cloudy		Light and Variable	10	57	4.5	55				21		26	26	2	294	16758	114	electronic					2410	
West Lakes Mine	WES96	10:34	3/8/2018				Clear	65	N	10	54	4.5	55				21		26	26	2	294	15876	108	electronic					2303	
West Lakes Mine	WES97	15:18	3/9/2018				Clear	70	N	10	35	4.5	55				21		28	28	2	294	10290	70	electronic					2276	
West Lakes Mine	WES98	10:28	3/19/2018				Clear	75	W	10	56	4.5	55				21		28	28	3	292	16352	112	non-electric					2217	
West Lakes Mine	WES99	10:24	3/22/2018				Clear	60	N	20	55	4.5	55				21		28	28	2	294	16170	110	electronic					2143	
West Lakes Mine	WES100	14:39	3/23/2018				Partly Cloudy	77	N	3	48	4.5	55				20.125		28	28	2	280	13432	92	non-electric					2117	
West Lakes Mine	WES101	11:08	3/27/2018				Windy	65	E	40	56	4.5	55				21		28	28	2	294	16464	112	electronic					1932	
West Lakes Mine	WES102	10:35	3/29/2018				Windy	80	SE	35	56	4.5	55				21		28	28	2	294	16464	112	electronic					1952	

White Rock Quarries

Mine Name	BlastEvent ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temperature (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes/ Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)	Comments
White Rock Quarries	WHI1	15:00	1/9/2017			Section 5	Partly Cloudy	68	NE		100	4.5	84		82		16	0	17	18	3	1,665	58,830	200	electronic					4013	
White Rock Quarries	WHI2	13:15	1/10/2017			Section 8	Mostly Cloudy	72	ENE		65	4.5	84		84		16	0	17	18	1	557	36,205	130	electronic					4375	
White Rock Quarries	WHI3	13:15	1/11/2017			Section 5	Partly Cloudy	75	E		90	4.5	84		82		16	0	17	18	2	1,110	49,950	180	electronic					4013	
White Rock Quarries	WHI4	13:15	1/12/2017			Section 8	Mostly Cloudy	77	E		65	4.5	84		84		16	0	17	18	1	557	36,205	130	electronic					4676	
White Rock Quarries	WHI5	11:30	1/13/2017			Section 5	Partly Cloudy	80	E		90	4.5	84		82		16	0	17	18	2	1,110	49,950	180	electronic					4047	
White Rock Quarries	WHI6	13:15	1/17/2017			Section 5	Partly Cloudy	80	E		57	4.5	84		82		16	0	17	18	2	1,110	31,080	114	electronic					3721	
White Rock Quarries	WHI7	13:15	1/18/2017			Section 5	Partly Cloudy	80	S		100	4.5	84		82		16	0	17	18	2	1,110	31,080	200	electronic					4027	
White Rock Quarries	WHI8	13:15	1/19/2017			Section 8	Fair	80	S		65	4.5	84		84		16	0	17	18	1	557	36,205	130	electronic					4898	
White Rock Quarries	WHI9	13:15	1/20/2017			Section 5	Partly Cloudy	80	S		55	4.5	84		82		16	0	17	18	1	555	30,525	110	electronic					4052	
White Rock Quarries	WHI10	13:15	1/23/2017			Section 5	Partly Cloudy	75	W		60	4.5	84		82		16	0	17	18	1	555	33,300	120	electronic					3912	
White Rock Quarries	WHI11	11:45	1/25/2017			Section 5	Partly Cloudy	75	W		90	4.5	84		82		16	0	17	18	1	555	49,950	180	electronic					2829	
White Rock Quarries	WHI12	11:00	1/27/2017			Section 5	Partly Cloudy	80	SW		55	4.5	84		82		16	0	17	18	1	555	30525	110	electronic					3530	
White Rock Quarries	WHI13	10:30	1/31/2017			Section 5	Clear	70	NW		89	4.5	84		82		16	0	17	18	1	555	49395	178	electronic					2847	
White Rock Quarries	WHI14	11:45	2/3/2017			Section 5	Partly Cloudy	76	N		55	4.5	84		82		16	0	17	18	1	555	30525	110	electronic					2923	
White Rock Quarries	WHI15	14:00	2/6/2017			Section 5	Partly Cloudy	80	N		89	4.5	84		82		16	0	17	18	1	555	49395	178	electronic					2827	
White Rock Quarries	WHI16	13:15	2/8/2017			Section 5	Partly Cloudy	80	N		58	4.5	84		82		16	0	17	18	1	555	32190	116	electronic					2827	
White Rock Quarries	WHI17	14:15	2/10/2017			Section 5	Partly Cloudy	80	S		87	4.5	84		82		16	0	17	18	1	555	47768	174	electronic					2830	
White Rock Quarries	WHI18	13:30	2/15/2017			Section 5	Partly Cloudy	80	W		91	4.5	84		82		16	0	17	18	1	555	50505	182	electronic					2826	
White Rock Quarries	WHI19	13:16	2/16/2017			Section 8	Mostly Cloudy	77	W		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					5229	
White Rock Quarries	WHI20	11:45	2/17/2017			Section 5	Clear	75	N		63	4.5	84		82		16	0	17	18	1	555	34965	126	electronic					2827	
White Rock Quarries	WHI21	13:30	2/21/2017			Section 8	Cloudy	76	W		70	4.5	84		82		16	0	17	18	1	557	38990	140	electronic					5061	
White Rock Quarries	WHI22	11:30	2/22/2017			Section 5	Clear	80	NE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2824	
White Rock Quarries	WHI23	13:30	2/23/2017			Section 8	Partly Cloudy	76	W		64	4.5	84		82		16	0	17	18	1	557	35648	128	electronic					4892	
White Rock Quarries	WHI24	13:15	2/24/2017			Section 5	Partly Cloudy	80	NW		120	4.5	84		82		16	0	17	18	2	1110	66600	240	electronic					2812	
White Rock Quarries	WHI25	13:15	2/27/2017			Section 5	Partly Cloudy	80	SE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2806	
White Rock Quarries	WHI26	15:00	2/28/2017			Section 5	Partly Cloudy	80	SE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2823	
White Rock Quarries	WHI27	13:31	3/1/2017			Section 8	Partly Cloudy	82	E		70	4.5	84		82		16	0	17	18	1	557	38990	140	electronic					5217	
White Rock Quarries	WHI28	13:15	3/2/2017			Section 5	Partly Cloudy	85	SE		120	4.5	84		82		16	0	17	18	2	1110	66600	240	electronic					3686	

White Rock Quarries	WHI29	13:15	3/3/2017			Section 8	Cloudy	78	NNE		60	4.5	84		82		16	0	17	18	1	557	33420	120	electronic					5528	
White Rock Quarries	WHI30	13:15	3/6/2017			Section 5	Partly Cloudy	72	SE		119	4.5	84		82		16	0	17	18	2	1110	66600	238	electronic					2816	
White Rock Quarries	WHI31	13:16	3/7/2017			Section 8	Partly Cloudy	77	E		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					6019	
White Rock Quarries	WHI32	13:18	3/8/2017			Section 5	Partly Cloudy	75	E		90	4.5	84		82		16	0	17	18	3	1665	49950	180	electronic					4039	
White Rock Quarries	WHI33	13:15	3/10/2017			Section 5	Partly Cloudy	80	E		89	4.5	84		82		16	0	17	18	3	1665	49395	178	electronic					4014	
White Rock Quarries	WHI34	14:45	3/13/2017			Section 5	Partly Cloudy	80	SE		63	4.5	84		82		16	0	17	18	2	1110	34965	126	electronic					4042	
White Rock Quarries	WHI35	10:00	3/16/2017			Section 5	Partly Cloudy	65	N		88	4.5	84		82		16	0	17	18	3	1665	48840	176	electronic					3763	
White Rock Quarries	WHI36	11:30	3/20/2017			Section 5	Partly Cloudy	75	NE		60	4.5	84		82		16	0	17	18	1	555	33300	120	electronic					3921	
White Rock Quarries	WHI37	13:15	3/21/2017			Section 8	Fair	77	E		41	4.5	84		82		16	0	17	18	1	557	22837	82	electronic					4471	
White Rock Quarries	WHI38	11:30	3/22/2017			Section 5	Partly Cloudy	79	W		60	4.5	84		82		16	0	17	18	1	555	33300	120	electronic					3468	
White Rock Quarries	WHI39	11:00	3/24/2017			Section 5	Partly Cloudy	75	NE		61	4.5	84		82		16	0	17	18	3	1665	33855	122	electronic					2833	
White Rock Quarries	WHI40	11:45	3/27/2017			Section 5	Partly Cloudy	80	NE		59	4.5	84		82		16	0	17	18	3	1665	32745	118	electronic					3704	
White Rock Quarries	WHI41	13:15	3/28/2017			Section 8	Mostly Cloudy	81	NE		61	4.5	84		82		16	0	17	18	1	557	33977	122	electronic					5853	
White Rock Quarries	WHI42	11:45	3/29/2017			Section 5	Partly Cloudy	80	E		59	4.5	84		82		16	0	17	18	1	555	32745	118	electronic					3044	
White Rock Quarries	WHI43	13:15	3/30/2017			Section 8	Mostly Cloudy	82	SE		60	4.5	84		82		16	0	17	18	1	557	33420	120	electronic					5716	
White Rock Quarries	WHI44	11:30	3/31/2017			Section 5	Partly Cloudy	85	SE		80	4.5	84		82		16	0	17	18	1	555	44400	160	electronic					2737	
White Rock Quarries	WHI45	13:15	4/4/2017			Section 8	Mostly Cloudy	86	SE		71	4.5	84		82		16	0	17	18	1	557	39547	142	electronic					4450	
White Rock Quarries	WHI46	14:00	4/5/2017			Section 5	Partly Cloudy	85	SE		89	4.5	84		82		16	0	17	18	1	555	49395	178	electronic					2740	
White Rock Quarries	WHI47	13:15	4/7/2017			Section 5	Partly Cloudy	70	N		69	4.5	84		82		16	0	17	18	1	555	36075	138	electronic					2743	
White Rock Quarries	WHI48	14:15	4/10/2017			Section 5	Partly Cloudy	80	E		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					5227	
White Rock Quarries	WHI49	13:32	4/11/2017			Section 6	Mostly Cloudy	77	ENE		90	4.5	85		80		15	0	17	18	1	557	50130	180	electronic					6953	
White Rock Quarries	WHI50	14:45	4/12/2017			Section 5	Overcast	80	NE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2751	
White Rock Quarries	WHI51	13:21	4/13/2017			Section 8	Mostly Cloudy	79	ENE		80	4.5	84		82		16	0	17	18	1	557	44560	160	electronic					6190	
White Rock Quarries	WHI52	11:15	4/17/2017			Section 5	Cloudy	76	E		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2747	
White Rock Quarries	WHI53	13:15	4/18/2017			Section 6	Mostly Cloudy	81	ENE		90	4.5	85		80		15	0	17	18	1	557	52097	180	electronic					5073	
White Rock Quarries	WHI54	14:00	4/19/2017			Section 5	Overcast	76	SE		91	4.5	84		82		16	0	17	18	2	1110	50505	182	electronic					2747	
White Rock Quarries	WHI55	14:30	4/20/2017			Section 8	Cloudy	79	E		80	4.5	84		82		16	0	17	18	1	557	44561	160	electronic					5560	
White Rock Quarries	WHI56	13:34	4/21/2017			Section 5	Cloudy	77	E		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2726	
White Rock Quarries	WHI57	13:15	4/24/2017			Section 5	Partly Cloudy	85	SE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2736	
White Rock Quarries	WHI58	14:00	5/1/2017			Section 5	Partly Cloudy	85	NW		91	4.5	84		82		16	0	17	18	1	555	50505	182	electronic					2723	
White Rock Quarries	WHI59	14:12	5/4/2017			Section 6	Mostly Cloudy	88	SE		90	4.5	85		80		16	1	17	18	0.5	252	40901	165	electronic					5073	
White Rock Quarries	WHI60	13:45	5/5/2017			Section 5	Partly Cloudy	80	S		119	4.5	84		82		16	0	17	18	3	1665	66045	238	electronic					2736	

White Rock Quarries	WH61	13:15	5/8/2017			Section 5	Partly Cloudy	84	NE		90	4.5	84		82		16	0	17	18	2	1110	49950	180	electronic					3880	
White Rock Quarries	WH62	14:31	5/10/2017			Section 5	Partly Cloudy	85	N		100	4.5	84		82		16	0	17	18	3	1665	59948	200	electronic					3165	
White Rock Quarries	WH63	15:00	5/11/2017			Section 6	Fair	87	SE		95	6	84		80		15	2	20.5	20.5	3	247	70396	285	electronic					5081	
White Rock Quarries	WH64	13:15	5/12/2017			Section 5	Clear	90	SW		101	4.5	84		82		16	0	17	18	2	1110	56055	202	electronic					3516	
White Rock Quarries	WH65	13:15	5/15/2017			Section 5	Clear	90	W		110	4.5	84		82		16	0	17	18	2	1110	61050	220	electronic					4130	
White Rock Quarries	WH66	14:50	5/17/2017			Section 5	Partly Cloudy	90	E		109	4.5	84		82		16	0	17	18	1	555	60495	218	electronic					4099	
White Rock Quarries	WH67	13:30	5/22/2017			Section 5	Partly Cloudy	90	E		110	4.5	84		82		16	0	17	18	1	555	61050	220	electronic					4099	
White Rock Quarries	WH68	14:17	5/23/2017			Section 6	Mostly Cloudy	88	SE		95	6	84		80		21	1	20	21	2	391	74291	190	electronic					5085	
White Rock Quarries	WH69	13:30	5/24/2017			Section 5	Partly Cloudy	89	E		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					4125	
White Rock Quarries	WH70	13:00	5/25/2017			Section 6	Mostly Cloudy	81	SW		102	4.5	84		80		16	1	16.6	17	1	557	56759	204	electronic					5161	
White Rock Quarries	WH71	14:00	5/26/2017			Section 5	Partly Cloudy	90	E		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					4149	
White Rock Quarries	WH72	13:15	5/30/2017			Section 6	Mostly Cloudy	88	SE		39	6	84		80		21	1	20	21	2	391	30498	78	electronic					5085	
White Rock Quarries	WH73	13:15	5/31/2017			Section 5	Partly Cloudy	90	SE		90	4.5	84		82		16	0	17	18	2	1110	49950	180	electronic					4167	
White Rock Quarries	WH74	11:45	6/1/2017			Section 6	Mostly Cloudy	86	SE		14	6	84		80		21	1	21	21	2	391	10948	28	electronic					5063	
White Rock Quarries	WH75	13:30	6/5/2017			Section 5	Overcast	75	N		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					4141	
White Rock Quarries	WH76	11:26	6/6/2017			Section 6	Cloudy w/rain	74	NE		12	4.5	84		80		16	0	17	18	1	557	6684	24	electronic					5170	
White Rock Quarries	WH77	13:17	6/16/2017			Section 5	Partly Cloudy	80	NE		70	4.5	84		82		16	0	17	18	1	555	38850	140	electronic					4122	
White Rock Quarries	WH78	11:15	6/19/2017			Section 5	Partly Cloudy	85	SE		50	4.5	84		82		16	0	17	18	2	1110	27750	100	electronic					4143	
White Rock Quarries	WH79	13:30	6/20/2017			Section 6	Mostly Cloudy	88	ESE		72	6	84		80		20	1	21.5	20	1	797	57384	144	electronic					5175	
White Rock Quarries	WH80	11:45	6/21/2017			Section 5	Partly Cloudy	85	SE		56	4.5	84		82		16	0	17	18	3	1665	31080	112	electronic					3796	
White Rock Quarries	WH81	13:15	6/22/2017			Section 6	Mostly Cloudy	89	ESE		40	4.5	84		80		16	0	16.6	18	1	558	22282	82	electronic					5176	
White Rock Quarries	WH82	11:45	6/23/2017			Section 5	Partly Cloudy	86	N		60	4.5	84		82		16	0	17	18	2	1110	33300	120	electronic					4025	
White Rock Quarries	WH83	11:45	6/26/2017			Section 5	Partly Cloudy	87	N		59	4.5	84		82		16	0	17	18	2	1110	32745	118	electronic					3806	
White Rock Quarries	WH84	13:30	6/27/2017			Section 6	Cloudy	84	E		72	6	84		80		20	1	21.5	20	1	797	57385	145	electronic					5223	
White Rock Quarries	WH85	13:15	7/5/2017			Section 5	Partly Cloudy	90	SE		60	4.5	84		82		16	0	17	18	2	1110	33300	120	electronic					2932	
White Rock Quarries	WH86	11:15	7/6/2017			Section 6	Partly Cloudy	89	ESE		18	6	84		80		16	0	21.8	24	1	986	17748	36	electronic					5174	
White Rock Quarries	WH87	13:15	7/7/2017			Section 5	Partly Cloudy	90	SE		60	4.5	84		82		16	0	17	18	2	1110	33300	120	electronic					3580	
White Rock Quarries	WH88	13:19	7/10/2017			Section 5	Partly Cloudy	85	ESE		60	4.5	84		82		16	0	17	18	1	557	33420	120	electronic					3167	
White Rock Quarries	WH89	13:15	7/11/2017			Section 5	Overcast	90	SE		51	4.5	84		82		16	0	17	18	2	1110	33300	102	electronic					2672	
White Rock Quarries	WH90	15:03	7/14/2017			Section 5	Partly Cloudy	90	E		84	4.5	84		82		16	0	17	18	1	557	46789	169	electronic					2730	
White Rock Quarries	WH91	11:45	7/17/2017			Section 5	Partly Cloudy	90	N		51	4.5	84		82		16	0	17	18	1	555	28305	102	electronic					2754	
White Rock Quarries	WH92	11:45	7/20/2017			Section 5	Partly Cloudy	93	SE		48	4.5	84		82		16	0	17	18	1	555	26640	96	electronic					2668	

White Rock Quarries	WHI93	11:20	7/21/2017			Section 23	Partly Cloudy	90	SE		52	4.5	65		62		16	0	17	18	1	436	22672	104	electronic					4240	
White Rock Quarries	WHI94	14:00	7/24/2017			Section 5	Partly Cloudy	88	SE		89	4.5	84		82		16	0	17	18	1	557	49573	178	electronic					2694	
White Rock Quarries	WHI95	14:15	7/26/2017			Section 5	Partly Cloudy	95	SE		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2658	
White Rock Quarries	WHI96	14:00	8/1/2017			Section 5	Cloudy	89	SW		89	4.5	84		82		16	0	17	18	1	557	49573	178	electronic					2696	
White Rock Quarries	WHI97	14:30	8/3/2017			Section 5	Partly Cloudy	90	S		110	4.5	84		82		16	0	17	18	2	1110	61050	220	electronic					3882	
White Rock Quarries	WHI98	15:00	8/7/2017			Section 5	Partly Cloudy	93	ESE		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2692	
White Rock Quarries	WHI99	14:31	8/10/2017			Section 5	Partly Cloudy	84	WSW		115	4.5	84		82		16	0	17	18	1	557	64056	231	electronic					3482	
White Rock Quarries	WHI100	13:15	8/11/2017			Section 5	Partly Cloudy	88	N		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					2694	
White Rock Quarries	WHI101	13:46	8/14/2017			Section 5	Partly Cloudy	95	SW		100	4.5	84		82		16	0	17	18	1	557	55700	200	electronic					2693	
White Rock Quarries	WHI102	13:06	8/16/2017			Section 5	Partly Cloudy	92	ESE		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2693	
White Rock Quarries	WHI103	13:15	8/17/2017			Section 5	Partly Cloudy	95	SE		89	4.5	84		82		16	0	17	18	1	555	49395	178	electronic					2653	
White Rock Quarries	WHI104	13:15	8/23/2017			Section 5	Partly Cloudy	90	NE		103	4.5	84		82		16	0	17	18	2	1110	57165	206	electronic					3030	
White Rock Quarries	WHI105	10:15	8/24/2017			Section 5	Cloudy	79	SSE		89	4.5	84		82		16	0	17	18	1	557	49573	178	electronic					2690	
White Rock Quarries	WHI106	11:00	8/28/2017			Section 5	Partly Cloudy	88	SW		89	4.5	84		82		16	0	17	18	1	557	49573	178	electronic					2646	
White Rock Quarries	WHI107	13:31	8/31/2017			Section 6	Fair	92	SE		120	4.5	84		82		16	0	17	18	1	557	66840	240	electronic					7284	
White Rock Quarries	WHI108	13:15	9/1/2017			Section 5	Partly Cloudy	92	NW		95	4.5	84		82		16	0	17	18	2	1110	52725	190	electronic					4223	
White Rock Quarries	WHI109	13:30	9/19/2017			Section 5	Partly Cloudy	92	N		90	4.5	84		82		16	0	17	18	1	555	49950	180	electronic					4228	
White Rock Quarries	WHI110	11:00	9/22/2017			Section 6	Cloudy	81	N		123	4.5	84		82		16	0	17	18	1	557	68514	246	electronic					4433	
White Rock Quarries	WHI111	13:30	10/2/2017			Section 5	Cloudy	84	NW		60	4.5	84		82		16	0	17	18	1	555	49950	120	electronic					3860	
White Rock Quarries	WHI112	13:30	10/4/2017			Section 8	Mostly Cloudy	85	ENE		74	4.5	84		82		16	0	17	18	1	557	41218	148	electronic					5775	
White Rock Quarries	WHI113	10:43	10/6/2017			Section 6	Overcast	85	NE		114	4.5	84		82		16	0	17	18	3	1565	63270	228	electronic					3934	
White Rock Quarries	WHI114	13:15	10/10/2017			Section 5	Cloudy	85	NE		55	4.5	84		82		16	0	17	18	1	555	30525	110	electronic					3437	
White Rock Quarries	WHI115	11:45	10/11/2017			Section 6	Partly Cloudy	86	ENE		30	4.5	84		82		16	0	17	18	1	557	16710	60	electronic					1836	
White Rock Quarries	WHI116	13:15	10/12/2017			Section 8	Mostly Cloudy	85	ENE		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					5750	
White Rock Quarries	WHI117	13:15	10/13/2017			Section 6	Partly Cloudy	86	E		45	4.5	84		82		16	0	17	18	1	557	25065	90	electronic					2272	
White Rock Quarries	WHI118	14:15	10/17/2017			Section 6	Partly Cloudy	87	ENE		120	4.5	84		82		16	0	17	18	1	557	25065	240	electronic					3533	
White Rock Quarries	WHI119	14:00	10/19/2017			Section 8	Mostly Cloudy	86	E		85	4.5	84		82		16	0	17	18	1	557	47345	170	electronic					6020	
White Rock Quarries	WHI120	13:15	10/21/2017			Section 8	Sunny	76	NNE		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					5597	
White Rock Quarries	WHI121	14:00	10/23/2017			Section 8	Mostly Cloudy	86	ESE		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					5756	
White Rock Quarries	WHI122	10:30	10/24/2017			Section 5	Partly Cloudy	85	N		5	4.5	84		82		16	0	17	18	1	555	2775	10	electronic					3429	
White Rock Quarries	WHI123	13:30	11/1/2017			Section 5	Clear	75	N		60	4.5	84		82		16	0	17	18	1	555	33300	120	electronic					3662	
White Rock Quarries	WHI124	11:30	11/7/2017			Section 5	Clear	82	N		60	4.5	84		82		16	0	17	18	1	555	33300	120	electronic					3243	

White Rock Quarries	WHI125	11:45	11/8/2017			Section 6	Partly Cloudy	83	NE		45	4.5	84		82		16	0	17	18	1	557	25065	90	electronic					1952	
White Rock Quarries	WHI126	11:45	11/9/2017			Section 5	Clear	85	N		51	4.5	84		82		16	0	17	18	1	555	28305	102	electronic					2829	
White Rock Quarries	WHI127	13:15	11/13/2017			Section 6	Partly Cloudy	83	ENE		45	4.5	84		82		16	0	17	18	1	557	25065	90	electronic					2119	
White Rock Quarries	WHI128	11:00	11/14/2017			Section 5	Partly Cloudy	85	N		50	4.5	84		82		16	0	17	18	1	555	27750	100	electronic					2578	
White Rock Quarries	WHI129	14:30	11/15/2017			Section 5	Partly Cloudy	85	N		60	4.5	84		82		16	0	17	18	3	1665	33300	120	electronic					4217	
White Rock Quarries	WHI130	11:32	11/16/2017			Section 6	Partly Cloudy	78	N		65	4.5	84		82		16	0	17	18	1	557	36205	130	electronic					3291	
White Rock Quarries	WHI131	11:30	11/17/2017			Section 5	Clear	78	N		45	4.5	84		82		16	0	17	18	3	1665	24975	90	electronic					2660	
White Rock Quarries	WHI132	14:00	11/20/2017			Section 5	Cloudy	78	NE		90	4.5	84		82		16	0	17	18	1	555	50130	180	electronic					2583	
White Rock Quarries	WHI133	13:30	11/21/2017			Section 5	Partly Cloudy	80	NW		45	4.5	84		82		16	0	17	18	1	555	33300	90	electronic					4082	
White Rock Quarries	WHI134	13:15	11/22/2017			Section 5	Partly Cloudy	83	E		88	4.5	84		82		16	0	17	18	1	555	49016	176	electronic					2584	
White Rock Quarries	WHI135	13:15	11/28/2017			Section 5	Cloudy	80	ENE		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2641	
White Rock Quarries	WHI136	11:30	11/29/2017			Section 5	Partly Cloudy	80	NE		50	4.5	84		82		16	0	17	18	1	555	27750	100	electronic					2767	
White Rock Quarries	WHI137	13:35	11/30/2017			Section 5	Partly Cloudy	81	NE		92	4.5	84		82		16	0	17	18	1	557	51244	184	electronic					2651	
White Rock Quarries	WHI138	14:16	12/1/2017			Section 13	Partly Cloudy	80	NE		50	4.5	65		62		12	0	16	18	1	436	21800	100	electronic					4115	
White Rock Quarries	WHI139	15:00	12/4/2017			Section 5	Partly Cloudy	80	E		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2622	
White Rock Quarries	WHI140	10:30	12/5/2017			Section 5	Sunny	80	W		51	4.5	84		82		16	0	17	18	1	555	28305	102	electronic					2579	
White Rock Quarries	WHI141	13:40	12/8/2017			Section 5	Partly Cloudy	84	S		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2647	
White Rock Quarries	WHI142	14:02	12/13/2017			Section 5	Sunny	71	W		105	4.5	84		82		16	0	17	18	1	557	58485	210	electronic					2967	
White Rock Quarries	WHI143	11:30	12/14/2017			Section 5	Clear		N		45	4.5	84		82		16	0	17	18	2	1110	24975	90	electronic					2620	
White Rock Quarries	WHI144	13:30	12/18/2017			Section 5	Cloudy	83	ESE		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2640	
White Rock Quarries	WHI145	13:45	12/21/2017			Section 5	Partly Cloudy	82	W		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					2640	
White Rock Quarries	WHI146	13:16	1/8/2018			Section 5	Partly Cloudy	76	ESE		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					3669	
White Rock Quarries	WHI147	13:48	1/10/2018			Section 5	Cloudy	73	E		100	4.5	84		82		16	0	17	18	1	557	55700	200	electronic					2607	
White Rock Quarries	WHI148	13:20	1/11/2018			Section 6	Partly Cloudy	75	E		80	4.5	84		80		16	0	17	18	2	1110	44400	160	electronic					2995	
White Rock Quarries	WHI149	13:15	1/12/2018			Section 5	Partly Cloudy	80	S		90	4.5	84		82		16	0	17	18	1	557	50130	180	electronic					3344	
White Rock Quarries	WHI150	13:45	1/16/2018			Section 5	Partly Cloudy	74	NNE		82	6	84		82		16	0	21	26	1	887	72734	164	electronic					4255	
White Rock Quarries	WHI151	14:00	1/17/2018			Section 5	Partly Cloudy	73	NNW		95	4.5	84		82		16	0	17	18	1	557	52915	190	electronic					3998	
White Rock Quarries	WHI152	11:30	1/18/2018			Section 8	Partly Cloudy	52	SE		65	4.5	84		82		16	0	17	18	2	1110	36075	130	electronic					5230	
White Rock Quarries	WHI153	13:16	1/19/2018			Section 5	Partly Cloudy	67	ENE		81	6	84		82		16	0	21	26	1	887	71848	162	electronic					4262	
White Rock Quarries	WHI154	13:20	1/23/2018			Section 6	Partly Cloudy	80	N		80	4.5	84		80		16	0	17	18	2	1110	44400	160	electronic					2741	
White Rock Quarries	WHI155	14:00	1/24/2018			Section 5	Partly Cloudy	70	NNW		68	6	84		82		18	1	21	20	1	766	52088	136	electronic					2853	
White Rock Quarries	WHI156	13:48	1/26/2018			Section 8	Partly Cloudy	75	NE		60	4.5	84		82		16	0	17	18	2	1110	33300	120	electronic					5031	

White Rock Quarries	WHI157	13:15	1/31/2018			Section 6	Partly Cloudy	70	N		75	4.5	84		80		16	0	17	18	2	1110	41625	150	electronic					2438	
White Rock Quarries	WHI158	13:15	2/2/2018			Section 5	Partly Cloudy	79	NNW		52	6	84		82		18	0	21	26	1	887	46124	104	electronic					4448	
White Rock Quarries	WHI159	14:02	2/9/2018			Section 5	Partly Cloudy	80	E		69	6	84		82		18	1	21	20	1	769	52994	138	electronic					2853	
White Rock Quarries	WHI160	13:15	2/13/2018			Section 5	Partly Cloudy	82	E		59	6	84		82		18	0	21	26	1	887	52392	118	electronic					2975	
White Rock Quarries	WHI161	13:34	2/14/2018			Section 6	Partly Cloudy	80	SE		126	4.5	84		80		16	0	17	18	2	1110	69930	252	electronic					4322	
White Rock Quarries	WHI162	11:30	2/16/2018			Section 5	Partly Cloudy	80	SSE		52	6	84		82		18	0	21	26	1	887	52392	104	electronic					3528	
White Rock Quarries	WHI163	14:00	2/19/2018			Section 5	Partly Cloudy	80	E		62	6	84		82		18	1	21	20	1	384	47554	124	electronic					2437	
White Rock Quarries	WHI164	13:15	2/20/2018			Section 6	Partly Cloudy	80	SE		125	4.5	84		80		16	0	17	18	2	1110	69375	250	electronic					3456	
White Rock Quarries	WHI165	13:31	2/22/2018			Section 5	Partly Cloudy	81	E		60	6	84		82		18	1	21	26	1	384	46020	120	electronic					2628	
White Rock Quarries	WHI166	14:00	2/26/2018			Section 5	Partly Cloudy	77	SSW		53	6	84		82		18	1	21	20	1	384	40704	106	electronic					2745	
White Rock Quarries	WHI167	13:33	2/27/2018			Section 6	Partly Cloudy	85	SE		125	4.5	84		80		16	0	17	18	2	1110	69375	250	electronic					2870	
White Rock Quarries	WHI168	14:00	3/5/2018			Section 5	Partly Cloudy	74	E		61	6	84		82		18	1	21	20	1	384	46787	122	electronic					2422	
White Rock Quarries	WHI169	11:37	3/7/2018			Section 6	Partly Cloudy	80	N		100	4.5	84		80		16	0	17	18	2	1110	55500	200	electronic					4812	
White Rock Quarries	WHI170	13:15	3/9/2018			Section 5	Sunny	70	ENE		49	6	84		82		18	1	21	20	1	384	37632	98	electronic					2342	
White Rock Quarries	WHI171	14:45	3/15/2018			Section 6	Partly Cloudy	78	N		1	4.5	84		80		16	0	1	1	1	515	515	2	electronic					1735	
White Rock Quarries	WHI172	14:18	3/19/2018			Section 5	Partly Cloudy	84	SW		57	6	84		82		18	1	21	20	1	384	43776	228	electronic					2624	
White Rock Quarries	WHI173	11:45	3/20/2018			Section 5	Sunny	88	SW		41	6	84		82		18	1	21	20	1	383	31406	82	electronic					2542	
White Rock Quarries	WHI174	14:18	3/21/2018			Section 6	Partly Cloudy	80	NW		10	4.5	84		80		16	0	17	18	1	515	5150	20	electronic					1704	
White Rock Quarries	WHI175	14:15	3/22/2018			Section 6	Clear	70	NW		10	4.5	84		80		16	0	17	18	1	515	5150	20	electronic					1735	
White Rock Quarries	WHI176	13:14	3/23/2018			Section 5	Sunny	73	N		40	6	84		82		18		21	20	1	383	30640	80	electronic					2539	
White Rock Quarries	WHI177	14:30	3/26/2018			Section 5	Partly Cloudy	85	ENE		67	6	84		82		18	1	21	20	1	766	51322	134	electronic					2640	

Krome Quarry

Mine Name	BlastEvent ID	Blast Time	Blast Date	GPS Northing	GPS Westing	Bench	Weather	Temp (°F)	Wind Direction	Wind Speed (mph)	Number Holes	Hole Diameter (inch)	Hole Depth (ft)	Number of Wet Holes	Water Depth (ft)	Stem Type	Stemming Length (ft)	Number Decks	Burden (ft)	Spacing (ft)	Max Holes / Delay	Max Lbs / Delay (lbs)	Total Expl Weight in Blast (lbs)	Number of Primers	Initiation System	Volume Shot (CY)	Tons Shot	Scaled Distance (ft/lb^0.5)	Powder Factor (lb/cy)	Distance to Nearest Structure (ft)
Krome Quarry	KRO1	11:15	1/10/2017			Shoma N	Cloudy		E		39	4.5	50	39	50		9		21	21	1	349	13611	78	electronic					2777
Krome Quarry	KRO2	11:30	1/23/2017			Shoma N	Partly Cloudy		W		33	4.5	50	33	50		9		21	21	2	698	11517	66	electronic					2708
Krome Quarry	KRO3	10:50	1/26/2017			Shoma S	Partly Cloudy		S		59	4.5	50	59	50		9		21	21	1	349	20591	118	electronic					2337
Krome Quarry	KRO4	11:45	2/2/2017			Shoma S	Partly Cloudy		N		60	4.5	50	60	50		9		21	21	1	349	20940	120	electronic					2014
Krome Quarry	KRO5	11:29	2/7/2017			Shoma S	Cloudy		SE		59	4.5	50	59	50		9		21	21	1	349	20591	118	electronic					2140
Krome Quarry	KRO6	13:23	2/8/2017			Shoma S	Partly Cloudy		E		60	4.5	50	60	50		9		21	21	1	349	20940	120	electronic					1968
Krome Quarry	KRO7	11:30	2/13/2017			Shoma S	Partly Cloudy		N		60	4.5	50	60	50		9		21	21	1	349	20940	120	electronic					2012
Krome Quarry	KRO8	11:14	2/21/2017			Shoma N	Overcast		E		59	4.5	50	59	50		9		20	21	1	349	20591	118	electronic					2909
Krome Quarry	KRO9	14:09	2/22/2017			Shoma S	Rain		S		32	4.5	50	32	50		9		21	21	1	349	11168	64	electronic					2186
Krome Quarry	KRO10	13:09	2/27/2017			Shoma N	Partly Cloudy		N		61	4.5	50	61	50		9		20	21	1	349	21289	122	electronic					2754
Krome Quarry	KRO11	11:30	3/1/2017			Shoma S	Cloudy		E		45	4.5	50	45	50		9		21	21	1	349	15705	90	electronic					2102
Krome Quarry	KRO12	11:32	3/9/2017			Shoma N	Partly Cloudy		E		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					2617
Krome Quarry	KRO13	13:00	3/23/2017			Shoma N	Partly Cloudy		NE		57	4.5	50	57	50		9		20	21	1	349	19893	114	electronic					2645
Krome Quarry	KRO14	11:45	3/27/2017			Shoma S	Partly Cloudy		E		59	4.5	50	59	50		9		20	21	1	349	20591	118	electronic					2290
Krome Quarry	KRO15	11:49	3/30/2017			Shoma S	Partly Cloudy		SE		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					2080
Krome Quarry	KRO16	11:38	4/11/2017			Shoma S	Cloudy		E		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					1921
Krome Quarry	KRO17	10:07	4/18/2017			Shoma S	Cloudy		E		48	4.5	50	48	50		9		20	21	1	349	16752	96	electronic					1918
Krome Quarry	KRO18	11:36	4/27/2017			Shoma S	Partly Cloudy		E		45	4.5	50	45	50		9		20	21	1	349	15705	90	electronic					1921
Krome Quarry	KRO19	13:00	5/17/2017			Shoma S	Partly Cloudy		E		45	4.5	50	45	50		9		20	21	1	349	15705	90	electronic					1996
Krome Quarry	KRO20	14:29	5/22/2017			Shoma S	Partly Cloudy		E		49	4.5	50	49	50		9		20	21	1	349	17101	100	electronic					2272
Krome Quarry	KRO21	11:22	5/25/2017			Shoma S	Overcast		SW		30	4.5	50	30	50		9		20	21	1	349	10470	60	electronic					2056
Krome Quarry	KRO22	10:45	5/30/2017			Shoma S	Partly Cloudy		E		28	4.5	50	28	50		9		20	21	1	420	11760	56	electronic					2136
Krome Quarry	KRO23	14:00	6/5/2017			Shoma S	Overcast		SE		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					7192
Krome Quarry	KRO24	11:39	6/15/2017			Shoma S	Partly Cloudy		N		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					1908
Krome Quarry	KRO25	10:41	6/22/2017			Shoma S	Partly Cloudy		N		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					1847
Krome Quarry	KRO26	11:29	7/11/2017			Shoma S	Partly Cloudy		N		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					1890
Krome Quarry	KRO27	15:29	7/20/2017			Shoma S	Cloudy		N		45	4.5	50	45	50		9		20	21	1	349	15705	90	electronic					1963
Krome Quarry	KRO28	10:05	7/26/2017			Shoma S	Partly Cloudy		N		41	4.5	50	41	50		9		20	21	1	349	14309	82	electronic					2081

Krome Quarry	KRO29	10:51	8/1/2017			Shoma N	Cloudy		N		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					2703
Krome Quarry	KRO30	10:57	8/10/2017			Shoma N	Rain		N		36	4.5	50	36	50		9		20	21	1	349	12584	72	electronic					2769
Krome Quarry	KRO31	11:24	8/14/2017			Shoma S	Sunny		N		41	4.5	50	41	50		9		20	21	1	349	14309	82	electronic					2251
Krome Quarry	KRO32	11:29	8/22/2017			Shoma S	Partly Cloudy		E		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					2081
Krome Quarry	KRO33	10:31	8/29/2017			Shoma S	Partly Cloudy		NW		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1950
Krome Quarry	KRO34	10:47	9/28/2017			Shoma S	Partly Cloudy		S		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1850
Krome Quarry	KRO35	11:56	10/3/2017			Shoma S	Overcast		E		43	4.5	50	43	50		9		20	21	1	349	14658	86	electronic					1798
Krome Quarry	KRO36	11:29	10/5/2017			Shoma S	Stormy		W		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1795
Krome Quarry	KRO37	11:33	10/12/2017			Shoma S	Rain		SE		41	4.5	50	41	50		9		20	21	1	349	14309	82	electronic					1832
Krome Quarry	KRO38	11:26	11/6/2017			Shoma S	Sunny		E		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1922
Krome Quarry	KRO39	11:29	11/8/2017			Shoma S	Sunny		W		43	4.5	50	43	50		9		20	21	1	349	15007	86	electronic					2197
Krome Quarry	KRO40	13:53	11/14/2017			Shoma S	Partly Cloudy		S		39	4.5	50	39	50		9		20	21	1	349	13611	78	electronic					2023
Krome Quarry	KRO41	10:50	11/16/2017			Shoma S			E		43	4.5	50	43	50		9		20	21	1	349	15007	86	electronic					2029
Krome Quarry	KRO42	13:51	11/21/2017			Shoma S	Sunny		NW		41	4.5	50	41	50		9		20	21	1	349	14309	82	electronic					1882
Krome Quarry	KRO43	10:49	11/28/2017			Shoma N	Rain		NW		43	4.5	50	43	50		9		20	21	1	349	15007	86	electronic					3016
Krome Quarry	KRO44	11:02	11/30/2017			Shoma N	Partly Cloudy		NE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					2891
Krome Quarry	KRO45	13:39	12/5/2017			Shoma N	Partly Cloudy		NE		42	4.5	50	42	50		9		20	21	1	348	14616	64	electronic					2801
Krome Quarry	KRO46	13:51	12/7/2017			Shoma S	Partly Cloudy		NE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1798
Krome Quarry	KRO47	11:57	12/12/2017			Shoma S	Sunny		E		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1734
Krome Quarry	KRO48	14:57	12/14/2017			Shoma S	Clear		N		33	4.5	50	33	50		9		20	21	1	349	11517	66	electronic					1725
Krome Quarry	KRO49	11:14	12/18/2017			Shoma N	Partly Cloudy		W		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					2708
Krome Quarry	KRO50	11:51	12/20/2017			Shoma N	Partly Cloudy		NW		60	4.5	50	60	50		9		20	21	1	349	20940	120	electronic					2678
Krome Quarry	KRO51	11:18	1/9/2018			Shoma S	Cloudy		NW		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1767
Krome Quarry	KRO52	10:31	1/16/2018			Shoma S	Partly Cloudy		S		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1845
Krome Quarry	KRO53	13:45	1/18/2018			Shoma S	Partly Cloudy		S		45	4.5	50	45	50		9		20	21	1	349	15705	90	electronic					1965
Krome Quarry	KRO54	11:40	1/30/2018			Shoma S	Partly Cloudy		SE		41	4.5	50	41	50		9		20	21	1	349	14309	82	electronic					2175
Krome Quarry	KRO55	11:00	2/1/2018			Shoma S	Partly Cloudy		SW		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1975
Krome Quarry	KRO56	10:44	2/6/2018			Shoma S	Cloudy		W		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1857
Krome Quarry	KRO57	11:00	2/13/2018			Shoma S	Partly Cloudy		S		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1750
Krome Quarry	KRO58	10:35	3/5/2018			Shoma S	Sunny		SE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1580
Krome Quarry	KRO59	9:59	3/8/2018			Shoma S	Sunny		SE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1576
Krome Quarry	KRO60	13:33	3/13/2018			Shoma S	Sunny		SE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1620

Krome Quarry	KRO61	13:00	3/15/2018			Shoma S	Sunny		NE		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1708
Krome Quarry	KRO62	10:19	3/20/2018			Shoma S	Partly Cloudy		N		35	4.5	50	35	50		9		20	21	1	349	12215	70	electronic					1832
Krome Quarry	KRO63	10:30	3/22/2018			Shoma S	Sunny		SE		40	4.5	50	40	50		9		20	21	1	349	13960	79	electronic					2068
Krome Quarry	KRO64	11:31	3/26/2018			Shoma S	Sunny		S		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1851
Krome Quarry	KRO65	14:51	3/28/2018			Shoma S	Partly Cloudy		E		42	4.5	50	42	50		9		20	21	1	349	14658	64	electronic					1762

APPENDIX C

BLAST VIBRATION REPORTS SUMMARY

Marianna Mine

Blast Event ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	Peak Vector Sum (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (dB)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Recorded	Date Printed	Comments
MAR1	MarSeis1		30-38-28.7	85-09-29.8		0.1475	0.145	4.9		0.0775	3.6		0.115	14.7		110.4	2	0.02	OFF		7411	3/8/2017	4/4/2017	4/4/2017	
MAR2	MarSeis2		30-38-28.7	85-09-29.8		0.0825	0.0725	16.7		0.07	7.6		0.065	31.3		115.2	4.6	0.02	OFF		7411	3/8/2017	7/12/2017	7/12/2017	
MAR3	MarSeis3		30-38-28.7	85-09-29.8		0.0875	0.0625	20.8		0.0625	19.2		0.0825	9.6		116.8	20.8	0.02	OFF		7411	3/8/2017	7/27/2017	7/28/2017	
MAR4	MarSeis4		30-38-28.7	85-09-29.8		0.085	0.0725	11.4		0.0575	15.6		0.075	9.6		110.1	19.2	0.02	OFF		7411	3/8/2017	8/9/2017	8/9/2017	
MAR5	MarSeis5		30-38-28.7	85-09-29.8		0.05	0.0325	6.4		0.03	11.4		0.04	12.5		112.3	17.9	0.02	OFF		7411	3/8/2017	8/11/2017	8/11/2017	
MAR6	MarSeis6		30-38-28.7	85-09-29.8		0.2625	0.1675	7.4		0.1425	6.1		0.205	7.6		114.2	10.4	0.02	OFF		7411	3/8/2017	8/24/2017	8/24/2017	
MAR7	MarSeis7		30-38-28.7	85-09-29.8		0.1875	0.1825	10.4		0.1225	9.3		0.145	14.7		118	3.7	0.02	OFF		7411	3/8/2017	10/16/2017	10/16/2017	
MAR8	MarSeis8		30-38-28.7	85-09-29.8		0.115	0.09	20.8		0.0875	9.6		0.0875	11.9		114.6	2.7	0.02	OFF		7411	3/8/2017	11/2/2017	11/3/2017	
MAR9	MarSeis9		30-38-28.7	85-09-29.8		0.1375	0.12	22.7		0.115	19.2		0.1075	19.2		115.3	8.6	0.02	OFF		7411	3/8/2017	12/14/2017	12/14/2017	

Branford Quarry

Blast Event ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Recorded	Date Printed/ Reported	Comments
BRA1	BraSeis1		29-58-7.0	82-50-15.7		0.250	9.3	2	0.240	30	1.5	0.620	32	1.3	122.1	12.0	0.03	127	10.00	BE20308	3/17/2016	1/4/2017	1/4/2017	
BRA1	BraSeis2		29-57-50.5	82-50-0.0		0.114	13	2.5	0.069	11	2.5	0.058	11	2.2	114.0	7.6	0.02	120	1.25	BE21473	3/17/2016	1/4/2017	1/4/2017	
BRA2	BraSeis3		29-58-7.0	82-50-15.7		0.150	5.5	2.5	0.170	7.3	3	0.165	9.3	1.9	117.1	8.3	0.03	127	10.00	BE20308	3/17/2016	1/10/2017	1/10/2017	Note: Not all blast and seismograph reports were provided. Data for these blasts was obtained from the operator log
BRA2	BraSeis4		29-57-50.5	82-50-0.0		0.127	9.8	2.5	0.073	13	3.1	0.063	7.6	3.2	111.8	5.3	0.02	120	1.25	BE21473	3/17/2016	1/10/2017	1/10/2017	
BRA3	BraSeis5		29-58-7.0	82-50-15.7		0.030	28		0.035	30		0.030	39		121.6	10.0	0.03	127	10.00	BE20308	3/17/2016	1/18/2017	4/3/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA3	BraSeis6		29-57-50.5	82-50-0.0		0.029	20		0.017	19		0.019	27		115.6	11.0	0.02	120	1.25	BE21473	3/17/2016	1/18/2017	4/3/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA4	BraSeis7		29-57-50.5	£2-50-0.0																BE21473	3/17/2016	1/20/2017	1/20/2017	Reported No Trigger on Jan. 20, 2017
BRA4	BraSeis8		29-58-7.0	82-50-15.7		0.030	22		0.015	24		0.010	>100		108.8	11.0	0.03	127	10.00	BE20308	3/17/2016	1/20/2017	4/3/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA5	BraSeis9		29-57-50.5	82-50-0.0		0.096	12	2.5	0.053	27	2.5	0.099	24	2.2	111.5	5.0	0.02	120	1.25	BE21473	3/17/2016	1/24/2017	1/24/2017	
BRA5	BraSeis10		29-58-7.0	82-50-15.7		0.130	18	2.0	0.095	6.1	2.3	0.100	34	1.7	114.8	7.4	0.03	127	10.00	BE20308	3/17/2016	1/24/2017	1/24/2017	
BRA6	BraSeis11		29-58-7.0	82-50-15.7		0.155	11	2.5	0.125	5.4	2.2	0.170	7.5	1.8	114.4	4.9	0.03	127	10.00	BE20308	3/17/2016	2/9/2017	2/9/2017	component directions corresponding to waveforms were not identified
BRA6	BraSeis12		29-57-50.5	82-50-0.0		0.166	8	2.8	0.118	18	2.2	0.134	7.8	1.8	116.6	10.0	0.02	120	1.25	BE21473	3/17/2016	2/9/2017	2/9/2017	component directions corresponding to waveforms were not identified
BRA7	BraSeis13		29-58-7.0	82-50-15.7																BE20308	3/17/2016	2/16/2017	2/25/2017	Reported No Trigger on Feb. 25, 2017
BRA7	BraSeis14		29-57-50.5	£2-50-0.0																BE21473	3/17/2016	2/16/2017	2/25/2017	Reported No Trigger on Feb. 25, 2017
BRA8	BraSeis15		29-58-7.0	82-50-15.7		0.025	17		0.030	6.7		0.020	32		109.2	11.0	0.03	127	10.00	BE20308	3/17/2016	2/22/2017	4/3/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA8	BraSeis16		29-57-50.5	£2-50-0.0																BE21473	3/17/2016	2/22/2017		No date given for No Trigger Report
BRA9	BraSeis17		29-58-7.0	82-50-15.7		0.030	9		0.025	12		0.030	47		117.1	11.0	0.03	127	10.00	BE20308	3/17/2016	3/1/2017	3/1/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA9	BraSeis18		29-57-50.5	82-50-0.0		0.021	18		0.012	21		0.010	14		108.8	12.0	0.02	120	1.25	BE21473	3/17/2016	3/1/2017	3/1/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA10	BraSeis19		29-57-50.5	£2-50-0.0																BE21473	3/17/2016	3/8/2017		No date given for No Trigger Report
BRA10	BraSeis20		29-58-7.0	82-50-15.7																BE20308	3/17/2016	3/8/2017		No date given for No Trigger Report
BRA11	BraSeis21		29-58-7.0	82-50-15.7		0.020	28		0.030	26		0.025	43		108.0	12.0	0.03	127	10.00	BE20308	3/17/2016	3/14/2017	4/3/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA11	BraSeis22		29-57-50.5	82-50-0.0																BE21473	3/17/2016	3/14/2017		No date given for No Trigger Report
BRA12	BraSeis23		29-57-50.5	£2-50-0.0																BE21473	3/17/2016	3/22/2017		No date given for No Trigger Report
BRA12	BraSeis24		29-58-7.0	82-50-15.7																BE20308	3/17/2016	3/22/2017		No date given for No Trigger Report
BRA13	BraSeis25		29-58-7.0	82-50-15.7																		4/14/2017		No Seismic Record Given
BRA13	BraSeis26		29-57-50.5	£2-50-0.0																		4/14/2017		No Seismic Record Given
BRA14	BraSeis27		29-58-7.0	82-50-15.7																		4/19/2017		No Seismic Record Given
BRA14	BraSeis28		29-57-50.5	£2-50-0.0																		4/19/2017		No Seismic Record Given
BRA15	BraSeis29		29-58-7.0	82-50-15.7																		4/24/2017		No Seismic Record Given
BRA15	BraSeis30		29-57-50.5	£2-50-0.0																		4/24/2017		No Seismic Record Given
BRA16	BraSeis31		29-58-7.0	82-50-15.7																		4/26/2017		No Seismic Record Given
BRA16	BraSeis32		29-57-50.5	82-50-0.0																		4/26/2017		No Seismic Record Given
BRA17	BraSeis33		29-58-7.0	82-50-15.7		0.09	5.1	2.5	0.100	32	2.5	0.115	34	1.7	113.1	2.9	0.03	127	10.00	BE19528	4/6/2017	5/1/2017	5/1/2017	PPV reported in operator log is lower than the recorded PPV
BRA17	BraSeis34		29-57-50.5	82-50-0.0		0.093	11	4.0	0.063	20	3.0	0.110	12	2.5	109.5	4.4	0.02	120	1.25	BE19562	4/6/2017	5/1/2017	5/1/2017	PPV reported in operator log is lower than the recorded PPV

BRA18	BraSeis35		29-58-7.0	82-50-15.7																BE19528	4/6/2017	5/5/2017		No date given for No Trigger Report
BRA18	BraSeis36		29-57-50.5	£2-50-0.0																BE19562	4/6/2017	5/5/2017		No date given for No Trigger Report
BRA19	BraSeis37		29-57-50.5	82-50-0.0		0.018	22		0.016	27		0.020	34		100.0	12.0	0.02	120	1.25	BE19562	4/6/2017	5/19/2017	7/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA19	BraSeis38		29-58-7.0	82-50-15.7																BE19528	4/6/2017	5/19/2017		No date given for No Trigger Report
BRA20	BraSeis39		29-57-50.5	82-50-0.0		0.119	14	2.5	0.066	13	3.3	0.071	6.5	2.6	111.5	4.8	0.02	120	1.25	BE19562	4/6/2017	6/2/2017	6/2/2017	
BRA20	BraSeis40		29-58-7.0	82-50-15.7		0.285	20	2.0	0.35	6.2	2.0	0.467	31	1.5	119.4	5.8	0.03	127	10.00	BE19528	4/6/2017	6/2/2017	6/2/2017	
BRA21	BraSeis41		29-58-7.0	82-50-15.7		0.235	5.1	2.8	0.256	26	2.0	0.320	27	1.7	118.1	10.0	0.03	127	10.00	BE19528	4/6/2017	6/20/2017		No date given for Print Date
BRA21	BraSeis42		29-57-50.5	82-50-0.0		0.112	10	2.6	0.066	17	2.9	0.088	8.5	2.5	108.4	5.6	0.02	120	1.25	BE19562	4/6/2017	6/20/2017	6/20/2017	
BRA22	BraSeis43		29-58-7.0	82-50-15.7																BE19528	4/6/2017	7/3/2017		No date given for No Trigger Report
BRA22	BraSeis44		29-57-50.5	£2-50-0.0																BE19562	4/6/2017	7/3/2017		No date given for No Trigger Report
BRA23	BraSeis45		29-57-50.5	82-50-0.0		0.151	13	3.1	0.123	7.2	2.5	0.162	14	2.0	116.6	5.0	0.02	120	1.25	BE19562	4/6/2017	7/7/2017	7/7/2017	
BRA23	BraSeis46		29-58-7.0	82-50-15.7		0.105	24	3.0	0.100	3.5	2.5	0.090	30	1.7	112.8	8.0	0.03	127	10.00	BE19528	4/6/2017	7/7/2017	7/7/2017	
BRA24	BraSeis47		29-57-50.5	£2-50-0.0																BE19562	4/6/2017	7/11/2017		No date given for No Trigger Report
BRA24	BraSeis48		29-58-7.0	82-50-15.7																BE19528	4/6/2017	7/11/2017		No date given for No Trigger Report
BRA25	BraSeis49		29-58-7.0	82-50-15.7		0.180	17	3.5	0.235	20	3.0	0.250	27	1.8	121.9	3.1	0.03	127	10.00	BE19528	4/6/2017	8/17/2017	8/17/2017	
BRA25	BraSeis50		29-57-50.5	£2-50-0.0																		8/17/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA26	BraSeis51		29-58-7.0	82-50-15.7	0.040										111.2							8/23/2017		Data taken from Operators Log
BRA26	BraSeis52		29-57-50.5	£2-50-0.0																		8/23/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA27	BraSeis53		29-58-7.0	82-50-15.7	0.235										116.7							8/30/2017		Data taken from Operators Log
BRA27	BraSeis54		29-57-50.5	£2-50-0.0																		8/30/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA28	BraSeis55		29-58-7.0	82-50-15.7																		9/20/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA28	BraSeis56		29-57-50.5	£2-50-0.0																		9/20/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA29	BraSeis57		29-58-7.0	82-50-15.7	0.240										122.4							9/27/2017		Data taken from Operators Log
BRA29	BraSeis58		29-57-50.5	82-50-0.0	0.031										104.2							9/27/2017		Data taken from Operators Log
BRA30	BraSeis59		29-57-50.5	82-50-0.0		0.132	6.9	3.4	0.112	19	3.2	0.102	32	2.9	113.5	8.3	0.02	120	1.25	BE19562	4/7/2017	10/02/2017	10/2/2017	Calibration Date Changed by One Day only for this event.
BRA30	BraSeis60		29-58-7.0	82-50-15.7		0.165	7.9	2.7	0.125	7.6	3.0	0.14	43	2.2	113.1	4.3	0.03	127	10.00	BE19528	4/6/2017	10/2/2017	10/02/2017	
BRA31	BraSeis61		29-57-50.5	£2-50-0.0																		10/6/2017	10/11/2017	No Trigger Reported Via Email
BRA31	BraSeis62		29-58-7.0	82-50-15.7																		10/6/2017	10/11/2017	No Trigger Reported Via Email
BRA32	BraSeis63		29-58-7.0	82-50-15.7																BE19528	4/6/2017	10/18/2017		No date given for No Trigger Report
BRA32	BraSeis64		29-57-50.5	£2-50-0.0																BE19562	4/6/2017	10/18/2017		No date given for No Trigger Report
BRA33	BraSeis65		29-58-7.0	82-50-15.7																BE19528	4/6/2017	10/24/2017		No date given for No Trigger Report
BRA33	BraSeis66		29-57-50.5	£2-50-0.0																BE19562	4/6/2017	10/24/2017		No date given for No Trigger Report
BRA34	BraSeis67		29-58-7.0	82-50-15.7		0.335	7.3	2.5	0.370	22	1.8	0.385	30	1.2	121.9	3.0	0.03	127	10.00	BE19528	4/6/2017	11/6/2017	11/6/2017	
BRA34	BraSeis68		29-57-50.5	82-50-0.0		0.115	9.5	3.0	0.112	12	3.0	0.137	9.8	2.5	113.4	9.7	0.04	120	1.25	BE19562	4/6/2017	11/6/2017	11/8/2017	
BRA35	BraSeis69		29-58-7.0	82-50-15.7	0.035										107.0							11/15/2017		Data taken from Operators Log
BRA35	BraSeis70		29-57-50.5	82-50-0.0	0.039										103.5							11/15/2017		Data taken from Operators Log
BRA36	BraSeis71		29-58-7.0	82-50-15.7	0.410										107.0							11/16/2017		Data taken from Operators Log
BRA36	BraSeis72		29-57-50.5	82-50-0.0	0.222										103.5							11/16/2017		Data taken from Operators Log
BRA37	BraSeis73		29-58-7.0	82-50-15.7																		11/21/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided

BRA37	BraSeis74		29-57-50.5	82-50-0.0	0.021										105.5							11/21/2017		Data taken from Operators Log
BRA38	BraSeis75		29-58-7.0	82-50-15.7	0.190										109.9							12/1/2017		Data taken from Operators Log
BRA38	BraSeis76		29-57-50.5	82-50-0.0	0.145										109.5							12/1/2017		Data taken from Operators Log
BRA39	BraSeis77		29-58-7.0	82-50-15.7	0.165										108.4							12/7/2017		Data taken from Operators Log
BRA39	BraSeis78		29-57-50.5	82-50-0.0	0.136										114.0							12/7/2017		Data taken from Operators Log
BRA40	BraSeis79		29-58-7.0	82-50-15.7																		12/14/2017		No Trigger Event recorded in Operators Log, but No Trigger Report Not Provided
BRA40	BraSeis80		29-57-50.5	82-50-0.0	0.165										114.8							12/14/2017		Data taken from Operators Log
BRA41	BraSeis81		29-58-07.0	82-50-15.7		0.220	6.2	2.2	0.245	34	1.8	0.525	39	1.5	121.7	2.8	0.03	127	10	BE19528	4/6/2017	1/10/2018	1/11/2018	
BRA41	BraSeis82		25-57-50.5	82-50-00.0		0.107	5.7	3.5	0.089	10	3.5	0.1	28	3.2	109.5	6.0	0.02	120	1.25	BE19562	4/6/2018	1/10/2018	1/10/2018	
BRA42	BraSeis83		29-58-07.0	82-50-15.7		0.16	11	2.4	0.145	32	2.5	0.375	32	1.6	115.0	3.7	0.03	127	10	BE19528	4/6/2017	1/16/2018	1/16/2018	
BRA42	BraSeis84		25-57-50.5	82-50-00.0		0.094	6.9	4.2	0.077	15	2.7	0.100	37	2.7	113.8	3.8	0.02	120	1.25	BE19562	4/6/2017	1/16/2018	1/16/2018	
BRA43	BraSeis85		29-58-07.0	82-50-15.7		0.100	10	2.5	0.090	20	2.4	0.120	39	2.2	109.9	7.3	0.03	127	10	BE19528	4/6/2017	1/26/2018	1/26/2018	
BRA43	BraSeis86		25-57-50.5	82-50-00.0		0.098	17	3.0	0.073	14	2.5	0.081	24	2.2	108.8	3.9	0.02	120	1.25	BE19562	4/6/2017	1/26/2018	1/26/2018	
BRA44	BraSeis87		29-58-07.0	82-50-15.7		0.140	8.5	3.7	0.095	17	2.5	0.150	12	2.4	114.6	6.6	0.03	127	10	BE19528	4/6/2017	1/31/2018	1/31/2018	
BRA44	BraSeis88		25-57-50.5	82-50-00.0		0.182	12	3.5	0.098	21	2.5	0.123	9.8	2.6	111.8	5.7	0.02	120	1.25	BE19562	4/6/2017	1/31/2018	1/31/2018	
BRA45	BraSeis89		29-58-07.0	82-50-15.7																BE19528	4/6/2017	2/5/2018		No date given for No Trigger Report
BRA45	BraSeis90		25-57-50.5	82-50-00.0																BE19562	4/6/2017	2/5/2018		No date given for No Trigger Report
BRA46	BraSeis91		29-58-07.0	82-50-15.7		0.015	39		0.03	27		0.02	47		107.0	7.4	0.03	127	10	BE19528	4/6/2017	2/8/2018	2/8/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA46	BraSeis92		25-57-50.5	82-50-00.0																BE19562	4/6/2017	2/8/2018		No date given for No Trigger Report
BRA47	BraSeis93		29-58-07.0	82-50-15.7																BE19528	4/6/2017	2/15/2018		No date given for No Trigger Report
BRA47	BraSeis94		25-57-50.5	82-50-00.0																BE19562	4/6/2017	2/15/2018		No date given for No Trigger Report
BRA48	BraSeis95		29-58-07.0	82-50-15.7		0.02	22		0.03	7.4		0.03	26		101.0	3.6	0.03	127	10	BE19528	4/6/2017	2/21/2018	2/21/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA48	BraSeis96		25-57-50.5	82-50-00.0		0.024	18		0.019	21		0.014	24		95.9	8.0	0.02	120	1.25	BE19562	4/6/2017	2/21/2018	2/24/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
BRA49	BraSeis97		29-58-07.0	82-50-15.7																BE19528	4/6/2017	3/8/2018		No date given for No Trigger Report
BRA49	BraSeis98		25-57-50.5	82-50-00.0																BE19562	4/6/2017	3/8/2018		No date given for No Trigger Report
BRA50	BraSeis99		29-58-07.0	82-50-15.7		0.135	4.1	3.1	0.12	3.8	3.4	0.13	34	2.5	114.8	3.6	0.03	127	10	BE19528	4/6/2017	3/26/2018	3/26/2018	
BRA50	BraSeis100		29-57-51.8	82-49-58.0		0.147	11	3.2	0.123	7.8	3	0.166	13	2.7	116.6	5.0	0.02	120	1.25	BE19570	2/20/2018	3/26/2018	4/2/2018	
BRA51	BraSeis101		29-58-07.0	82-50-15.7		0.135	16	3.5	0.100	23	3.2	0.090	30	2.4	111.2	6.7	0.03	127	10	BE19528	4/6/2017	3/29/2018	3/29/2018	
BRA51	BraSeis120		29-57-51.8	82-49-58.0		0.188	12	2.6	0.078	21	3	0.158	21	2.3	114.2	6.1	0.02	120	1.25	BE19570	2/20/2018	3/29/2018	3/29/2018	

Brooksville Quarry

Blas tEvent ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Recorded	Date Printed	Notes
BR01	BroSeis1		28-33-46.1	82-27-41.0	0.050										116									
BR02	BroSeis2		28-33-46.1	82-27-41.0	0.068										116									
BR03	BroSeis3		28-37-03.4	82-26-50.0																				No Trigger
BR04	BroSeis4		28-33-24.9	82-27-01.7	0.025										106									
BR04	BroSeis5		28-33-46.1	82-27-41.0	0.063										111									
BR05	BroSeis6		28-37-03.4	82-26-50.0																				No Trigger
BR06	BroSeis7		28-33-46.1	82-27-41.0	0.070										112									
BR07	BroSeis8		28-33-20.9	82-26-09.7	0.063										110									
BR08	BroSeis9		28-33-24.9	82-27-01.7	0.023										107									
BR08	BroSeis10		28-33-46.1	82-27-41.0	0.065										118									
BR09	BroSeis11		28-33-46.1	82-27-41.0	0.065										111									
BR010	BroSeis12		28-33-20.9	82-26-09.7		0.028	13.9		0.038	13.9		0.023	15.2		108	15.2	0.02			9646	5/31/2016	3/9/2017	3/10/2017	Seismograph report provided. Note seismograph trigger time is 10min before time listed on blast report, blast report indicates no trigger.
BR011	BroSeis13		28-37-03.4	82-26-50.0																				No Trigger
BR012	BroSeis14		28-33-46.1	82-27-41.0	0.073										113									
BR013	BroSeis15		28-35-25.3	82-24-52.4	0.035										110									
BR014	BroSeis16		28-37-03.4	82-26-50.0	0.05										120									
BR015	BroSeis17		28-37-03.4	82-26-50.0																				No Trigger
BR016	BroSeis18		28-37-03.4	82-26-50.0																				No Trigger
BR017	BroSeis19		28-37-03.4	82-26-50.0	0.058										116									
BR018	BroSeis20		28-37-07.0	82-27-24.0	0.105										113									
BR018	BroSeis21		28-37-03.4	82-26-50.0	0.033										110									
BR018	BroSeis22		28-37-06.7	82-27-20.7	0.195										113									
BR019	BroSeis23		28-37-12.0	82-26-40.9	0.053										111									
BR020	BroSeis24		28-37-12.0	82-26-40.9	0.053										120									
BR021	BroSeis25		28-33-24.9	82-27-01.7	0.023										103									
BR021	BroSeis26		28-33-46.1	82-27-41.0	0.063										119									
BR022	BroSeis27		28-37-12.0	82-26-40.9	0.133										126									
BR023	BroSeis28		28-33-24.9	82-27-01.7	0.070										102									
BR023	BroSeis29		28-33-46.1	82-27-41.0	0.288										117									
BR024	BroSeis30		28-37-12.0	82-26-40.9	0.073										111									
BR025	BroSeis31		28-37-12.0	82-26-40.9	0.048										122									
BR026	BroSeis32		28-37-12.0	82-26-40.9	0.048										122									PPV, dB, and GPS Coordinates are same as 5/31 blast, but location is different
BR027	BroSeis33		28-37-12.0	82-26-40.9	0.085										120									
BR028	BroSeis34		28-37-12.0	82-26-40.9	0.048										115									
BR029	BroSeis35		28-33-24.9	82-27-01.7	0.060										105									
BR029	BroSeis36		28-33-46.1	82-27-41.0	0.078										118									

BR030	BroSeis37		28-35-25.3	82-24-52.4																			No Trigger
BR031	BroSeis38		28-37-12.0	82-26-40.9	0.060										127								
BR032	BroSeis39		28-33-24.9	82-27-01.7	0.063										106								
BR032	BroSeis40		28-33-46.1	82-27-41.0	0.203										116								
BR033	BroSeis41		28-33-24.9	82-27-01.7	0.058										104								
BR033	BroSeis42		28-33-46.1	82-27-41.0	0.133										114								
BR034	BroSeis43		28-33-24.9	82-27-01.7	0.053										106								
BR034	BroSeis44		28-33-46.1	82-27-41.0	0.100										113								
BR035	BroSeis45		28-37-12.0	82-26-40.9	0.095										112								
BR036	BroSeis46		28-37-12.0	82-26-40.9	0.035										111								
BR037	BroSeis47		28-33-24.9	82-27-01.7	<0.063										103								
BR037	BroSeis48		28-33-46.1	82-27-41.0	<0.138										112								
BR038	BroSeis49		28-37-12.0	82-26-40.9	0.048										113								
BR039	BroSeis50		28-33-24.9	82-27-01.7	0.080										106								
BR039	BroSeis51		28-33-46.1	82-27-41.0	0.113										114								
BR040	BroSeis52		28-33-24.9	82-27-01.7	0.110										108								
BR040	BroSeis53		28-33-46.1	82-27-41.0	0.098										115								
BR041	BroSeis54		28-33-24.9	82-27-01.7	0.075										110								
BR041	BroSeis55		28-33-46.1	82-27-41.0	0.148										118								
BR042	BroSeis56		28-33-24.9	82-27-01.7	0.108										113								
BR042	BroSeis57		28-33-46.1	82-27-41.0	0.085										113								
BR043	BroSeis58		28-33-24.9	82-27-01.7	0.040										113								
BR043	BroSeis59		28-33-46.1	82-27-41.0	0.085										114								
BR044	BroSeis60		28-33-24.9	82-27-01.7	0.075										113								
BR044	BroSeis61		28-33-46.1	82-27-41.0	0.073										119								
BR045	BroSeis62		28-33-24.9	82-27-01.7	0.068										112								
BR045	BroSeis63		28-33-46.1	82-27-41.0	0.078										118								
BR046	BroSeis64		28-33-24.9	82-27-01.7	0.083										111								
BR046	BroSeis65		28-33-46.1	82-27-41.0	0.115										115								
BR047	BroSeis66		28-33-24.9	82-27-01.7	0.07										110								
BR047	BroSeis67		28-33-46.1	82-27-41.0	0.08										116								
BR048	BroSeis68		28-37-03.4	82-26-50.0																			No Trigger
BR049	BroSeis69		28-37-06.7	82-27-20.7	0.08										119								
BR049	BroSeis70		28-37-06.5	82-27-11.7	0.418										124								
BR050	BroSeis71		28-37-06.5	82-27-11.7	0.023										111								
BR051	BroSeis72		28-37-06.7	82-27-20.7	0.115										118								
BR051	BroSeis73		28-37-06.5	82-27-11.7	0.300										125								
BR052	BroSeis74		28-33-24.9	82-27-01.7	0.105										110								
BR052	BroSeis75		28-33-46.1	82-27-41.0	0.093										118								
BR053	BroSeis76		28-33-24.9	82-27-01.7	0.125										113								
BR053	BroSeis77		28-33-46.1	82-27-41.0	0.118										116								

BR054	BroSeis78		28-33-24.9	82-27-01.7	0.090									106									
BR054	BroSeis79		28-33-46.1	82-27-41.0	0.095									113									
BR055	BroSeis80		28-33-24.9	82-27-01.7	0.068									126									
BR055	BroSeis81		28-33-46.1	82-27-41.0	0.098									113									
BR056	BroSeis82		28-37-06.7	82-27-20.7	0.190									125									
BR056	BroSeis83		28-37-06.5	82-27-11.7	0.208									128									
BR057	BroSeis84		28-37-06.5	82-27-11.7																			No Trigger
BR058	BroSeis85		28-33-34.2	82-25-40.5																			No Trigger
BR059	BroSeis86		28-33-34.2	82-25-40.5																			No Trigger
BR060	BroSeis87		28-33-24.9	82-27-01.7	0.098									107									
BR060	BroSeis88		28-33-46.1	82-27-41.0	0.098									114									
BR061	BroSeis89		28-33-34.2	82-25-40.5	0.168									125									
BR062	BroSeis90		28-33-24.9	82-27-01.7	0.070									110									
BR062	BroSeis91		28-33-46.1	82-27-41.0	0.130									115									
BR063	BroSeis92		28-33-34.2	82-25-40.5																			No Trigger
BR064	BroSeis93		28-33-24.9	82-27-01.7	<0.128									108									
BR064	BroSeis94		28-33-46.1	82-27-41.0	<0.105									115									
BR065	BroSeis95		28-33-34.2	82-25-40.5																			No Trigger
BR066	BroSeis96		28-33-24.9	82-27-01.7	0.145									111									
BR066	BroSeis97		28-33-46.1	82-27-41.0	0.103									114									
BR067	BroSeis98		28-33-24.9	82-27-01.7	0.075									110									
BR067	BroSeis99		28-33-46.1	82-27-41.0	0.090									113									
BR068	BroSeis100		28-33-34.2	82-25-40.5																			No Trigger
BR069	BroSeis101		28-33-24.9	82-27-01.7	0.120									113									
BR069	BroSeis102		28-33-46.1	82-27-41.0	0.108									113									
BR070	BroSeis103		28-33-34.2	82-25-40.5	0.068									118									
BR071	BroSeis104		28-33-24.9	82-27-01.7	0.110									111									
BR071	BroSeis105		28-33-46.1	82-27-41.0	0.115									110									
BR072	BroSeis106		28-33-34.2	82-25-40.5	0.083									116									
BR073	BroSeis107		28-33-24.9	82-27-01.7	0.095									111									
BR073	BroSeis108		28-33-46.1	82-27-41.0	0.083									112									

West Lakes and University Lakes Mines

Blast Event ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	Peak Vector Sum (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Recorded	Date Printed	Notes
WES1	WesSeis1		26-28-52.0	81-41-51.0		0.318	0.263	6.4	4.3	0.233	15.6	3.8	0.285	50.0	4.5	109.6	6.1	0.02	OFF		9745	9/9/2016	1/9/2017	1/13/2017	
WES1	WesSeis2		26-27-50.0	81-42-16.0		0.075	0.058	16.7	7.6	0.050	15.2	8.4	0.040	18.5	8.3	115.7	1.7	0.02	OFF		10560	9/1/2016	1/9/2017	1/13/2017	
WES1	WesSeis3		26-28-53.3	81-43-02.2		0.030	0.015	15.2	5.1	0.028	16.7	8.8	0.020	2.1	8.8	100.8	3.0	0.02	OFF		9407	9/9/2016	1/9/2017	1/13/2017	
WES2	WesSeis4		26-28-52.0	81-41-51.0		0.343	0.235	2.8	3.5	0.273	7.6	2.7	0.323	2.6	3.4	111.2	3.8	0.02	OFF		9745	9/9/2016	1/9/2017	1/13/2017	
WES2	WesSeis5		26-27-50.0	81-42-16.0		0.040	0.028	16.7	6.3	0.035	20.8	8.3	0.018	18.5	8.3	119.2	6.4	0.02	OFF		10560	9/1/2016	1/9/2017	1/13/2017	
WES2	WesSeis6		26-28-53.3	81-43-02.2		0.038	0.018	2.5	6.3	0.030	12.8	8.1	0.038	2.4	8.8	103.4	4.0	0.02	OFF		9407	9/9/2016	1/9/2017	1/13/2017	Calibration pulse looks odd.
WES3	WesSeis7		26-28-52.0	81-41-51.0		0.838	0.518	11.4	2.5	0.550	5.7	2.5	0.773	31.3	2.2	115.1	6.9	0.02	OFF		9745	9/9/2016	1/9/2017	1/13/2017	
WES3	WesSeis8		26-27-50.0	81-42-16.0		0.043	0.035	11.9	9.8	0.033	12.8	7.1	0.025	11.1	8.1	118.1	6.0	0.02	OFF		10560	9/1/2016	1/9/2017	1/13/2017	
WES3	WesSeis9		26-28-53.3	81-43-02.2		0.035	0.020	2.4	4.4	0.033	11.9	7.8	0.023	2.1	7.9	102.9	3.6	0.02	OFF		9407	9/9/2016	1/9/2017	1/13/2017	
WES4	WesSeis10		26-27-50.0	81-42-16.0		0.060	0.048	15.2	7.3	0.048	18.5	7.8	0.028	16.7	8.8	103.4	10.4	0.02	OFF		10560	9/1/2016	1/12/2017	1/13/2017	
WES4	WesSeis11		26-28-52.0	81-41-51.0		0.345	0.248	2.4	3.7	0.295	16.7	3.7	0.180	25.0	4.0	110.3	4.3	0.02	OFF		9745	9/9/2016	1/12/2017	1/13/2017	
WES5	WesSeis12		26-27-50.0	81-42-16.0		0.070	0.053	15.2	6.6	0.050	16.7	8.1	0.035	15.2	9.1	105.2	8.8	0.02	OFF		10560	9/1/2016	1/12/2017	1/13/2017	
WES5	WesSeis13		26-28-52.0	81-41-51.0		0.340	0.243	3.0	3.7	0.210	3.4	3.3	0.303	41.7	3.0	113.7	20.8	0.02	OFF		9745	9/9/2016	1/12/2017	1/16/2017	
WES6	WesSeis14		26-28-52.0	81-41-51.0		0.810	0.448	6.9	2.3	0.433	8.3	2.4	0.798	35.7	2.3	115.8	2.6	0.02	OFF		9745	9/9/2016	1/12/2017	1/16/2017	
WES6	WesSeis15		26-27-50.0	81-42-16.0		0.048	0.038	13.9	9.6	0.030	15.2	9.4	0.025	13.9	12.1	105.2	4.9	0.02	OFF		10560	9/1/2016	1/12/2017	1/16/2017	
WES7	WesSeis16		26-28-52.0	81-41-51.0		0.303	0.163	2.5	3.5	0.288	3.1	3.8	0.255	2.4	4.0	112.8	6.4	0.02	OFF		9745	9/9/2016	1/18/2017	1/19/2017	
WES7	WesSeis17		26-28-53.3	81-43-02.2		0.043	0.013	3.7	5.4	0.030	2.1	9.4	0.043	2.3	9.4	101.1	6.7	0.02	OFF		9407	9/9/2016	1/18/2017	1/19/2017	
WES7	WesSeis18		26-27-50.0	81-42-16.0		0.053	0.038	13.9	9.4	0.033	15.2	9.7	0.028	33.3	8.7	100.5	2.8	0.02	OFF		10560	9/1/2016	1/18/2017	1/19/2017	
WES8	WesSeis19		26-28-53.3	81-43-02.2		0.053	0.020	2.4	6.2	0.035	15.2	8.4	0.053	2.3	8.7	102.3	3.3	0.02	OFF		9407	9/9/2016	1/18/2017	1/19/2017	
WES8	WesSeis20		26-28-52.0	81-41-51.0		0.403	0.225	2.7	3.0	0.308	2.9	3.0	0.398	2.5	3.0	114.1	3.8	0.02	OFF		9745	9/9/2016	1/18/2017	1/19/2017	
WES8	WesSeis21		26-27-50.0	81-42-16.0		0.073	0.050	15.2	7.5	0.048	13.9	8.5	0.035	13.9	8.5	102.6	3.3	0.02	OFF		10560	9/1/2016	1/18/2017	1/19/2017	
WES9	WesSeis22		26-27-50.0	81-42-16.0		0.025	0.018	2.1	9.4	0.020	16.7	9.4	0.020	6.2	9.1	100.8	4.0	0.02	OFF		10560	9/1/2016	1/18/2017	1/19/2017	
WES9	WesSeis23		26-28-52.0	81-41-51.0		0.505	0.260	9.3	2.5	0.350	19.2	2.3	0.498	19.2	2.5	114.8	5.4	0.02	OFF		9745	9/9/2016	1/18/2017	1/19/2017	
WES9	WesSeis24		26-28-53.3	81-43-02.2		0.050	0.015	2.8		0.023	2.9		0.050	2.5		100.2	7.6	0.02	OFF		9407	9/9/2016	1/18/2017	1/19/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES 10	WesSeis25		26-28-52.0	81-41-51.0		0.470	0.255	11.9	3.5	0.405	14.7	3.0	0.200	41.7	3.5	114.4	6.4	0.02	OFF		9745	9/9/2016	1/23/2017	1/24/2017	
WES 10	WesSeis26		26-28-53.3	81-43-02.2		0.060	0.020	16.7	5.6	0.058	13.9	9.3	0.023	2.2	9.3	85.5	5.4	0.02	OFF		9407	9/9/2016	1/23/2017	1/24/2017	
WES 10	WesSeis27		26-27-50.0	81-42-16.0		0.083	0.065	13.9	7.2	0.060	15.2	8.5	0.068	16.7	8.5	124.9	9.3	0.02	OFF		10560	9/1/2016	1/23/2017	1/24/2017	
WES 11	WesSeis28		26-28-53.3	81-43-02.2		0.043	0.018	3.2	6.9	0.040	13.9	8.4	0.035	2.2	8.9	106.4	1.8	0.02	OFF		9407	9/9/2016	1/23/2017	1/24/2017	
WES 11	WesSeis29		26-27-50.0	81-42-16.0		0.065	0.050	15.2	8.6	0.045	16.7	9.4	0.038	13.9	9.3	117.9	5.2	0.02	OFF		10560	9/1/2016	1/23/2017	1/24/2017	
WES 11	WesSeis30		26-28-52.0	81-41-51.0		0.330	0.193	5.3	3.5	0.268	3.3	3.0	0.300	31.3	3.3	116.7	12.5	0.02	OFF		9745	9/9/2016	1/23/2017	1/24/2017	
WES 12	WesSeis31		26-27-50.0	81-42-16.0		0.035	0.025	13.9	7.9	0.025	15.2	7.4	0.023	12.8	9.4	121.7	11.1	0.02	OFF		10560	9/1/2016	1/23/2017	1/24/2017	
WES 12	WesSeis32		26-28-52.0	81-41-51.0		0.525	0.373	16.7	2.5	0.318	16.7	2.3	0.430	2.7	2.7	118.6	2.9	0.02	OFF		9745	9/9/2016	1/23/2017	1/24/2017	
WES 12	WesSeis33		26-28-53.3	81-43-02.2		0.048	0.015	3.0		0.023	2.7		0.048	2.5		104.9	5.7	0.02	OFF		9407	9/9/2016	1/23/2017	1/24/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES 13	WesSeis34		26-28-52.0	81-41-51.0		0.235	0.140	3.4	3.5	0.218	15.6	3.5	0.163	41.7	5.4	103.4	5.6	0.02	OFF		9745	9/9/2016	1/26/2017	1/27/2017	
WES 13	WesSeis35		26-28-53.3	81-43-02.2		0.043	0.015	2.4	5.9	0.043	15.2	5.4	0.020	2.2	9.3	85.5	5.4	0.02	OFF		9407	9/9/2016	1/26/2017	1/27/2017	

WES13	WesSeis36		26-27-50.0	81-42-16.0		0.065	0.045	16.7	7.1	0.053	16.7	7.9	0.028	15.2	8.6	113.3	11.1	0.02	OFF		10560	9/1/2016	1/26/2017	1/27/2017	
WES14	WesSeis37		26-28-52.0	81-41-51.0		0.385	0.258	5.4	3.4	0.303	14.7	3.3	0.378	2.6	4.0	110.6	4.6	0.02	OFF		9745	9/9/2016	1/26/2017	1/27/2017	
WES14	WesSeis38		26-28-53.3	81-43-02.2		0.053	0.018	3.0	7.0	0.035	11.1	8.7	0.053	2.3	8.7	91.9	2.2	0.02	OFF		9407	9/9/2016	1/26/2017	1/27/2017	
WES14	WesSeis39		26-27-50.0	81-42-16.0		0.083	0.058	15.2	8.0	0.058	13.9	7.8	0.035	11.9	9.0	114.4	16.7	0.02	OFF		10560	9/1/2016	1/26/2017	1/27/2017	
WES15	WesSeis40		26-28-52.0	81-41-51.0		0.418	0.335	3.8	3.3	0.305	10.4	2.9	0.350	35.7	2.8	110.5	6.3	0.02	OFF		9745	9/9/2016	1/26/2017	1/27/2017	
WES15	WesSeis41		26-28-53.3	81-43-02.2		0.030	0.018	2.4	4.6	0.023	13.9	8.2	0.030	2.2	8.4	82.3	2.3	0.02	OFF		9407	9/9/2016	1/26/2017	1/27/2017	
WES15	WesSeis42		26-27-50.0	81-42-16.0		0.035	0.025	15.2	9.3	0.023	13.9	8.2	0.023	15.2	9.0	114.4	7.2	0.02	OFF		10560	9/1/2016	1/26/2017	1/27/2017	
WES16	WesSeis43		26-28-52.0	81-41-51.0		0.493	0.255	16.7	3.2	0.305	10.9	2.8	0.363	2.5	3.3	120.0	4.7	0.02	OFF		9745	9/9/2016	2/02/2017	2/6/2017	
WES16	WesSeis44		26-28-53.3	81-43-02.2		0.048	0.005	3.9		0.015	2.2		0.048	2.5		102.6	4.6	0.02	OFF		9407	9/9/2016	2/02/2017	2/6/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES16	WesSeis45		26-27-50.0	81-42-16.0		0.043	0.030	12.8	9.6	0.028	12.8	8.3	0.015	11.1	9.1	102.0	4.8	0.02	OFF		10560	9/1/2016	2/02/2017	2/6/2017	
WES17	WesSeis46		26-28-52.0	81-41-51.0		0.240	0.133	17.9	5.3	0.203	17.9	5.5	0.188	19.2	6.0	100.0	13.2	0.02	OFF		9745	9/9/2016	2/02/2017	2/6/2017	
WES17	WesSeis47		26-27-50.0	81-42-16.0		0.053	0.033	16.7	8.6	0.045	16.7	8.3	0.028	20.8	8.9	98.3	9.3	0.02	OFF		10560	9/1/2016	2/02/2017	2/6/2017	
WES18	WesSeis48		26-28-52.0	81-41-51.0		0.223	0.138	4.1	4.0	0.190	15.6	4.0	0.215	50.0	5.4	102.0	20.8	0.02	OFF		9745	9/9/2016	2/02/2017	2/6/2017	
WES18	WesSeis49		26-28-53.3	81-43-02.2		0.030	0.015	1.9	5.8	0.028	12.8	4.8	0.025	2.2	9.2	93.5	20.8	0.02	OFF		9407	9/9/2016	2/02/2017	2/6/2017	
WES18	WesSeis50		26-27-50.0	81-42-16.0		0.058	0.033	16.7	7.2	0.050	15.2	8.2	0.028	23.8	8.5	100.0	23.8	0.02	OFF		10560	9/1/2016	2/02/2017	2/6/2017	
WES19	WesSeis51		26-28-52.0	81-41-51.0		0.325	0.228	4.2	3.7	0.288	9.6	3.3	0.248	31.3	3.3	102.3	5.8	0.02	OFF		9745	9/9/2016	2/02/2017	2/6/2017	
WES19	WesSeis52		26-28-53.3	81-43-02.2		0.033	0.015	1.9	8.2	0.030	9.8	9.2	0.028	2.3	9.4	91.9	5.7	0.02	OFF		9407	9/9/2016	2/02/2017	2/6/2017	
WES19	WesSeis53		26-27-50.0	81-42-16.0		0.073	0.050	12.8	6.6	0.055	16.7	8.1	0.028	9.8	8.6	100.2	8.3	0.02	OFF		10560	9/1/2016	2/02/2017	2/6/2017	
WES20	WesSeis54		26-28-52.0	81-41-51.0		0.495	0.355	13.9	3.3	0.333	17.9	2.4	0.423	22.7	3.0	104.9	4.5	0.02	OFF		9745	9/9/2016	2/02/2017	2/6/2017	
WES20	WesSeis55		26-28-53.3	81-43-02.2		0.043	0.018	2.5	4.6	0.028	10.4	8.4	0.043	2.5	8.6	91.9	8.8	0.02	OFF		9407	9/9/2016	2/02/2017	2/6/2017	
WES20	WesSeis56		26-27-50.0	81-42-16.0		0.025	0.018	2.3		0.020	2.1		0.013	23.8		93.5	6.2	0.02	OFF		10560	9/1/2016	2/02/2017	2/6/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES21	WesSeis57		26-28-52.0	81-41-51.0		0.125	0.090	3.1	5.5	0.098	2.6	5.5	0.100	41.7	6.8	88.7	2.3	0.02	OFF		9745	9/9/2016	2/08/2017	2/9/2017	
WES21	WesSeis58		26-28-53.3	81-43-02.2		0.025	0.013	2.8		0.020	2.4		0.023	2.5		80.7	8.8	0.02	OFF		9407	9/9/2016	2/08/2017	2/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES21	WesSeis59		26-27-50.0	81-42-16.0		0.033	0.020	10.4	9.4	0.030	12.8	8.6	0.018	16.7	8.9	102.9	16.7	0.02	OFF		10560	9/1/2016	2/08/2017	2/9/2017	
WES22	WesSeis60		26-28-52.0	81-41-51.0		0.275	0.180	2.9	3.5	0.203	3.3	4.0	0.235	41.7	4.5	102.0	4.1	0.02	OFF		9745	9/9/2016	2/08/2017	2/9/2017	
WES22	WesSeis61		26-28-53.3	81-43-02.2		0.028	0.005	4.8		0.008	1.9		0.028	2.4		83.9	1.6	0.02	OFF		9407	9/9/2016	2/08/2017	2/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES22	WesSeis62		26-27-50.0	81-42-16.0		0.050	0.035	12.8	7.2	0.043	16.7	7.4	0.045	10.4	7.7	109.3	18.5	0.02	OFF		10560	9/1/2016	2/08/2017	2/9/2017	
WES23	WesSeis63		26-28-52.0	81-41-51.0		0.493	0.300	15.6	3.3	0.353	13.9	2.5	0.415	50.0	3.3	109.9	16.7	0.02	OFF		9745	9/9/2016	2/08/2017	2/9/2017	
WES23	WesSeis64		26-28-53.3	81-43-02.2		0.033	0.013	2.0	4.6	0.028	9.8	7.9	0.033	2.4	8.2	80.7	6.0	0.02	OFF		9407	9/9/2016	2/08/2017	2/9/2017	
WES23	WesSeis65		26-27-50.0	81-42-16.0		0.040	0.028	10.4	9.2	0.035	9.8	7.2	0.023	16.7	8.7	111.2	16.7	0.02	OFF		10560	9/1/2016	2/08/2017	2/9/2017	
WES24	WesSeis66		26-28-52.0	81-41-51.0		0.443	0.365	13.2	3.5	0.335	16.7	2.5	0.383	31.3	3.3	104.6	3.5	0.02	OFF		9745	9/9/2016	2/14/2017	2/15/2017	
WES24	WesSeis67		26-28-53.3	81-43-02.2		0.040	0.020	2.2	7.4	0.028	13.9	8.6	0.040	2.3	8.7	87.1	3.3	0.02	OFF		9407	9/9/2016	2/14/2017	2/15/2017	
WES24	WesSeis68		26-27-50.0	81-42-16.0		0.040	0.023	16.7	9.6	0.033	15.2	9.6	0.025	12.8	8.6	95.1	13.9	0.02	OFF		10560	9/1/2016	2/14/2017	2/15/2017	
WES25	WesSeis69		26-28-53.3	81-43-02.2		0.273	0.265	15.2	6.2	0.100	1.8	6.0	0.200	20.8	5.2	112.0	6.2	0.02	OFF		9407	9/9/2016	2/16/2017	2/20/2017	
WES25	WesSeis70		26-27-50.0	81-42-16.0		0.115	0.095	18.5	11.5	0.058	18.5	11.0	0.098	15.2	11.0	110.6	5.2	0.02	OFF		10560	9/1/2016	2/16/2017	2/20/2017	
WES25	WesSeis71		26-28-52.0	81-41-51.0		0.093	0.055	16.7	4.5	0.090	15.6	4.5	0.088	14.7	7.3	100.5	3.6	0.02	OFF		9745	9/9/2016	2/16/2017	2/20/2017	
WES26	WesSeis72		26-28-53.3	81-43-02.2		0.318	0.318	11.9	5.5	0.088	55.6	4.5	0.233	2.4	8.9	113.4	1.3	0.02	OFF		9407	9/9/2016	3/03/2017	3/6/2017	
WES26	WesSeis73		26-27-50.0	81-42-16.0		0.133	0.050	20.8	11.6	0.038	1.8	8.6	0.133	2.3	11.1	113.7	2.9	0.02	OFF		10560	9/1/2016	3/03/2017	3/6/2017	

WES26	WesSeis74		26-27-10.0	81-43-00.0		0.170	0.063	2.3		0.050	2.3		0.165	2.3		118.0	2.5	0.02			9745 v6.5	9/9/2016	3/03/2017	3/6/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES27	WesSeis75		26-28-53.3	81-43-02.2		0.448	0.198	7.2	4.0	0.135	2.4	3.2	0.440	2.2	9.2	115.9	2.1	0.02	OFF		9407	9/9/2016	3/03/2017	3/6/2017	
WES27	WesSeis76		26-27-50.0	81-42-16.0		0.163	0.118	18.5	6.5	0.043	15.2	8.0	0.160	2.3	9.1	114.6	23.8	0.02	OFF		10560	9/1/2016	3/03/2017	3/6/2017	
WES27	WesSeis77		26-27-10.0	81-43-00.0		0.203	0.078	2.4		0.065	2.4		0.198	2.3		102.0	2.8	0.02			9745 v6.5	9/9/2016	3/03/2017	3/6/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES28	WesSeis78		26-28-53.3	81-43-02.2		0.528	0.265	16.7	4.0	0.133	2.1	3.2	0.523	2.2	9.2	118.7	2.0	0.02	OFF		9407	9/9/2016	3/08/2017	3/14/2017	
WES28	WesSeis79		26-27-50.0	81-42-16.0		0.145	0.108	12.8	10.5	0.055	12.8	10.9	0.138	2.3	11.0	107.2	2.2	0.02	OFF		10560	9/1/2016	3/08/2017	3/14/2017	
WES28	WesSeis80		26-27-10.0	81-43-00.0		0.200	0.068	2.3		0.060	2.3		0.198	2.2		100.5	2.5	0.02	OFF		9745	9/9/2016	3/08/2017	3/14/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES29	WesSeis81		26-28-53.3	81-43-02.2		0.475	0.295	13.9	3.2	0.163	13.9	4.0	0.473	2.3	4.2	112.3	1.4	0.02	OFF		9407	9/9/2016	3/10/2017	3/14/2017	
WES29	WesSeis82		26-27-50.0	81-42-16.0		0.168	0.138	11.9	7.0	0.063	13.9	10.0	0.168	2.4	10.8	120.2	3.9	0.02	OFF		10560	9/1/2016	3/10/2017	3/14/2017	
WES29	WesSeis83		26-27-10.0	81-43-00.0		0.180	0.053	2.2		0.058	10.0		0.180	2.1		102.3	2.1	0.02	OFF		9745	9/9/2016	3/10/2017	3/14/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES30	WesSeis84		26-28-53.3	81-43-02.2		0.415	0.320	18.5	3.5	0.200	20.8	2.8	0.413	2.2	6.8	112.5	10.4	0.02	OFF		9407	9/9/2016	3/14/2017	3/14/2017	
WES30	WesSeis85		26-27-50.0	81-42-16.0		0.163	0.095	20.8	9.0	0.040	23.8	10.0	0.163	2.4	10.5	125.2	4.0	0.02	OFF		10560	9/1/2016	3/14/2017	3/14/2017	
WES30	WesSeis86		26-27-10.0	81-43-00.0		0.180	0.058	2.3		0.053	2.3		0.180	2.1		111.4	2.8	0.02	OFF		9745	9/9/2016	3/14/2017	3/14/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES31	WesSeis87		26-28-53.3	81-43-02.2		0.455	0.360	15.2	4.5	0.218	16.7	4.5	0.453	2.2	5.2	117.8	1.6	0.02	OFF		9407	9/9/2016	3/16/2017	3/17/2017	
WES31	WesSeis88		26-27-50.0	81-42-16.0		0.195	0.118	11.1	8.8	0.060	11.9	10.5	0.195	2.3	10.5	121.8	3.5	0.02	OFF		10560	9/1/2016	3/16/2017	3/17/2017	
WES31	WesSeis89		26-27-10.0	81-43-00.0		0.215	0.06	2.1		0.055	9.3		0.215	2.1		109.3	2.3	0.02	OFF		9745	9/9/2016	3/16/2017	3/17/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES32	WesSeis90		26-28-53.3	81-43-02.2		0.335	0.27	13.9	5.0	0.198	15.2	54.5	0.255	2.2	8.5	113.9	1.5	0.02	OFF		9407	9/9/2016	3/20/2017	4/4/2017	
WES32	WesSeis91		26-27-50.0	81-42-16.0		0.158	0.108	15.2	10.0	0.048	16.7	8.5	0.158	2.3	10.5	118.0	3.5	0.02	OFF		10560	9/1/2016	3/20/2017	4/4/2017	
WES32	WesSeis92		26-27-10.0	81-43-00.0		0.163	0.043	2.5		0.050	2.4		0.163	2.1		104.3	1.9	0.02	OFF		9745	9/9/2016	3/20/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES33	WesSeis93		26-28-53.3	81-43-02.2		0.453	0.203	2.5	5.8	0.145	2.1	7.5	0.453	2.1	9.0	117.9	2.3	0.02	OFF		9407	9/9/2016	3/22/2017	4/4/2017	
WES33	WesSeis94		26-27-50.0	81-42-16.0		0.238	0.078	16.7	7.5	0.055	16.7	7.5	0.238	2.3	9.3	123.8	4.1	0.02	OFF		10560	9/1/2016	3/22/2017	4/4/2017	
WES33	WesSeis95		26-27-10.0	81-43-00.0		0.263	0.073	2.4		0.078	2.3		0.260	2.1		102.0	2.7	0.02	OFF		9745	9/9/2016	3/22/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES34	WesSeis96		26-28-53.3	81-43-02.2		0.398	0.133	2.5	4.1	0.153	15.2	4.2	0.398	2.1	8.3	115.5	1.9	0.02	OFF		9407	9/9/2016	3/24/2017	4/4/2017	
WES34	WesSeis97		26-27-50.0	81-42-16.0		0.200	0.083	11.1	8.0	0.050	2.4	7.5	0.198	2.3	9.0	119.7	3.8	0.02	OFF		10560	9/1/2016	3/24/2017	4/4/2017	
WES34	WesSeis98		26-27-10.0	81-43-00.0		0.250	0.065	2.5		0.065	2.4		0.248	2.3		107.2	2.3	0.02	OFF		9745	9/9/2016	3/24/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES35	WesSeis99		26-28-53.3	81-43-02.2		0.485	0.175	13.9	4.0	0.208	15.2	4.5	0.483	2.3	6.0	117.5	2.0	0.02	OFF		9407	9/9/2016	3/28/2017	4/4/2017	
WES35	WesSeis100		26-27-50.0	81-42-16.0		0.195	0.118	11.9	10.0	0.055	12.8	10.5	0.193	2.3	11.0	119.2	3.8	0.02	OFF		10560	9/1/2016	3/28/2017	4/4/2017	
WES35	WesSeis101		26-27-10.0	81-43-00.0		0.255	0.078	2.6		0.068	2.4		0.253	2.4		104.9	2.3	0.02	OFF		9745	9/9/2016	3/28/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES36	WesSeis102		26-28-53.3	81-43-02.2		0.423	0.133	2.5	4.0	0.143	2.3	4.5	0.415	2.2	4.8	116.7	2.1	0.02	OFF		9407	9/9/2016	3/30/2017	4/4/2017	
WES36	WesSeis103		26-27-50.0	81-42-16.0		0.170	0.058	15.2	10.5	0.045	16.7	10.5	0.168	2.4	10.8	117.9	4.0	0.02	OFF		10560	9/1/2016	3/30/2017	4/4/2017	
WES36	WesSeis104		26-27-10.0	81-43-00.0		0.238	0.078	2.7		0.060	2.4		0.235	2.5		102.3	2.6	0.02	OFF		9745	9/9/2016	3/30/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event

WES37	WesSeis105		26-28-53.3	81-43-02.2		0.430	0.143	2.4	3.2	0.135	11.9	4.8	0.428	2.5	5.2	117.3	3.5	0.02	OFF		9407	9/9/2016	3/31/2017	4/4/2017	
WES37	WesSeis106		26-27-50.0	81-42-16.0		0.153	0.053	2.2	11.0	0.040	2.5	10.0	0.153	2.4	11.0	114.6	3.5	0.02	OFF		10560	9/1/2016	3/31/2017	4/4/2017	
WES37	WesSeis107		26-27-10.0	81-43-00.0		0.195	0.065	2.7		0.053	3.2		0.195	2.5		111.8	1.8	0.02	OFF		9745	9/9/2016	3/31/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES38	WesSeis108		26-28-53.3	81-43-02.2		0.423	0.170	2.0	3.5	0.190	12.8	4.0	0.420	2.4	6.0	118.4	3.1	0.02	OFF		9407	9/9/2016	4/03/2017	4/4/2017	
WES38	WesSeis109		26-27-50.0	81-42-16.0		0.155	0.048	2.3	11.0	0.040	2.3	11.5	0.153	2.4	10.9	114.0	3.7	0.02	OFF		10560	9/1/2016	4/03/2017	4/4/2017	
WES38	WesSeis110		26-27-10.0	81-43-00.0		0.188	0.068	2.5		0.050	2.6		0.185	2.4		106.4	2.4	0.02	OFF		9745	9/9/2016	4/03/2017	4/4/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES39	WesSeis111		26-28-53.3	81-43-02.2		0.160	0.060	15.2	6.8	0.050	12.8	5.8	0.160	2.1	7.1	109.6	2.0	0.02	OFF		9407	9/9/2016	4/06/2017	4/7/2017	
WES39	WesSeis112		26-27-50.0	81-42-16.0		0.148	0.070	1.8	10.5	0.085	16.7	10.5	0.140	2.2	10.5	106.4	7.9	0.02	OFF		10560	9/1/2016	4/06/2017	4/7/2017	
WES39	WesSeis113		26-27-10.0	81-43-00.0		0.205	0.080	3.1		0.088	2.4		0.203	2.3		117.5	3.2	0.02	OFF		9745	9/9/2016	4/06/2017	4/7/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES40	WesSeis114		26-27-50.0	81-42-16.0		0.210	0.168	20.8	7.0	0.113	13.9	4.8	0.205	2.4	7.5	107.8	2.1	0.02	OFF		10560	9/1/2016	4/13/2017	4/13/2017	
WES40	WesSeis115		26-28-53.3	81-43-02.2		0.150	0.095	12.8	8.0	0.035	1.9	9.0	0.150	2.1	9.0	111.4	3.1	0.02	OFF		9407	9/9/2016	4/13/2017	4/13/2017	
WES40	WesSeis116		26-27-10.0	81-43-00.0		0.190	0.095	2.1		0.108	2.0		0.178	2.5		112.5	2.9	0.02	OFF		9745	9/9/2016	4/13/2017	4/13/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES41	WesSeis117		26-27-50.0	81-42-16.0		0.183	0.173	12.8	6.5	0.118	13.9	5.2	0.135	2.2	9.2	110.9	8.3	0.02	OFF		10560	9/1/2016	4/14/2017	4/14/2017	
WES41	WesSeis118		26-28-53.3	81-43-02.2		0.178	0.085	15.2	7.9	0.068	2.4	6.5	0.178	2.2	8.5	114.2	2.2	0.02	OFF		9407	9/9/2016	4/14/2017	4/14/2017	
WES41	WesSeis119		26-27-10.0	81-43-00.0		0.140	0.053	10.4		0.130	11.4		0.060	2.2		95.1	4.3	0.02	OFF		9745	9/9/2016	4/14/2017	4/14/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES42	WesSeis120		26-27-50.0	81-42-16.0		0.203	0.108	1.7	6.0	0.088	1.7	7.0	0.203	2.4	9.5	111.4	9.8	0.02	OFF		10560	9/1/2016	4/18/2017	4/18/2017	
WES42	WesSeis121		26-28-53.3	81-43-02.2		0.243	0.070	2.3	5.5	0.073	2.3	5.8	0.240	2.4	8.7	111.6	2.2	0.02	OFF		9407	9/9/2016	4/18/2017	4/18/2017	
WES42	WesSeis122		26-27-10.0	81-43-00.0		0.150	0.060	2.2		0.083	13.9		0.140	2.3		102.9	1.9	0.02	OFF		9745	9/9/2016	4/18/2017	4/18/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES43	WesSeis123		26-27-50.0	81-42-16.0		0.165	0.115	1.7	6.0	0.095	1.9	7.2	0.165	2.4	8.5	112.6	2.3	0.02	OFF		10560	9/1/2016	4/19/2017	4/19/2017	
WES43	WesSeis124		26-28-53.3	81-43-02.2		0.175	0.055	2.2	7.6	0.060	2.2	6.1	0.175	2.3	7.6	114.1	2.3	0.02	OFF		9407	9/9/2016	4/19/2017	4/19/2017	
WES43	WesSeis125		26-27-10.0	81-43-00.0		0.110	0.050	1.9		0.060	2.1		0.105	2.4		100.0	1.8	0.02	OFF		9745	9/9/2016	4/19/2017	4/19/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES44	WesSeis126		26-27-50.0	81-42-16.0		0.080	0.058	16.7	7.5	0.055	2.4	6.5	0.068	55.6	8.3	106.9	3.3	0.02	OFF		10560	9/1/2016	4/20/2017	4/24/2017	
WES44	WesSeis127		26-28-53.3	81-43-02.2		0.160	0.060	13.9	5.6	0.030	1.8	5.5	0.160	2.3	6.3	113.1	2.2	0.02	OFF		9407	9/9/2016	4/20/2017	4/24/2017	
WES44	WesSeis128		26-27-10.0	81-43-00.0		0.085	0.030	2.0		0.083	12.5		0.043	2.7		105.8	11.9	0.02	OFF		9745	9/9/2016	4/20/2017	4/24/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES45	WesSeis129		26-27-50.0	81-42-16.0		0.098	0.055	16.7	6.1	0.048	5.4	6.1	0.095	41.7	6.3	110.1	7.2	0.02	OFF		10560	9/1/2016	4/21/2017	4/24/2017	
WES45	WesSeis130		26-28-53.3	81-43-02.2		0.170	0.078	12.8	5.9	0.023	1.6	5.9	0.170	2.3	6.0	113.8	2.5	0.02	OFF		9407	9/9/2016	4/21/2017	4/24/2017	
WES45	WesSeis131		26-27-10.0	81-43-00.0		0.095	0.035	8.3		0.090	9.3		0.048	2.6		104.3	3.1	0.02	OFF		9745	9/9/2016	4/21/2017	4/24/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event
WES46	WesSeis132		26-27-50.0	81-42-16.0		0.105	0.088	20.8	6.0	0.065	3.2	6.1	0.090	23.8	7.3	110.5	3.0	0.02	OFF		10560	9/1/2016	4/27/2017	4/27/2017	

WES46	WesSeis133		26-28-53.3	81-43-02.2		0.243	0.088	12.8	5.6	0.030	23.8	5.6	0.243	2.3	6.3	115.4	2.3	0.02	OFF		9407	9/9/2016	4/27/2017	4/27/2017	
WES46	WesSeis134		26-27-10.0	81-43-00.0		0.113	0.050	15.6		0.108	14.7		0.075	2.6		102.0	2.7	0.02	OFF		9745	9/9/2016	4/27/2017	4/27/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES47	WesSeis135		26-27-50.0	81-42-16.0		0.090	0.060	20.8	6.1	0.048	3.3	6.1	0.085	55.6	7.6	107.8	4.5	0.02	OFF		10560	9/1/2016	4/28/2017	5/8/2017	
WES47	WesSeis136		26-28-53.3	81-43-02.2		0.215	0.063	15.2	5.3	0.033	2.6	5.1	0.215	2.4	8.4	115.5	2.6	0.02	OFF		9407	9/9/2016	4/28/2017	5/8/2017	
WES47	WesSeis137		26-27-10.0	81-43-00.0		0.085	0.035	3.6		0.080	14.7		0.045	17.9		100.0	3.4	0.02	OFF		9745	9/9/2016	4/28/2017	5/8/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES48	WesSeis138		26-27-50.0	81-42-16.0		0.098	0.060	1.5	9.1	0.045	2.6	7.6	0.085	2.3	10.4	102.3	9.8	0.02	OFF		10560	9/1/2016	5/04/2017	5/9/2017	
WES48	WesSeis139		26-28-53.3	81-43-02.2		0.250	0.090	12.8	5.1	0.040	1.4	5.2	0.250	2.4	5.3	112.7	3.0	0.02	OFF		9407	9/9/2016	5/04/2017	5/9/2017	
WES48	WesSeis140		26-27-10.0	81-43-00.0		0.148	0.060	10.4		0.123	10.0		0.143	2.4		113.5	2.2	0.02	OFF		9745	9/9/2016	5/04/2017	5/9/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES49	WesSeis141		26-27-50.0	81-42-16.0		0.110	0.045	2.1	9.1	0.045	1.8	5.9	0.108	2.3	10.6	112.3	12.8	0.02	OFF		10560	9/1/2016	5/05/2017	5/9/2017	
WES49	WesSeis142		26-28-53.3	81-43-02.2		0.320	0.088	2.6	5.3	0.048	2.3	5.2	0.320	2.4	5.4	112.8	3.5	0.02	OFF		9407	9/9/2016	5/05/2017	5/9/2017	
WES49	WesSeis143		26-27-10.0	81-43-00.0		0.163	0.043	2.3		0.065	2.3		0.160	2.4		118.0	2.1	0.02	OFF		9745	9/9/2016	5/05/2017	5/9/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES50	WesSeis144		26-27-50.0	81-42-16.0		0.080	0.070	1.7	7.0	0.038	16.7	7.7	0.065	41.7	7.2	105.8	18.5	0.02	OFF		10560	9/1/2016	5/09/2017	5/9/2017	
WES50	WesSeis145		26-28-53.3	81-43-02.2		0.340	0.108	13.9	5.0	0.048	2.0	5.0	0.340	2.4	5.2	118.4	3.1	0.02	OFF		9407	9/9/2016	5/09/2017	5/9/2017	
WES50	WesSeis146		26-27-10.0	81-43-00.0		0.090	0.053	3.3		0.080	10.9		0.070	2.3		91.9	8.6	0.02	OFF		9745	9/9/2016	5/09/2017	5/9/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES51	WesSeis147		26-28-53.3	81-43-02.2		0.225	0.070	2.3	5.3	0.048	16.7	5.1	0.225	2.4	7.0	111.3	2.9	0.02	OFF		9407	9/9/2016	5/09/2017	5/24/2017	
WES51	WesSeis148		26-27-50.0	81-42-16.0		0.083	0.055	12.8	10.0	0.060	13.9	10.0	0.080	2.2	11.2	112.2	13.9	0.02	OFF		10560	9/1/2016	5/09/2017	5/24/2017	
WES51	WesSeis149		26-27-10.0	81-43-00.0		0.120	0.043	6.4		0.060	2.0		0.118	2.4		109.0	4.6	0.02	OFF		9745	9/9/2016	5/09/2017	5/24/2017	
WES52	WesSeis150		26-28-53.3	81-43-02.2		0.170	0.048	2.9	5.7	0.035	2.6	5.4	0.170	2.3	6.4	114.1	3.8	0.02	OFF		9407	9/9/2016	5/19/2017	5/24/2017	
WES52	WesSeis151		26-27-50.0	81-42-16.0		0.093	0.070	12.8	7.2	0.090	15.2	8.5	0.080	2.1	11.5	111.0	4.9	0.02	OFF		10560	9/1/2016	5/19/2017	5/24/2017	
WES52	WesSeis152		26-27-10.0	81-43-00.0		0.138	0.048	11.4		0.053	13.9		0.138	2.5		100.8	1.7	0.02	OFF		9745	9/9/2016	5/19/2017	5/24/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES53	WesSeis153		26-28-52.0	81-41-51.0		0.168	0.143	2.9	5.0	0.138	2.7	4.5	0.140	27.8	6.3	121.4	2.4	0.02	OFF		9745	9/9/2016	6/02/2017	6/7/2017	
WES53	WesSeis154		26-27-50.0	81-42-16.0		0.040	0.025	2.2		0.038	2.7		0.033	2.6		100.8	7.9	0.02	OFF		10560	9/1/2016	6/02/2017	6/7/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES53	WesSeis155		26-28-53.3	81-43-02.2		0.043	0.025	2.5		0.035	2.4		0.028	2.2		104.6	13.9	0.02	OFF		9407	9/9/2016	6/02/2017	6/7/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES54	WesSeis156		26-28-52.0	81-41-51.0		0.158	0.143	12.5	5.5	0.145	2.4	4.7	0.093	14.7	6.5	111.2	2.7	0.02	OFF		9745	9/9/2016	6/05/2017	6/7/2017	
WES54	WesSeis157		26-27-50.0	81-42-16.0		0.035	0.020	3.1	8.8	0.033	2.4	8.8	0.023	2.6	9.4	98.3	7.2	0.02	OFF		10560	9/1/2016	6/05/2017	6/7/2017	
WES54	WesSeis158		26-28-53.3	81-43-02.2		0.035	0.020	2.2		0.030	2.1		0.023	2.2		87.1	2.5	0.02	OFF		9407	9/9/2016	6/05/2017	6/7/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES55	WesSeis159		26-28-52.0	81-41-51.0		0.165	0.143	3.2	5.5	0.098	2.7	3.4	0.115	27.8	5.7	119.4	6.0	0.02	OFF		9745	9/9/2016	6/06/2017	6/9/2017	
WES55	WesSeis160		26-28-53.3	81-43-02.2		0.035	0.020	2.3		0.028	2.3		0.025	2.4		95.1	27.8	0.02	OFF		9407	9/9/2016	6/06/2017	6/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.

WES55	WesSeis161		26-27-50.0	81-42-16.0		0.035	0.018	2.2		0.033	2.5		0.023	2.6		96.7	3.4	0.02	OFF		10560	9/1/2016	6/06/2017	6/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES56	WesSeis162		26-28-52.0	81-41-51.0		0.288	0.180	19.2	3.5	0.090	6.9	3.8	0.278	31.3	5.3	103.4	9.6	0.02	OFF		9745	9/9/2016	6/08/2017	6/9/2017	
WES56	WesSeis163		26-28-53.3	81-43-02.2		0.028	0.015	2.4		0.023	2.1		0.028	2.3		82.3	2.0	0.02	OFF		9407	9/9/2016	6/08/2017	6/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES56	WesSeis164		26-27-50.0	81-42-16.0		0.025	0.020	1.7		0.023	2.3		0.020	2.4		106.9	11.1	0.02	OFF		10560	9/1/2016	6/08/2017	6/9/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES57	WesSeis165		26-28-53.3	81-43-02.2		0.255	0.225	15.2	5.0	0.080	27.8	4.5	0.230	23.8	4.7	117.5	18.5	0.02	OFF		9479	7/24/2017	8/31/2017	9/5/2017	
WES57	WesSeis166		26-27-50.0	81-42-16.0		0.145	0.085	10.4	7.5	0.093	20.8	10.5	0.138	2.2	9.0	116.9	2.5	0.02	OFF		7705	7/21/2017	8/31/2017	9/5/2017	
WES57	WesSeis167		26-27-10.0	81-43-00.0		0.063	0.040	11.9		0.025	19.2		0.063	4.0		91.9	5.4	0.02	OFF		10687	4/6/2017	8/31/2017	9/5/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES58	WesSeis168		26-28-53.3	81-43-02.2		0.368	0.240	20.8	4.0	0.165	20.8	3.5	0.315	20.8	5.0	115.1	27.8	0.02	OFF		9479	7/24/2017	9/01/2017	9/5/2017	
WES58	WesSeis169		26-27-50.0	81-42-16.0		0.113	0.088	16.7	8.5	0.048	11.1	9.5	0.100	2.4	9.2	112.7	3.3	0.02	OFF		7705	7/21/2017	9/01/2017	9/5/2017	
WES58	WesSeis170		26-27-10.0	81-43-00.0		0.075	0.038	10.9		0.030	2.4		0.073	2.4		87.1	3.2	0.02	OFF		10687	4/6/2017	9/01/2017	9/5/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES59	WesSeis171		26-28-53.3	81-43-02.2		0.118	0.055	1.9	6.4	0.108	15.2	8.2	0.083	2.3	8.2	110.1	2.5	0.02	OFF		9479	7/24/2017	9/07/2017	9/8/2017	
WES59	WesSeis172		26-27-50.0	81-42-16.0		0.078	0.060	18.5	9.5	0.063	18.5	8.5	0.068	2.1	10.8	108.7	3.3	0.02	OFF		7705	7/21/2017	9/07/2017	9/8/2017	
WES59	WesSeis173		26-27-10.0	81-43-00.0		0.088	0.088	16.7	7.7	0.058	1.2	7.6	0.070	2.2	7.0	100.0	11.9	0.02	OFF		10687	4/6/2017	9/07/2017	9/8/2017	
WES60	WesSeis174		26-28-53.3	81-43-02.2		0.265	0.218	13.9	4.0	0.118	16.7	4.1	0.233	23.8	5.0	114.3	4.4	0.02	OFF		9479	7/24/2017	10/02/2017	10/3/2017	
WES60	WesSeis175		26-27-50.0	81-42-16.0		0.140	0.088	18.5	8.0	0.070	18.5	9.9	0.138	27.8	9.5	115.4	7.2	0.02	OFF		7705	7/21/2017	10/02/2017	10/3/2017	
WES60	WesSeis176		26-27-10.0	81-43-00.0		0.063	0.040	14.7		0.020	17.9		0.063	2.2		105.2	10.9	0.02	OFF		10687	4/6/2017	10/02/2017	10/3/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES61	WesSeis177		26-28-53.3	81-43-02.2		0.320	0.190	15.2	4.0	0.153	16.7	4.9	0.268	23.8	4.2	113.9	6.2	0.02	OFF		9479	7/24/2017	10/05/2017	10/9/2017	
WES61	WesSeis178		26-27-50.0	81-42-16.0		0.148	0.115	20.8	9.7	0.078	18.5	9.0	0.138	23.8	9.5	116.1	2.0	0.02	OFF		7705	7/21/2017	10/05/2017	10/9/2017	
WES61	WesSeis179		26-27-10.0	81-43-00.0		0.055	0.038	13.2		0.020	17.9		0.055	2.4		104.3	10.4	0.02	OFF		10687	4/6/2017	10/05/2017	10/9/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES62	WesSeis180		26-28-53.3	81-43-02.2		0.583	0.453	16.7	3.5	0.290	15.2	3.5	0.548	23.8	4.5	117.9	33.3	0.02	OFF		9479	7/24/2017	10/10/2017	10/11/2017	
WES62	WesSeis181		26-27-50.0	81-42-16.0		0.130	0.095	13.9	8.5	0.090	11.9	7.5	0.088	16.7	10.0	115.6	2.6	0.02	OFF		7705	7/21/2017	10/10/2017	10/11/2017	
WES62	WesSeis182		26-27-10.0	81-43-00.0		0.075	0.043	11.4		0.023	10.4		0.075	2.1		102.6	11.9	0.02	OFF		10687	4/6/2017	10/10/2017	10/11/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES63	WesSeis183		26-28-53.3	81-43-02.2		0.663	0.320	18.5	4.0	0.313	16.7	4.0	0.610	20.8	4.0	117.7	6.0	0.02	OFF		9479	7/24/2017	10/11/2017	10/11/2017	
WES63	WesSeis184		26-27-50.0	81-42-16.0		0.183	0.113	11.9	8.0	0.150	13.9	7.2	0.100	20.8	10.5	116.3	2.5	0.02	OFF		7705	7/21/2017	10/11/2017	10/11/2017	
WES63	WesSeis185		26-27-10.0	81-43-00.0		0.070	0.058	10.0		0.040	12.5		0.070	2.1		104.9	7.6	0.02	OFF		10687	4/6/2017	10/11/2017	10/11/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES64	WesSeis186		26-28-53.3	81-43-02.2		0.370	0.200	11.1	3.5	0.253	13.9	3.5	0.355	23.8	4.5	118.7	1.7	0.02	OFF		9479	7/24/2017	10/16/2017	10/18/2017	
WES64	WesSeis187		26-27-10.0	81-43-00.0		0.118	0.038	2.1		0.020	9.3		0.118	2.1		101.4	6.9	0.02	OFF		10687	4/6/2017	10/16/2017	10/18/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES64	WesSeis188		26-27-50.0	81-42-16.0		0.093	0.073	11.1	9.7	0.078	18.5	8.5	0.090	2.3	10.5	116.8	3.1	0.02	OFF		7705	7/21/2017	10/16/2017	10/18/2017	

WES65	WesSeis189		26-28-53.3	81-43-02.2		0.360	0.170	9.3	3.7	0.243	13.9	3.5	0.333	27.8	4.1	117.1	1.2	0.02	OFF		9479	7/24/2017	11/13/2017	11/14/2017	
WES65	WesSeis190		26-27-50.0	81-42-16.0		0.095	0.030	13.9	8.1	0.043	15.2	7.7	0.095	2.4	10.7	117.8	2.6	0.02	OFF		7705	7/21/2017	11/13/2017	11/14/2017	
WES65	WesSeis191		26-27-10.0	81-43-00.0		0.120	0.038	2.2		0.023	2.1		0.120	2.2		107.8	2.3	0.02	OFF		10687	4/6/2017	11/13/2017	11/14/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES66	WesSeis192		26-28-53.3	81-43-02.2		0.258	0.150	20.8	4.0	0.198	16.7	4.5	0.258	2.3	4.7	113.5	2.9	0.02	OFF		9479	7/24/2017	11/14/2017	11/15/2017	
WES66	WesSeis193		26-27-50.0	81-42-16.0		0.093	0.038	20.8	8.0	0.053	15.2	8.0	0.090	2.3	9.0	114.2	4.6	0.02	OFF		7705	7/21/2017	11/14/2017	11/15/2017	
WES66	WesSeis194		26-27-10.0	81-43-00.0		0.138	0.048	2.3		0.025	2.1		0.138	4.6		110.4	3.5	0.02	OFF		10687	4/6/2017	11/14/2017	11/15/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES67	WesSeis195		26-28-53.3	81-43-02.2		0.320	0.175	23.8	3.5	0.210	23.8	4.2	0.320	2.2	5.0	113.9	1.5	0.02	OFF		9479	7/24/2017	11/15/2017	11/16/2017	
WES67	WesSeis196		26-27-50.0	81-42-16.0		0.105	0.028	20.8	10.0	0.053	18.5	10.6	0.103	2.3	11.2	117.0	2.7	0.02	OFF		7705	7/21/2017	11/15/2017	11/16/2017	
WES67	WesSeis197		26-27-10.0	81-43-00.0		0.133	0.045	2.3		0.023	2.8		0.133	2.3		111.4	2.6	0.02	OFF		10687	4/6/2017	11/15/2017	11/16/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES68	WesSeis198		26-28-53.3	81-43-02.2		0.285	0.095	20.8	3.3	0.165	18.5	4.2	0.285	2.2	4.5	114.0	1.6	0.02	OFF		9479	7/24/2017	11/17/2017	11/20/2017	
WES68	WesSeis199		26-27-50.0	81-42-16.0		0.093	0.035	15.2	9.0	0.060	18.5	11.0	0.090	2.3	9.0	114.2	3.3	0.02	OFF		7705	7/21/2017	11/17/2017	11/20/2017	
WES68	WesSeis200		26-27-10.0	81-43-00.0		0.125	0.045	2.3		0.023	2.2		0.125	2.3		106.9	3.9	0.02	OFF		10687	4/6/2017	11/17/2017	11/20/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES69	WesSeis201		26-28-53.3	81-43-02.2		0.270	0.085	5.2	3.5	0.133	15.2	3.2	0.268	2.3	5.2	114.1	1.8	0.02	OFF		9479	7/24/2017	11/22/2017	11/22/2017	
WES69	WesSeis202		26-27-50.0	81-42-16.0		0.070	0.035	15.2	8.6	0.030	15.2	8.6	0.068	2.4	9.1	112.7	3.0	0.02	OFF		7705	7/21/2017	11/22/2017	11/22/2017	
WES69	WesSeis203		26-27-10.0	81-43-00.0		0.090	0.035	2.4		0.018	3.6		0.090	2.4		105.2	2.7	0.02	OFF		10687	4/6/2017	11/22/2017	11/22/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
WES70	WesSeis204		26-28-53.3	81-43-02.2		0.198	0.123	2.8	4.0	0.145	16.7	4.0	0.193	2.4	4.9	111.8	2.0	0.02	OFF		9479	7/24/2017	11/27/2017	11/28/2017	
WES70	WesSeis205		26-27-50.0	81-42-16.0		0.053	0.028	15.2	8.7	0.028	12.8	8.7	0.050	2.4	9.2	106.4	3.1	0.02	OFF		7705	7/21/2017	11/27/2017	11/28/2017	
WES70	WesSeis206		26-27-10.0	81-43-00.0		0.068	0.025	3.0		0.020	2.1		0.068	2.4		104.0	3.5	0.02	OFF		10687	4/6/2017	11/27/2017	11/28/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES71	WesSeis207		26-27-50.0	81-42-16.0		0.268	0.183	13.9	5.5	0.218	13.9	4.2	0.133	20.8	5.0	111.4	5.2	0.02	OFF		7705	7/21/2017	12/12/2017	12/13/2017	
WES71	WesSeis208		26-27-10.0	81-43-00.0		0.100	0.088	11.9	7.3	0.050	10.9	6.3	0.053	2.3	7.6	100.2	3.5	0.02	OFF		10687	4/6/2017	12/12/2017	12/13/2017	
WES71	WesSeis209		26-28-53.3	81-43-02.2		0.153	0.153	13.9	6.1	0.045	12.8	5.9	0.098	2.3	6.6	110.6	2.3	0.02	OFF		9479	7/24/2017	12/12/2017	12/13/2017	
WES72	WesSeis210		26-27-50.0	81-42-16.0		0.173	0.120	1.7	5.8	0.148	16.7	5.0	0.110	23.8	5.5	113.7	4.3	0.02	OFF		7705	7/21/2017	12/21/2017	12/27/2017	
WES72	WesSeis211		26-27-10.0	81-43-00.0		0.095	0.088	15.6	7.7	0.035	10.4	7.7	0.083	2.4	8.4	107.5	5.2	0.02	OFF		10687	4/6/2017	12/21/2017	12/27/2017	
WES72	WesSeis212		26-28-53.3	81-43-02.2		0.075	0.073	11.9	6.5	0.033	1.7	7.0	0.058	1.9	8.5	109.3	2.3	0.02	OFF		9479	7/24/2017	12/21/2017	12/27/2017	
WES73	WesSeis213		26-27-50.0	81-42-16.0		0.250	0.155	15.2	5.0	0.195	16.7	4.5	0.145	15.2	6.5	114.8	6.0	0.02	OFF		7705	7/21/2017	12/22/2017	12/27/2017	
WES73	WesSeis214		26-27-10.0	81-43-00.0		0.130	0.118	13.2	6.6	0.065	10.9	7.1	0.053	2.3	8.3	117.5	8.3	0.02	OFF		10687	4/6/2017	12/22/2017	12/27/2017	
WES73	WesSeis215		26-28-53.3	81-43-02.2		0.098	0.085	15.2	6.0	0.043	20.8	6.8	0.088	20.8	6.5	111.8	5.7	0.02	OFF		9479	7/24/2017	12/22/2017	12/27/2017	
WES74	WesSeis216		26-27-50.0	81-42-16.0		0.223	0.133	16.7	5.0	0.168	16.7	5.3	0.158	16.7	5.3	116.8	3.3	0.02	OFF		7705	7/21/2017	12/26/2017	12/27/2017	
WES74	WesSeis217		26-28-53.3	81-43-02.2		0.088	0.085	11.9	6.1	0.050	2.1	6.1	0.075	2.1	7.0	109.9	1.4	0.02	OFF		9479	7/24/2017	12/26/2017	12/27/2017	

WES74	WesSeis218		26-27-10.0	81-43-00.0		0.128	0.115	12.5		0.060	10.4		0.115	2.4		104.3	11.9	0.02	OFF		10687	4/6/2017	12/26/2017	12/27/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES75	WesSeis219		26-27-50.0	81-42-16.0		0.213	0.145	13.9	5.3	0.178	16.7	4.5	0.110	23.8	5.3	113.3	4.9	0.02	OFF		7705	7/21/2017	12/27/2017	12/28/2017	
WES75	WesSeis220		26-27-10.0	81-43-00.0		0.158	0.148	12.5		0.068	11.4		0.120	2.3		107.2	7.1	0.02	OFF		10687	4/6/2017	12/27/2017	12/28/2017	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES75	WesSeis221		26-28-53.3	81-43-02.2		0.128	0.115	12.8	6.4	0.045	1.4	6.1	0.113	2.2	9.0	110.3	2.8	0.02	OFF		9479	7/24/2017	12/27/2017	12/28/2017	
WES76	WesSeis222		26-27-10.0	81-43-00.0		0.190	0.173	10.4	7.3	0.095	13.2	7.5	0.095	2.4	7.8	111.5	3.6	0.02	OFF		10687	4/6/2017	12/29/2017	12/29/2017	
WES76	WesSeis223		26-27-50.0	81-42-16.0		0.183	0.113	15.2	5.5	0.170	16.7	5.5	0.100	20.8	6.0	113.4	4.3	0.02	OFF		7705	7/21/2017	12/29/2017	12/29/2017	
WES76	WesSeis224		26-28-53.3	81-43-02.2		0.120	0.118	13.9	6.2	0.043	2.0	6.0	0.078	16.7	7.0	109.9	1.4	0.02	OFF		9479	7/24/2017	12/29/2017	12/29/2017	
WES77	WesSeis225		26-28-53.3	81-43-02.2		0.125	0.103	12.8	6.2	0.045	2.2	6.3	0.123	2.2	8.2	106.4	1.0	0.02	OFF		9479	7/24/2017	1/02/2017	1/3/2018	
WES77	WesSeis226		26-27-50.0	81-42-16.0	0.175	0.225	0.140	15.2	4.7	0.190	18.5	5.0	0.175	27.8	5.5	117.0	8.8	0.02	OFF		7705	7/21/2017	1/02/2017	1/3/2018	
WES77	WesSeis227		26-27-10.0	81-43-00.0		0.143	0.130	13.9		0.058	9.3		0.138	2.4		111.4	5.4	0.02	OFF		10687	4/6/2017	1/02/2017	1/3/2018	Durations were not estimated because the seismograph did not record the entire duration of the vibration event.
WES78	WesSeis228		26-27-10.0	81-43-00.0		0.088	0.082	19.2	7.2	0.045	2.1	7.0	0.060	19.2	7.6	108.1	31.3	0.02	OFF		10687	4/6/2017	1/03/2017	1/4/2018	
WES78	WesSeis229		26-27-50.0	81-42-16.0	0.145	0.158	0.125	13.9	3.2	0.145	15.2	4.0	0.088	16.7	4.2	114.0	23.8	0.02	OFF		7705	7/21/2017	1/03/2017	1/4/2018	
WES78	WesSeis230		26-28-53.3	81-43-02.2		0.093	0.093	16.7	5.0	0.035	20.8	5.0	0.073	2.1	5.4	109.9	1.3	0.02	OFF		9479	7/24/2017	1/03/2017	1/4/2018	
WES79	WesSeis231		26-27-50.0	81-42-16.0	0.085											111.8									
WES80	WesSeis232		26-27-50.0	81-42-16.0	0.088											104.6									
WES81	WesSeis233		26-27-50.0	81-42-16.0	0.075											109.3									
WES82	WesSeis234		26-27-50.0	81-42-16.0	0.098											112.5									
WES83	WesSeis235		26-27-50.0	81-42-16.0	0.100											110.8									
WES84	WesSeis236		26-27-50.0	81-42-16.0	0.083											113.7									
WES85	WesSeis237		26-27-50.0	81-42-16.0	0.070											113.3									
WES86	WesSeis238		26-28-53.3	81-43-02.2	0.038											96.7									
WES87	WesSeis239		26-28-53.3	81-43-02.2	0.235											112.1									
WES88	WesSeis240		26-28-53.3	81-43-02.2	0.183											113.4									
WES89	WesSeis241		26-28-53.3	81-43-02.2	0.203											114.0									
WES90	WesSeis242		26-28-53.3	81-43-02.2	0.158											113.3									
WES91	WesSeis243		26-28-53.3	81-43-02.2	0.073											108.4									
WES92	WesSeis244		26-27-50.0	81-42-16.0	0.130											101.4									
WES93	WesSeis245		26-27-08.7	81-42-38.2	0.223											122.0									
WES94	WesSeis246		26-27-08.7	81-42-38.2	0.265											125.0									
WES95	WesSeis247		26-28-53.3	81-43-02.2	0.235											113.0									
WES96	WesSeis248		26-28-53.3	81-43-02.2	0.263											112.0									

WES97	WesSeis249		26-28-53.3	81-43-02.2	0.355											115.6									
WES98	WesSeis250		26-28-53.3	81-43-02.2	0.410											118.0									
WES99	WesSeis251		26-28-53.3	81-43-02.2	0.340											118.0									
WES100	WesSeis252		26-28-53.3	81-43-02.2	0.383											118.0									
WES101	WesSeis253		26-28-53.3	81-43-02.2	0.245											118.0									
WES102	WesSeis254		26-28-53.3	81-43-02.2	0.268											116.8									

White Rock Quarries

Blast Event ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	Peak Vector Sum (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Created	Date Printed	Comments
WHI1	WhiSeis1				0.098											110.0							1/9/2017		
WHI2	WhiSeis2				0.163											106.0							1/10/2017		
WHI3	WhiSeis3				0.080											111.0							1/11/2017		
WHI3	WhiSeis4				0.100											102.0							1/11/2017		
WHI4	WhiSeis5				0.103											113.0							1/12/2017		
WHI5	WhiSeis6				0.118											110.0							1/13/2017		
WHI5	WhiSeis7				0.118											104.0							1/13/2017		
WHI6	WhiSeis8				0.208											113.0							1/17/2017		
WHI6	WhiSeis9				0.238											110.0							1/17/2017		
WHI7	WhiSeis10				0.133											112.0							1/18/2017		
WHI8	WhiSeis11				0.158											103.0							1/19/2017		
WHI9	WhiSeis12				0.093											110.0							1/20/2017		
WHI9	WhiSeis13				0.123											109.0							1/20/2017		
WHI10	WhiSeis14				0.128											110.0							1/23/2017		
WHI10	WhiSeis15				0.175											112.0							1/23/2017		
WHI11	WhiSeis16				0.180											111.0							1/25/2017		
WHI11	WhiSeis17				0.105											111.0							1/25/2017		
WHI12	WhiSeis18				0.170											108.0							1/27/2017		
WHI12	WhiSeis19				0.205											108.0							1/27/2017		
WHI13	WhiSeis20				0.168											107.0							1/31/2017		
WHI14	WhiSeis21				0.210											109.0							2/3/2017		
WHI14	WhiSeis22				0.170											111.0							2/3/2017		
WHI15	WhiSeis23				0.223											110.0							2/6/2017		
WHI16	WhiSeis24				0.203											117.0							2/8/2017		
WHI16	WhiSeis25				0.180											112.0							2/8/2017		
WHI17	WhiSeis26				0.198											106.0							2/10/2017		
WHI18	WhiSeis27				0.215											113.0							2/15/2107		
WHI19	WhiSeis28				0.163											114.0							2/16/2017		
WHI20	WhiSeis29				0.190											114.0							2/17/2017		
WHI20	WhiSeis30				0.160											114.0							2/17/2017		
WHI21	WhiSeis31				0.123											107.0							2/21/2017		
WHI22	WhiSeis32				0.253											115.0							2/22/2017		
WHI23	WhiSeis33				0.208											115.0							2/23/2017		
WHI24	WhiSeis34				0.135											108.0							2/24/2017		
WHI25	WhiSeis35				0.168											110.0							2/27/2017		
WHI26	WhiSeis36				0.208											112.0							2/28/2017		
WHI27	WhiSeis37				0.093											101.0							3/01/2017		

WHI28	WhiSeis38				0.113											113.0							3/02/2017		
WHI29	WhiSeis39				0.095											110.0							3/03/2017		
WHI30	WhiSeis40				0.198											108.0							3/06/2017		
WHI31	WhiSeis41				0.135											103.0							3/07/2017		
WHI31	WhiSeis42				0.088											103.0							3/07/2017		
WHI32	WhiSeis43				0.108											112.0							3/08/2017		
WHI32	WhiSeis44				0.133											110.0							3/08/2017		
WHI33	WhiSeis45				0.105											114.0							3/10/2017		
WHI34	WhiSeis46				0.120											115.0							3/13/2017		
WHI34	WhiSeis47				0.173											115.0							3/13/2017		
WHI35	WhiSeis48				0.128											109.0							3/16/2017		
WHI35	WhiSeis49				0.165											111.0							3/16/2017		
WHI36	WhiSeis50				0.285											107.0							3/20/2017		
WHI36	WhiSeis51				0.205											112.0							3/20/2017		
WHI37	WhiSeis52				0.115											111.0							3/21/2017		
WHI38	WhiSeis53				0.213											109.0							3/22/2017		
WHI38	WhiSeis54				0.208											113.0							3/22/2017		
WHI39	WhiSeis55				0.280											114.0							3/24/2017		
WHI39	WhiSeis56				0.283											111.0							3/24/2017		
WHI40	WhiSeis57				0.153											111.0							3/27/2017		
WHI40	WhiSeis58				0.225											111.0							3/27/2017		
WHI41	WhiSeis59				0.178											113.0							3/28/2017		
WHI41	WhiSeis60				0.070											106.0							3/28/2017		
WHI41	WhiSeis61				0.078											108.0							3/28/2017		
WHI42	WhiSeis62				0.153											111.0							3/29/2017		
WHI42	WhiSeis63				0.225											109.0							3/29/2017		
WHI43	WhiSeis64				0.078											110.0							3/30/2017		
WHI44	WhiSeis65				0.275											113.0							3/31/2017		
WHI44	WhiSeis66				0.140											110.0							3/31/2017		
WHI45	WhiSeis67				0.128											109.0							4/04/2017		
WHI46	WhiSeis68				0.240											114.0							4/05/2017		
WHI46	WhiSeis69				0.143											112.0							4/05/2017		
WHI47	WhiSeis70				0.270											107.0							4/07/2017		
WHI47	WhiSeis71				0.163											112.0							4/07/2017		
WHI48	WhiSeis72				0.103											114.0							4/10/2017		
WHI49	WhiSeis73				0.073											113.0							4/11/2017		
WHI50	WhiSeis74				0.158											110.0							4/12/2017		
WHI51	WhiSeis75				0.115											110.0							4/13/2017		
WHI51	WhiSeis76				0.085											102.0							4/13/2017		
WHI51	WhiSeis77				0.088											95.0							4/13/2017		
WHI52	WhiSeis78				0.175											107.0							4/17/2017		

WHI53	WhiSeis79				0.063											108.0							4/18/2017		
WHI54	WhiSeis80				0.163											110.0							4/19/2017		
WHI55	WhiSeis81				0.083											95.0							4/20/2017		
WHI56	WhiSeis82				0.218											112.0							4/21/2017		
WHI57	WhiSeis83				0.225											116.0							4/24/2107		
WHI58	WhiSeis84				0.265											113.0							5/01/2017		
WHI59	WhiSeis85				0.083											107.0							5/04/2017		
WHI60	WhiSeis86				0.248											112.0							5/05/2017		
WHI61	WhiSeis87				0.148											103.0							5/08/2017		
WHI62	WhiSeis88				0.110											111.0							5/10/2017		
WHI63	WhiSeis89				0.128											120.0							5/11/2017		
WHI64	WhiSeis90				0.095											111.0							5/12/2017		
WHI65	WhiSeis91				0.100											108.0							5/15/2017		
WHI66	WhiSeis92				0.070											110.0							5/17/2017		
WHI67	WhiSeis93				0.088											111.0							5/22/2017		
WHI68	WhiSeis94				0.120											111.0							5/23/2017		
WHI69	WhiSeis95				0.100											113.0							5/24/2017		
WHI69	WhiSeis96				0.098											106.0							5/24/2017		
WHI70	WhiSeis97				0.093											113.0							5/25/2017		
WHI71	WhiSeis98				0.148											112.0							5/26/2017		
WHI71	WhiSeis99				0.090											112.0							5/26/2017		
WHI72	WhiSeis100				0.063											110.0							5/30/2017		
WHI73	WhiSeis101				0.080											109.0							5/31/2017		
WHI73	WhiSeis102				0.080											102.0							5/31/2017		
WHI74	WhiSeis103				0.063											103.0							6/01/2017		
WHI75	WhiSeis104				0.073											106.0							6/05/2017		
WHI75	WhiSeis105				0.070											103.0							6/05/2017		
WHI76	WhiSeis106				0.040											101.0							6/06/2017		
WHI77	WhiSeis107				0.145											107.0							6/16/2017		
WHI77	WhiSeis108				0.120											109.0							6/16/2017		
WHI78	WhiSeis109				0.163											111.0							6/19/2017		
WHI78	WhiSeis110				0.168											113.0							6/19/2017		
WHI79	WhiSeis111				0.155											113.0							6/20/2017		
WHI80	WhiSeis112				0.203											107.0							6/21/2017		
WHI80	WhiSeis113				0.143											110.0							6/21/2017		
WHI81	WhiSeis114				0.053											111.0							6/22/2017		
WHI82	WhiSeis115				0.255											101.0							6/23/2017		

WHI82	WhiSeis116				0.168											106.0							6/23/2017		
WHI83	WhiSeis117				0.220											101.0							6/26/2017		
WHI83	WhiSeis118				0.265											108.0							6/26/2017		
WHI84	WhiSeis119				0.075											106.0							6/27/2017		
WHI85	WhiSeis120				0.215											107.0							7/05/2017		
WHI85	WhiSeis121				0.150											107.0							7/05/2017		
WHI86	WhiSeis122				0.070											111.0							7/06/2017		
WHI87	WhiSeis123				0.098											106.0							7/07/2017		
WHI87	WhiSeis124				0.175											107.0							7/07/2017		
WHI88	WhiSeis125				0.178											117.0							7/10/2017		
WHI88	WhiSeis126				0.258											111.0							7/10/2017		
WHI89	WhiSeis127				0.400											106.0							7/11/2017		
WHI89	WhiSeis128				0.183											107.0							7/11/2017		
WHI90	WhiSeis129				0.283											137.0							7/14/2017		
WHI90	WhiSeis130				0.123											119.0							7/14/2017		
WHI91	WhiSeis131				0.200											107.0							7/17/2017		
WHI91	WhiSeis132				0.163											113.0							7/17/2017		
WHI92	WhiSeis133				0.258											98.0							7/20/2017		
WHI92	WhiSeis134				0.220											108.0							7/20/2017		
WHI93	WhiSeis135				0.155											106.0							7/21/2017		
WHI94	WhiSeis136				0.265											108.0							7/24/2017		
WHI94	WhiSeis137				0.138											110.0							7/24/2017		
WHI95	WhiSeis138				0.190											109.0							7/26/2017		
WHI96	WhiSeis139				0.168											109.0							8/01/2017		
WHI97	WhiSeis140				0.135											107.0							8/03/2017		
WHI98	WhiSeis141				0.150											115.0							8/07/2017		
WHI99	WhiSeis142				0.128											109.0							8/10/2017		
WHI100	WhiSeis143				0.145											110.0							8/11/2017		
WHI101	WhiSeis144				0.208											111.0							8/14/2017		
WHI102	WhiSeis145				0.350											110.0							8/16/2017		
WHI103	WhiSeis146				0.183											108.0							8/17/2017		
WHI104	WhiSeis147				0.138											107.0							8/23/2017		

WHI105	WhiSeis148				0.175											108.0							8/24/2017		
WHI106	WhiSeis149				0.210											135.0							8/28/2017		
WHI107	WhiSeis150				0.053											103.0							8/31/2017		
WHI108	WhiSeis151				0.163											109.0							9/01/2017		
WHI109	WhiSeis152				0.163											110.0							9/19/2017		
WHI110	WhiSeis153				0.070											104.0							9/22/2017		
WHI111	WhiSeis154				0.143											108.0							10/02/2017		
WHI111	WhiSeis155				0.245											111.0							10/02/2017		
WHI112	WhiSeis156				0.065											96.0							10/04/2017		
WHI112	WhiSeis157				0.068											104.0							10/04/2017		
WHI112	WhiSeis158				0.078											107.0							10/04/2017		
WHI113	WhiSeis159				0.290											110.0							10/06/2017		
WHI114	WhiSeis160				0.153											108.0							10/10/2017		
WHI114	WhiSeis161				0.203											111.0							10/10/2017		
WHI115	WhiSeis162				0.315											111.0							10/11/2017		
WHI116	WhiSeis163				0.158											101.0							10/12/2017		
WHI117	WhiSeis164				0.243											116.0							10/13/2017		
WHI118	WhiSeis165				0.113											108.0							10/17/2017		
WHI119	WhiSeis166				0.073											96.0							10/19/2017		
WHI119	WhiSeis167				N/A											N/A							10/19/2017		
WHI119	WhiSeis168				0.175											115.0							10/19/2017		
WHI120	WhiSeis169				0.128											103.0							10/21/2017		
WHI121	WhiSeis170				0.098											95.0							10/23/2017		
WHI121	WhiSeis171				0.105											100.0							10/23/2017		
WHI122	WhiSeis172				0.145											113.0							10/24/2017		
WHI122	WhiSeis173				0.170											111.0							10/24/2017		
WHI123	WhiSeis174				0.130											112.0							11/01/2017		
WHI123	WhiSeis175				0.210											111.0							11/01/2017		
WHI124	WhiSeis176				0.208											111.0							11/07/2017		
WHI124	WhiSeis177				0.170											113.0							11/07/2017		
WHI125	WhiSeis178				0.260											118.0							11/08/2017		
WHI126	WhiSeis179				0.185											108.0							11/09/2017		

WHI126	WhiSeis180				0.190											105.0							11/09/2017		
WHI127	WhiSeis181				0.238											113.0							11/13/2017		
WHI128	WhiSeis182				0.333											106.0							11/14/2017		
WHI128	WhiSeis183				0.115											108.0							11/14/2017		
WHI129	WhiSeis184				0.130											103.0							11/15/2017		
WHI129	WhiSeis185				0.230											112.0							11/15/2017		
WHI130	WhiSeis186				0.110											100.0							11/16/2017		
WHI131	WhiSeis187				0.150											104.0							11/17/2017		
WHI131	WhiSeis188				0.173											104.0							11/17/2017		
WHI132	WhiSeis189				0.325											107.0							11/20/2017		
WHI133	WhiSeis190				0.135											109.0							11/21/2017		
WHI133	WhiSeis191				0.260											108.0							11/21/2017		
WHI134	WhiSeis192				0.265											109.0							11/22/2017		
WHI135	WhiSeis193				0.230											108.0							11/28/2017		
WHI136	WhiSeis194				0.143											110.0							11/29/2017		
WHI137	WhiSeis195				0.285											111.0							11/30/2017		
WHI138	WhiSeis196				0.078											102.0							12/01/2017		
WHI139	WhiSeis197				0.230											111.0							12/04/2017		
WHI140	WhiSeis198				0.435											107.0							12/05/2017		
WHI140	WhiSeis199				0.135											108.0							12/05/2017		
WHI141	WhiSeis200				0.308											114.0							12/08/2017		
WHI142	WhiSeis201				0.160											111.0							12/13/2017		
WHI143	WhiSeis202				0.110											112.0							12/14/2017		
WHI143	WhiSeis203				0.093											112.0							12/14/2017		
WHI144	WhiSeis204				0.313											112.0							12/18/2017		
WHI145	WhiSeis205				0.310											111.0							12/21/2017		
WHI146	WhiSeis206				0.118											110.0							1/08/2018		
WHI147	WhiSeis207				0.290											116.0							1/10/2018		
WHI148	WhiSeis208				0.230											109.0							1/11/2018		
WHI149	WhiSeis209				0.120											114.0							1/12/2018		
WHI150	WhiSeis210				0.155											111.0							1/16/2018		
WHI150	WhiSeis211				0.118											106.0							1/16/2018		

WHI151	WhiSeis212				0.150											112.0							1/17/2018		
WHI152	WhiSeis213				0.233											112.0							1/18/2018		
WHI153	WhiSeis214				0.148											116.0							1/19/2018		
WHI153	WhiSeis215				0.143											110.0							1/19/2018		
WHI154	WhiSeis216				0.213											110.0							1/23/2018		
WHI155	WhiSeis217				0.280											113.0							1/24/2018		
WHI156	WhiSeis218				0.143											105.0							1/26/2018		
WHI157	WhiSeis219				0.178											117.0							1/31/2018		
WHI158	WhiSeis220				0.178											114.0							2/02/2018		
WHI159	WhiSeis221				0.230											110.0							2/09/2018		
WHI160	WhiSeis222				0.240											124.0							2/13/2018		
WHI161	WhiSeis223				0.140											103.0							2/14/2018		
WHI162	WhiSeis224				0.140											110.0							2/16/2018		
WHI162	WhiSeis225				0.160											115.0							2/16/2018		
WHI163	WhiSeis226				0.213											110.0							2/19/2018		
WHI164	WhiSeis227				0.190											110.0							2/20/2018		
WHI165	WhiSeis228				0.223											111.0							2/22/2018		
WHI165	WhiSeis229				0.195											109.0							2/22/2018		
WHI166	WhiSeis230				0.260											115.0							2/26/2018		
WHI167	WhiSeis231				0.118											106.0							2/27/2018		
WHI168	WhiSeis232				0.185											113.0							3/05/2018		
WHI169	WhiSeis233				0.090											110.0							3/07/2018		
WHI170	WhiSeis234				0.228											108.0							3/09/2018		
WHI171	WhiSeis235				0.193											102.0							3/15/2018		
WHI172	WhiSeis236				0.175											115.0							3/19/2018		
WHI172	WhiSeis237				0.238											109.0							3/19/2018		
WHI173	WhiSeis238				0.278											113.0							3/20/2018		
WHI173	WhiSeis239				0.240											113.0							3/20/2018		
WHI174	WhiSeis240				0.153											109.0							3/21/2018		
WHI175	WhiSeis241				0.223											110.0							3/22/2018		
WHI176	WhiSeis242				0.338											111.0							3/23/2018		
WHI176	WhiSeis243				0.375											119.0							3/23/2018		

WHI177	WhiSeis244				0.260											113.0							3/26/2018		
WHI177	WhiSeis245				0.173											111.0							3/26/2018		

Krome Quarry

Blast Event ID	Seis Event ID	Distance to Seismograph (ft)	Seis Northing	Seis Westing	PPV (ips)	Peak Vector Sum (ips)	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Range Geo. (ips)	Serial Number	Unit Calibration	Date Created	Date Printed	Comments
KRO1	KroSeis1	2777	25-40-20.5	80-29-05.299									0.080	1.7		114.0							1/10/2017		
KRO1	KroSeis2	2871	25-40-36.6	80-28-24.0			0.120	56.0								109.0							1/10/2017		
KRO1	KroSeis3	5318	25-40-35.8	80-27-56.6			0.040	28.0								93.0							1/10/2017		
KRO2	KroSeis4	2708	25-40-20.5	80-29-05.299			0.100	42.0								113.0							1/23/2017		
KRO2	KroSeis5	3024	25-40-36.6	80-28-24.0			0.210	42.0								124.0							1/23/2017		
KRO2	KroSeis6	5477	25-40-35.8	80-27-56.6			0.040	24.0								112.0							1/23/2017		
KRO3	KroSeis7	2337	25-40-20.5	80-29-05.299			0.170	42.0								108.0							1/26/2017		
KRO3	KroSeis8	5048	25-40-36.6	80-28-24.0			0.180	33.0								106.0							1/26/2017		
KRO3	KroSeis9	7554	25-40-35.8	80-27-56.6						0.030	8.0					114.0							1/26/2017		
KRO4	KroSeis10	2014	25-40-20.5	80-29-05.299			0.210	36.0								118.0							2/2/2017		
KRO4	KroSeis11	3887	25-40-36.6	80-28-24.0			0.150	42.0								106.0							2/2/2017		
KRO4	KroSeis12	6349	25-40-35.8	80-27-56.6			0.040	42.0								91.0							2/2/2017		
KRO5	KroSeis13	2140	25-40-20.5	80-29-05.299			0.200	42.0								109.0							2/7/2017		
KRO5	KroSeis14	4629	25-40-36.6	80-28-24.0			0.090	42.0								106.0							2/7/2017		
KRO5	KroSeis15	7134	25-40-35.8	80-27-56.6									0.030	2.0		88.0							2/7/2017		
KRO6	KroSeis16	1968	25-40-20.5	80-29-05.299			0.200	31.0								109.0							2/8/2017		
KRO6	KroSeis17	3790	25-40-36.6	80-28-24.0			0.130	42.0								104.0							2/8/2017		
KRO6	KroSeis18	6294	25-40-35.8	80-27-56.6						0.020	11.0					93.0							2/8/2017		
KRO7	KroSeis19	2012	25-40-20.5	80-29-05.299			0.180	42.0								114.0							2/13/2017		
KRO7	KroSeis20	3375	25-40-36.6	80-28-24.0			0.080	42.0								107.0							2/13/2017		
KRO7	KroSeis21	5878	25-40-35.8	80-27-56.6						0.030	5.0					91.0							2/13/2017		
KRO8	KroSeis22	2909	25-40-20.5	80-29-05.299			0.050	28.0								104.0							2/21/2017		
KRO8	KroSeis23	5142	25-40-36.6	80-28-24.0			0.060	42.0								99.0							2/21/2017		
KRO8	KroSeis24		25-40-35.8	80-27-56.6																			2/21/2017		Seismograph did not trigger.
KRO9	KroSeis25	2186	25-40-20.5	80-29-05.299			0.200	42.0								112.0							2/22/2017		
KRO9	KroSeis26	2858	25-40-36.6	80-28-24.0			0.100	33.0								110.0							2/22/2017		
KRO9	KroSeis27	5360	25-40-35.8	80-27-56.6			0.050	28.0								95.0							2/22/2017		
KRO10	KroSeis28	2754	25-40-20.5	80-29-05.299									0.080	5.0		104.0							2/27/2017		
KRO10	KroSeis29	4738	25-40-36.6	80-28-24.0			0.080	46.0								115.0							2/27/2017		
KRO10	KroSeis30	7219	25-40-35.8	80-27-56.6			0.030	46.0								112.0							2/27/2017		
KRO11	KroSeis31	2102	25-40-20.5	80-29-05.299						0.180	33.0					112.0							3/1/2017		
KRO11	KroSeis32	3082	25-40-36.6	80-28-24.0			0.090	42.0								108.0							3/1/2017		
KRO11	KroSeis33	5584	25-40-35.8	80-27-56.6																			3/1/2017		Seismograph did not trigger.
KRO12	KroSeis34	2617	25-40-20.5	80-29-05.299			0.060	56.0								111.0							3/9/2017		
KRO12	KroSeis35	3919	25-40-36.6	80-28-24.0			0.110	42.0								103.0							3/9/2017		
KRO12	KroSeis36	6388	25-40-35.8	80-27-56.6			0.060	28.0								90.0							3/9/2017		
KRO13	KroSeis37	2645	25-40-20.5	80-29-05.299			0.060	56.0								113.0							3/23/2017		

KRO13	KroSeis38	3531	25-40-36.6	80-28-24.0			0.070	56.0								103.0							3/23/2017		
KRO13	KroSeis39	5992	25-40-35.8	80-27-56.6			0.050	28.0								95.0							3/23/2017		
KRO14	KroSeis40	2290	25-40-20.5	80-29-05.299			0.100	56.0								106.0							3/27/2017		
KRO14	KroSeis41	5036	25-40-36.6	80-28-24.0			0.060	56.0								96.0							3/27/2017		
KRO14	KroSeis42	7542	25-40-35.8	80-27-56.6																			3/27/2017		Seismograph did not trigger.
KRO15	KroSeis43	2080	25-40-20.5	80-29-05.299			0.180	33.0								104.0							3/30/2017		
KRO15	KroSeis44	4616	25-40-36.6	80-28-24.0			0.100	33.0								106.0							3/30/2017		
KRO15	KroSeis45	7121	25-40-35.8	80-27-56.6			0.040	33.0								88.0							3/30/2017		
KRO16	KroSeis46	1921	25-40-20.5	80-29-05.299			0.190	33.0								112.0							4/11/2017		
KRO16	KroSeis47	5037	25-40-36.6	80-28-24.0			0.090	33.0								104.0							4/11/2017		
KRO16	KroSeis48	7223	25-40-35.8	80-27-56.6			0.050	28.0								98.0							4/11/2017		
KRO17	KroSeis49	1918	25-40-20.5	80-29-05.299			0.220	33.0								112.0							4/18/2017		
KRO17	KroSeis50	3859	25-40-36.6	80-28-24.0			0.110	42.0								109.0							4/18/2017		
KRO17	KroSeis51	6364	25-40-35.8	80-27-56.6			0.040	21.0								90.0							4/18/2017		
KRO18	KroSeis52	1921	25-40-20.5	80-29-05.299			0.220	33.0								113.0							4/27/2017		
KRO18	KroSeis53	3548	25-40-36.6	80-28-24.0			0.160	42.0								107.0							4/27/2017		
KRO18	KroSeis54	6053	25-40-35.8	80-27-56.6			0.040	28.0								91.0							4/27/2017		
KRO19	KroSeis55	1996	25-40-20.5	80-29-05.299			0.180	33.0								111.0							5/17/2017		
KRO19	KroSeis56	3230	25-40-36.6	80-28-24.0			0.080	33.0								107.0							5/17/2017		
KRO19	KroSeis57	5735	25-40-35.8	80-27-56.6			0.050	42.0								91.0							5/17/2017		
KRO20	KroSeis58	2272	25-40-20.5	80-29-05.299			0.090	56.0								103.0							5/22/2017		
KRO20	KroSeis59	5106	25-40-36.6	80-28-24.0			0.050	56.0								99.0							5/22/2017		
KRO20	KroSeis60	7612	25-40-35.8	80-27-56.6			0.030	21.0								87.0							5/22/2017		
KRO21	KroSeis61	2056	25-40-20.5	80-29-05.299			0.210	21.0								111.0							5/25/2017		
KRO21	KroSeis62	3020	25-40-36.6	80-28-24.0			0.090	21.0								118.0							5/25/2017		
KRO21	KroSeis63	6624	25-40-35.8	80-27-56.6			0.060	24.0								118.0							5/25/2017		
KRO22	KroSeis64	2136	25-40-20.5	80-29-05.299			0.190	33.0								111.0							5/30/2017		
KRO22	KroSeis65	2856	25-40-36.6	80-28-24.0			0.130	42.0								109.0							5/30/2017		
KRO22	KroSeis66	5361	25-40-35.8	80-27-56.6			0.080	21.0								101.0							5/30/2017		
KRO23	KroSeis67	7192	25-40-35.8	80-27-56.6			0.040	21.0								91.0							6/5/2017		
KRO23	KroSeis68	2056	25-40-20.5	80-29-05.29			0.130	28.0								109.0							6/5/2017		
KRO23	KroSeis69	4685	25-40-36.6	80-28-24.00																			6/5/2017		Seismograph did not trigger.
KRO24	KroSeis70	1908	25-40-20.5	80-29-05.299			0.180	24.0								108.0							6/15/2017		
KRO24	KroSeis71	4685	25-40-36.6	80-28-24.0			0.150	33.0								107.0							6/15/2017		
KRO24	KroSeis72	7192	25-40-35.8	80-27-56.6			0.060	28.0								91.0							6/15/2017		
KRO25	KroSeis73	1847	25-40-20.5	80-29-05.299			0.220	33.0								113.0							6/22/2017		
KRO25	KroSeis74	3844	25-40-36.6	80-28-24.0			0.200	42.0								108.0							6/22/2017		
KRO25	KroSeis75	6351	25-40-35.8	80-27-56.6			0.050	28.0								101.0							6/22/2017		
KRO26	KroSeis76	1890	25-40-20.5	80-29-05.299			0.210	21.0								118.0							7/11/2017		
KRO26	KroSeis77	3426	25-40-36.6	80-28-24.0			0.100	42.0								99.0							7/11/2017		
KRO26	KroSeis78	5932	25-40-35.8	80-27-56.6			0.040	21.0								90.0							7/11/2017		

KRO27	KroSeis79	1963	25-40-20.5	80-29-05.299			0.230	33.0								112.0							7/20/2017		
KRO27	KroSeis80	3115	25-40-36.6	80-28-24.0			0.140	42.0								106.0							7/20/2017		
KRO27	KroSeis81	5621	25-40-35.8	80-27-56.6			0.060	24.0								91.0							7/20/2017		
KRO28	KroSeis82	2081	25-40-20.5	80-29-05.299			0.210	42.0								112.0							7/26/2017		
KRO28	KroSeis83	2843	25-40-36.6	80-28-24.0			0.240	42.0								109.0							7/26/2017		
KRO28	KroSeis84	5348	25-40-35.8	80-27-56.6			0.070	28.0								99.0							7/26/2017		
KRO29	KroSeis85	2703	25-40-20.5	80-29-05.299																			8/1/2017		Seismograph did not trigger.
KRO29	KroSeis86	3251	25-40-36.6	80-28-24.0			0.140	56.0								109.0							8/1/2017		
KRO29	KroSeis87	5704	25-40-35.8	80-27-56.6			0.050	42.0								109.0							8/1/2017		
KRO30	KroSeis88	2769	25-40-20.5	80-29-05.299									0.110	4.0		113.0							8/10/2017		
KRO30	KroSeis89	3034	25-40-36.6	80-28-24.0			0.190	42.0								111.0							8/10/2017		
KRO30	KroSeis90	5480	25-40-35.8	80-27-56.6			0.070	28.0								99.0							8/10/2017		
KRO31	KroSeis91	2251	25-40-20.5	80-29-05.299																			8/14/2017		Seismograph did not trigger.
KRO31	KroSeis92	5149	25-40-36.6	80-28-24.0			0.090	42.0								106.0							8/14/2017		
KRO31	KroSeis93	7656	25-40-35.8	80-27-56.6																			8/14/2017		Seismograph did not trigger.
KRO32	KroSeis94	2081	25-40-20.5	80-29-05.299			0.140	56.0								107.0							8/22/2017		
KRO32	KroSeis95	4848	25-40-36.6	80-28-24.0			0.150	42.0								107.0							8/22/2017		
KRO32	KroSeis96	7354	25-40-35.8	80-27-56.6			0.040	42.0								95.0							8/22/2017		
KRO33	KroSeis97	1950	25-40-20.5	80-29-05.299			0.140	42.0								111.0							8/29/2017		
KRO33	KroSeis98	4564	25-40-36.6	80-28-24.0			0.140	28.0								104.0							8/29/2017		
KRO33	KroSeis99	7071	25-40-35.8	80-27-56.6			0.040	33.0								91.0							8/29/2017		
KRO34	KroSeis100	1850	25-40-20.5	80-29-05.299			0.180	33.0								110.0							9/28/2017		
KRO34	KroSeis101	4263	25-40-36.6	80-28-24.0			0.120	42.0								103.0							9/28/2017		
KRO34	KroSeis102	6769	25-40-35.8	80-27-56.6			0.080	83.0								88.0							9/28/2017		
KRO35	KroSeis103	1798	25-40-20.5	80-29-05.299			0.400	28.0								116.0							10/3/2017		
KRO35	KroSeis104	3682	25-40-36.6	80-28-24.0			0.250	42.0								116.0							10/3/2017		
KRO35	KroSeis105	6189	25-40-35.8	80-27-56.6			0.080	50.0								108.0							10/3/2017		
KRO36	KroSeis106	1795	25-40-20.5	80-29-05.299			0.230	42.0								112.0							10/5/2017		
KRO36	KroSeis107	3970	25-40-36.6	80-28-24.0			0.170	42.0								116.0							10/5/2017		
KRO36	KroSeis108	6477	25-40-35.8	80-27-56.6			0.040	24.0								88.0							10/5/2017		
KRO37	KroSeis109	1832	25-40-20.5	80-29-05.299			0.218	58.0								117.0							10/12/2017		
KRO37	KroSeis110	3414	25-40-36.6	80-28-24.0			0.155	33.0								111.0							10/12/2017		
KRO37	KroSeis111	5920	25-40-35.8	80-27-56.6			0.035	24.0								98.0							10/12/2017		
KRO38	KroSeis112	1922	25-40-20.5	80-29-05.299			0.240	33.0								117.0							11/6/2017		
KRO38	KroSeis113	3094	25-40-36.6	80-28-24.0			0.200	42.0								112.0							11/6/2017		
KRO38	KroSeis114	5600	25-40-35.8	80-27-56.6			0.030	42.0								90.0							11/6/2017		
KRO39	KroSeis115	2197	25-40-20.5	80-29-05.299						0.110	42.0					110.0							11/8/2017		
KRO39	KroSeis116	5139	25-40-36.6	80-28-24.0			0.140	33.0								105.0							11/8/2017		
KRO39	KroSeis117	7645	25-40-35.8	80-27-56.6									0.030	3.0		90.0							11/8/2017		
KRO40	KroSeis118	2023	25-40-20.5	80-29-05.299			0.190	56.0								119.0							11/14/2017		
KRO40	KroSeis119	2848	25-40-36.6	80-28-24.0			0.250	42.0								111.0							11/14/2017		

KRO40	KroSeis120	5354	25-40-35.8	80-27-56.6			0.050	24.0								98.0							11/14/2017		
KRO41	KroSeis121	2029	25-40-20.5	80-29-05.299			0.130	39.0								111.0							11/16/2017		
KRO41	KroSeis122	4846	25-40-36.6	80-28-24.0			0.140	46.0								101.0							11/16/2017		
KRO41	KroSeis123	7352	25-40-35.8	80-27-56.6			0.040	56.0								88.0							11/16/2017		
KRO42	KroSeis124	1882	25-40-20.5	80-29-05.299			0.150	42.0								116.0							11/21/2017		
KRO42	KroSeis125	4508	25-40-36.6	80-28-24.0			0.220	42.0								108.0							11/21/2017		
KRO42	KroSeis126	7014	25-40-35.8	80-27-56.6			0.040	42.0								88.0							11/21/2017		
KRO43	KroSeis127	3016	25-40-20.5	80-29-05.299									0.060	3.0		106.0							11/28/2017		
KRO43	KroSeis128	5290	25-40-36.6	80-28-24.0			0.120	42.0								122.0							11/28/2017		
KRO43	KroSeis129	7775	25-40-35.8	80-27-56.6																			11/28/2017		Seismograph did not trigger.
KRO44	KroSeis130	2891	25-40-20.5	80-29-05.299			0.060	21.0								109.0							11/30/2017		
KRO44	KroSeis131	5002	25-40-36.6	80-28-24.0			0.150	33.0								100.0							11/30/2017		
KRO44	KroSeis132	7484	25-40-35.8	80-27-56.6			0.040	33.0								106.0							11/30/2017		
KRO45	KroSeis133	2801	25-40-20.5	80-29-05.299			0.070	19.0								106.0							12/5/2017		
KRO45	KroSeis134	4714	25-40-36.6	80-28-24.0			0.150	33.0								105.0							12/5/2017		
KRO45	KroSeis135	7193	25-40-35.8	80-27-56.6			0.030	28.0								88.0							12/5/2017		
KRO46	KroSeis136	1798	25-40-20.5	80-29-05.299			0.180	28.0								110.0							12/7/2017		
KRO46	KroSeis137	4255	25-40-36.6	80-28-24.0			0.200	42.0								108.0							12/7/2017		
KRO46	KroSeis138	6763	25-40-35.8	80-27-56.6			0.060	33.0								98.0							12/7/2017		
KRO47	KroSeis139	1734	25-40-20.5	80-29-05.299			0.260	42.0								115.0							12/12/2017		
KRO47	KroSeis140	3959	25-40-36.6	80-28-24.0			0.200	42.0								111.0							12/12/2017		
KRO47	KroSeis141	6466	25-40-35.8	80-27-56.6			0.040	24.0								95.0							12/12/2017		
KRO48	KroSeis142	1725	25-40-20.5	80-29-05.299			0.270	42.0								117.0							12/14/2017		
KRO48	KroSeis143	3731	25-40-36.6	80-28-24.0			0.190	42.0								112.0							12/14/2017		
KRO48	KroSeis144	6239	25-40-35.8	80-27-56.6			0.030	42.0								93.0							12/14/2017		
KRO49	KroSeis145	2708	25-40-20.5	80-29-05.299									0.070	3.0		107.0							12/18/2017		
KRO49	KroSeis146	4306	25-40-36.6	80-28-24.0			0.280	33.0								106.0							12/18/2017		
KRO49	KroSeis147	6777	25-40-35.8	80-27-56.6																			12/18/2017		Seismograph did not trigger.
KRO50	KroSeis148	2678	25-40-20.5	80-29-05.299									0.100	3.0		108.0							12/20/2017		
KRO50	KroSeis149	3900	25-40-36.6	80-28-24.0			0.120	42.0								110.0							12/20/2017		
KRO50	KroSeis150	6363	25-40-35.8	80-27-56.6									0.030	3.0		88.0							12/20/2017		
KRO51	KroSeis151	1767	25-40-20.5	80-29-05.299			0.250	42.0								115.0							1/9/2018		
KRO51	KroSeis152	3439	25-40-36.6	80-28-24.0			0.140	56.0								111.0							1/9/2018		
KRO51	KroSeis153	5945	25-40-35.8	80-27-56.6			0.030	28.0								88.0							1/9/2018		
KRO52	KroSeis154	1845	25-40-20.5	80-29-05.299			0.200	33.0								115.0							1/16/2018		
KRO52	KroSeis155	3146	25-40-36.6	80-28-24.0			0.180	42.0								108.0							1/16/2018		
KRO52	KroSeis156	5653	25-40-35.8	80-27-56.6			0.030	42.0								91.0							1/16/2018		
KRO53	KroSeis157	1965	25-40-20.5	80-29-05.299									0.160	2.0		117.0							1/18/2018		
KRO53	KroSeis158	2854	25-40-36.6	80-28-24.0			0.180	56.0								114.0							1/18/2018		
KRO53	KroSeis159	5360	25-40-35.8	80-27-56.6			0.040	56.0								93.0							1/18/2018		
KRO54	KroSeis160	2175	25-40-20.5	80-29-05.299									0.090	42.0		116.0							1/30/2018		

KRO54	KroSeis161	5165	25-40-36.6	80-28-24.0			0.090	42.0								111.0							1/30/2018		
KRO54	KroSeis162	7671	25-40-35.8	80-27-56.6																			1/30/2018		
KRO55	KroSeis163	1975	25-40-20.5	80-29-05.299			0.120	33.0								108.0							2/1/2018		
KRO55	KroSeis164	4873	25-40-36.6	80-28-24.0			0.090	42.0								117.0							2/1/2018		
KRO55	KroSeis165	7878	25-40-35.8	80-27-56.6						0.020	5.0					87.0							2/1/2018		
KRO56	KroSeis166	1857	25-40-20.5	80-29-05.299			0.200	24.0								110.0							2/6/2018		
KRO56	KroSeis167	4580	25-40-36.6	80-28-24.0			0.130	56.0								102.0							2/6/2018		
KRO56	KroSeis168	7086	25-40-35.8	80-27-56.6			0.030	33.0								95.0							2/6/2018		
KRO57	KroSeis169	1750	25-40-20.5	80-29-05.299			0.310	28.0								111.0							2/13/2018		
KRO57	KroSeis170	4263	25-40-36.6	80-28-24.0			0.140	56.0								118.0							2/13/2018		
KRO57	KroSeis171	6770	25-40-35.8	80-27-56.6			0.040	21.0								95.0							2/13/2018		
KRO58	KroSeis172	1580	25-40-20.5	80-29-05.299			0.260	56.0								116.0							3/5/2018		
KRO58	KroSeis173	3931	25-40-36.6	80-28-24.0			0.110	56.0								79.0							3/5/2018		
KRO58	KroSeis174	6436	25-40-35.8	80-27-56.6			0.040	42.0								88.0							3/5/2018		
KRO59	KroSeis175	1576	25-40-20.5	80-29-05.299			0.280	33.0								116.0							3/8/2018		
KRO59	KroSeis176	3657	25-40-36.6	80-28-24.0			0.090	56.0								81.0							3/8/2018		
KRO59	KroSeis177	6162	25-40-35.8	80-27-56.6			0.030	24.0								99.0							3/8/2018		
KRO60	KroSeis178	1620	25-40-20.5	80-29-05.299			0.250	42.0								113.0							3/13/2018		
KRO60	KroSeis179	3382	25-40-36.6	80-28-24.0			0.130	42.0								79.0							3/13/2018		
KRO60	KroSeis180	5889	25-40-35.8	80-27-56.6			0.030	42.0								90.0							3/13/2018		
KRO61	KroSeis181	1708	25-40-20.5	80-29-05.299			0.190	33.0								117.0							3/15/2018		
KRO61	KroSeis182	3088	25-40-36.6	80-28-24.0			0.110	42.0								81.0							3/15/2018		
KRO61	KroSeis183	5596	25-40-35.8	80-27-56.6			0.030	24.0								90.0							3/15/2018		
KRO62	KroSeis184	1832	25-40-20.5	80-29-05.299			0.170	42.0								118.0							3/20/2018		
KRO62	KroSeis185	2834	25-40-36.6	80-28-24.0			0.140	42.0								79.0							3/20/2018		
KRO62	KroSeis186	5339	25-40-35.8	80-27-56.6									0.040	3.0		110.0							3/20/2018		
KRO63	KroSeis187	2068	25-40-20.5	80-29-05.299			0.100	56.0								111.0							3/22/2018		
KRO63	KroSeis188	5120	25-40-36.6	80-28-24.0			0.070	56.0								101.0							3/22/2018		
KRO63	KroSeis189	7625	25-40-35.8	80-27-56.6																			3/22/2018		
KRO64	KroSeis190	1851	25-40-20.5	80-29-05.299			0.140	28.0								111.0							3/26/2018		
KRO64	KroSeis191	4754	25-40-36.6	80-28-24.0			0.060	56.0								98.0							3/26/2018		
KRO64	KroSeis192	7259	25-40-35.8	80-27-56.6						0.020	4.0					90.0							3/26/2018		
KRO65	KroSeis193	1762	25-40-20.5	80-29-05.299			0.240	28.0								109.0							3/28/2018		
KRO65	KroSeis194	4571	25-40-36.6	80-28-24.0			0.080	24.0								130.0							3/28/2018		
KRO65	KroSeis195	2777	25-40-35.8	80-27-56.6																			3/28/2018		Seismograph did not trigger.

APPENDIX D

CITIZEN COMPLAINT DATA SUMMARY

Complaint #	Mine Site	Damage Claim?	General Damage	General Cracking	Interior Wall	Interior Ceiling	Exterior	Foundation	Driveway	Sidewalk	Garage Floor	Tile Floor	Patio	Pool	Roof	Fallen Items	Water Pipe	Water Leaks	Other	Description	Number of Damage Claims Per Complaint
1	WRQ	y	X		X				X						X		X			driveway, wall crack, unknown structural damage, roof, sprinkler system	5
2	WRQ	n																			0
3	WRQ	n																			0
4	WRQ	n																			0
5	WRQ	y						X		X						X				fish tank rocks fallen over, cracks in foundation and sidewalks	3
6	WRQ	y			X															wall cracks	1
7	WRQ	n																			0
8	WRQ	n																			0
9	WRQ	n																			0
10	WRQ	n																			0
11	WRQ	n																			0
12	WRQ	y														X				picture fell	1
13	WRQ	y		X																cracking	1
14	WRQ	y								X										sidewalk cracking	1
15	WRQ	n																			0
16	WRQ	n																			0
17	WRQ	n																			0
18	WRQ	n																			0
19	WRQ	n																			0
20	WRQ	n																			0
21	WRQ	n																			0
22	WRQ	n																			0
23	WRQ	n																			0
24	WRQ	n																			0
25	WRQ	n																			0
26	WRQ	n																			0
27	WRQ	n																			0
28	WRQ	n																			0
29	WRQ	n																			0
30	WRQ	n																			0
31	WRQ	n																			0
32	WRQ	n																			0
33	WRQ	n																			0
34	WRQ	n																			0

35	WRQ	n																			0
36	WRQ	n																			0
37	WRQ	y																X		house leaking	1
38	WRQ	n																			0
39	WRQ	n																			0
40	WRQ	n																			0
41	WRQ	y																X		water leaks	1
42	WRQ	n																			0
43	WRQ	n																			0
44	WRQ	n																			0
45	WRQ	n																			0
46	WRQ	n																			0
47	WRQ	n																			0
48	WRQ	n																			0
49	WRQ	n																			0
50	WRQ	n																			0
51	WRQ	n																			0
52	WRQ	n																			0
53	WRQ	n																			0
54	WRQ	n																			0
55	WRQ	n																			0
56	WRQ	n																			0
57	WRQ	n																			0
58	WRQ	n																			0
59	WRQ	n																			0
60	WRQ	n																			0
61	WRQ	n																			0
62	WRQ	n																			0
63	WRQ	n																			0
64	WRQ	n																			0
65	WRQ	n																			0
66	WRQ	n																			0
67	WRQ	n																			0
68	WRQ	n																			0
69	WRQ	n																			0
70	WRQ	n																			0
71	WRQ	n																			0
72	WRQ	y															X			water line broke	1

73	WRQ	n																			0
74	WRQ	n																			0
75	WRQ	n																			0
76	WRQ	n																			0
77	WRQ	n																			0
78	WRQ	n																			0
79	WRQ	n																			0
80	WRQ	y											X							patio cracks	1
81	WRQ	n																			0
82	WRQ	n																			0
83	WRQ	n																			0
84	WRQ	n																			0
85	WRQ	n																			0
86	WRQ	n																			0
87	WRQ	n																			0
88	WRQ	n																			0
89	WRQ	n																			0
90	WRQ	n																			0
91	WRQ	n																			0
92	WRQ	n																			0
93	WRQ	n																			0
94	WRQ	n																			0
95	WRQ	n																			0
96	WRQ	y	X																	general damage	1
97	WRQ	y			X															wall cracks	1
98	WRQ	y			X															wall cracks	1
99	WRQ	y			X															wall cracks	1
100	WRQ	y			X															wall cracks	1
101	WRQ	n																			0
102	WRQ	y			X															wall cracks	1
103	WRQ	y			X															wall cracks	1
104	WRQ	y			X															wall cracks	1
105	WRQ	y			X															wall cracks	1
106	WRQ	y			X															wall cracks	1
107	WRQ	y			X															wall cracks	1
108	WRQ	y			X															wall cracks	1
109	WRQ	n																			0
110	WRQ	y										X								cracks in floor	1

111	WRQ	y							X											driveway shifted and cracked	1
112	WRQ	n																			0
113	WRQ	n																			0
114	WRQ	n																			0
115	WRQ	n																			0
116	WRQ	n																			0
117	WRQ	n																			0
118	WRQ	n																			0
119	WRQ	n																			0
120	WRQ	y	X																	general damage	1
121	WRQ	n																			0
122	WRQ	n																			0
123	WRQ	n																			0
124	WRQ	n																			0
125	WRQ	n																			0
126	WRQ	y																	X	floor buckled	1
127	WRQ	y			X	X	X		X	X			X						X	driveway, sidewalk, patio, exterior, drywall, wood floor cracking and buckling	7
128	WRQ	n																			0
129	WRQ	n																			0
130	WRQ	y						X					X			X				heirlooms fell off shelf, cracks in foundation, pavers moving	3
131	WRQ	n																			0
132	WRQ	n																			0
133	WRQ	n																			0
134	WRQ	n																			0
135	WRQ	n																			0
136	WRQ	n																			0
137	WRQ	n																			0
138	WRQ	n																			0
139	WRQ	n																			0
140	WRQ	n																			0
141	WRQ	n																			0
142	WRQ	n																			0
143	WRQ	y		X																cracking but not specified	1
144	WRQ	n																			0
145	WRQ	y					X											X		exterior cracking resulting in water damage	2
146	WRQ	n																			0

147	WRQ	n																			0
148	WRQ	n																			0
149	WRQ	n																			0
150	WRQ	y			X							X								wall cracks, floor tiles popping	2
151	WRQ	y									X									garage floor cracking	1
152	WRQ	n																			0
153	WRQ	n																			0
154	WRQ	y							X											driveway cracks	1
155	WRQ	n																			0
156	WRQ	y															X			water pipe leak	1
157	WRQ	n																			0
158	WRQ	n																			0
159	WRQ	n																			0
160	WRQ	y										X								floors cracked	1
161	WRQ	n																			0
162	WRQ	n																			0
163	WRQ	y															X			water pipe leaks	1
164	WRQ	y				X			X			X		X						pool leaks, cracked driveway, cracked ceiling, cracked tiles	4
165	WRQ	y			X		X					X							X	cracks in exterior, tile, walls, floors, granite counter	4
166	WRQ	n																			0
167	WRQ	y			X	X														cracks in walls and ceiling	2
168	WRQ	y												X						pool damage	1
169	WRQ	y			X		X									X	X		X	broken water pipes, wall cracks, stair support cracks, artwork fell off shelf and broke, exterior cracking	5
170	WRQ	y		X																crack extensions	1
171	WRQ	y									X									crack in concrete floor	1
172	WRQ	y						X												foundation cracks	1
173	WRQ	n																			0
174	WRQ	y			X														X	cracks in walls, alarm system set off, holes in yard,	2
175	WRQ	n																			0
176	WRQ	y														X				pictures fell off wall	1
177	WRQ	n																			0
178	WRQ	n																			0
179	WRQ	n																			0
180	WRQ	n																			0

181	WRQ	n																			0
182	WRQ	y							X				X						X	granite countertops cracked, driveway, patio, boat ramped cracked in half	3
183	WRQ	y			X											X			X	shelf holding wine bottles collapsed, chipped counter and broke floor, cracks in walls	3
184	WRQ	y										X								broken tiles	1
185	WRQ	n																			0
186	WRQ	y					X	X			X					X				pictures fallen off walls, stucco pieces falling off exterior, foundation cracks, cracked concrete floor in garage	4
187	WRQ	y					X								X					stucco falling off, separation between roof tiles and wall	2
188	WRQ	y					X		X		X							X		cracks in garage concrete, driveway section sinking, water leak at window, cracks at windows	4
189	WRQ	y				X														cracks in ceiling extending	1
190	WRQ	y										X								floor tiles cracking	1
191	WRQ	y										X								tile damage	1
192	WRQ	y	X																X	sinkholes, general damage	2
193	WRQ	y									X									crack in garage concrete	1
194	WRQ	n																			0
195	WRQ	y				X					X									cracks in concrete and ceiling	2
196	WRQ	y																	X	sinkhole	1
197	WRQ	y			X						X			X						cracks on pool deck, garage floor, wall	3
198	WRQ	y				X	X		X				X							driveway, patio, exterior walls, interior ceiling	4
199	WRQ	n																			0
200	WRQ	y		X															X	cracks all over house, A/C line broke under house	2
201	WRQ	y		X					X											driveway cracks and general cracking in house	2
202	WRQ	n																			0
203	WRQ	y			X	X	X					X		X	X					loose roof tiles, pool deck cracked, cracked outdoor tiles, exterior, interior, ceiling cracks	6
204	WRQ	n																			0
205	WRQ	n																			0
206	WRQ	y														X				items falling on shelves	1
207	WRQ	n																			0
208	WRQ	n																			0
209	WRQ	n																			0

210	WRQ	y										X				X			X	smoke detector fell, paintings fell of wall, window cracked, tile cracks	3
211	WRQ	n																			0
212	WRQ	n																			0
213	WRQ	n																			0
214	WRQ	y							X			X	X							driveway, patio, bathrooms, floors cracked	3
215	WRQ	y		X					X											cracks, cracked driveway	2
216	WRQ	n																			0
217	WRQ	n																			0
218	WRQ	y				X					X									garage floor cracks and ceiling cracks	2
219	WRQ	n																			0
220	WRQ	n																			0
221	WRQ	y	X																	general damage	1
222	WRQ	y							X											cracked and sunken driveway, cracked concrete	1
223	WRQ	y		X																cracks	1
224	WRQ	y													X					roof tiles fell off	1
225	WRQ	n																			0
226	WRQ	y										X		X						tiles popping, pool leak	2
227	WRQ	n																			0
228	WRQ	y			X							X							X	cracked windows, floors, walls, ac pipes leaking	3
229	WRQ	n																			0
230	WRQ	y			X	X	X													exterior, interior, wall, ceiling cracks	3
231	WRQ	y	X																	general damage	1
232	WRQ	n																			0
233	WRQ	n																			0
234	WRQ	y	X																	general damage	1
235	WRQ	y	X																	general damage	1
236	WRQ	y		X			X													general cracks, exterior cracks	2
237	WRQ	y	X																	general damage	1
238	WRQ	y					X													exterior cracks	1
239	WRQ	y															X			pipes around home had to be repaired	1
240	WRQ	n																			0
241	WRQ	y		X																general cracking	1
242	WRQ	n																			0
243	WRQ	n																			0
244	WRQ	y			X		X											X		interior and exterior cracks, water damage	3
245	WRQ	y		X														X		water leaks and cracking	2

246	WRQ	n																			0
247	WRQ	y		X					X											concrete cracking, interior cracking	2
248	WRQ	y	X																	general damage	1
249	WRQ	y										X								tiles popped	1
250	WRQ	y																	X	doors no longer shut properly	1
251	WRQ	y	X																	general damage	1
252	WRQ	y		X						X									X	cracking, sinkholes, sidewalk cracking	3
253	WRQ	y	X																	general damage	1
254	WRQ	y		X								X								general cracking, tiles	2
255	WRQ	y		X																general cracking	1
256	WRQ	y	X																	general damage	1
257	WRQ	y		X																general cracking	1
258	WRQ	y										X								floor cracking	1
259	WRQ	y						X				X								cracks in floor and foundation	2
260	WRQ	n																			0
261	WRQ	y	X																	general damage	1
262	WRQ	y	X																	general damage	1
263	WRQ	y					X	X										X	X	settling, masonry shifted, concrete blocks shifted, stucco separation, water leaks	4
264	WRQ	y	X																	general damage	1
265	WRQ	y			X	X								X						pool cracks, ceilings cracked at all joints, wall cracks	3
266	WRQ	y	X																	general damage	1
267	WRQ	y	X																	general damage	1
268	WRQ	y			X							X		X						cracks on walls, floor tiles, pool	3
269	WRQ	y	X																	general damage	1
270	WRQ	y			X		X						X	X			X			pool cracks, broken pool pipes, broken stucco witnessed at time of blast, wall and patio cracks	5
271	WRQ	y					X					X		X						pool cracks, floor tile cracks, exterior wall cracks	3
272	WRQ	n																			0
273	WRQ	n																			0
274	WRQ	n																			0
275	WRQ	n																			0
276	WRQ	y		X																crack below window	1
277	WRQ	n																			0
278	WRQ	y														X				picture frame fell broke	1
279	WRQ	n																			0

280	WRQ	n																			0
281	WRQ	y			X							X	X	X						pool cracks, patio, interior flooring, interior wall	4
282	WRQ	n																			0
283	WRQ	n																			0
284	WRQ	n																			0
285	WRQ	n																			0
286	WRQ	n																			0
287	WRQ	n																			0
288	WRQ	y												X						pool deck cracks	1
289	WRQ	y													X					roof damage	1
290	WRQ	y										X								tile floor cracking	1
291	WRQ	n																			0
292	WRQ	n																			0
293	WRQ	y	X																	general damage	1
294	WRQ	y										X								bathroom tiles detached from wall	1
295	WRQ	n																			0
296	WRQ	y					X					X							X	sliding doors rattle, recessed lighting detached from ceiling, tiles and exterior walls cracked	3
297	WRQ	n																			0
298	WRQ	y														X				pictures fell off wall	1
299	WRQ	n																			0
300	WRQ	n																			0
301	WRQ	y	X																	general damage	1
302	WRQ	n																			0
303	WRQ	n																			0
304	WRQ	n																			0
305	WRQ	n																			0
306	WRQ	n																			0
307	WRQ	n																			0
308	WRQ	n																			0
309	WRQ	n																			0
310	WRQ	n																			0
311	WRQ	y	X																	general damage	1
312	WRQ	y				X	X							X	X					crack on pool deck, exterior walls, interior ceiling, loose roof tiles	4
313	WRQ	y		X															X	general cracking, building sinking	2
314	WRQ	y																	X	ac and water heater replacement	1

315	WRQ	y		X												X				picture frames fell off walls, general cracking	2
316	WRQ	y	X																	general damage	1
317	WRQ	y		X										X						pool deck cracks, general cracking	2
318	WRQ	y		X																general cracking	1
319	WRQ	y														X				books fell of bookcase	1
320	WRQ	n																			0
321	WRQ	n																			0
322	WRQ	y					X					X								exterior cracking, floor tiles lifting	2
323	WRQ	y	X																	general damage	1
324	WRQ	n																			0
325	WRQ	n																			0
326	WRQ	n																			0
327	WRQ	n																			0
328	WRQ	n																			0
329	WRQ	n																			0
330	WRQ	n																			0
331	WRQ	n																			0
332	WRQ	n																			0
333	WRQ	y			X							X		X					X	cracked windows, tiles, walls, pool deck	4
334	WRQ	n																			0
335	WRQ	y			X							X							X	cracked tiles, walls, damaged landscaping	3
336	WRQ	n																			0
337	WRQ	y	X																	general damage	1
338	WRQ	n																			0
339	WRQ	n																			0
340	WRQ	y		X			X													cracked facia, general cracking	2
341	WRQ	y			X	X														cracks on walls and ceiling	2
342	WRQ	y																	X	cracks on crown molding	1
343	WRQ	y		X																general cracking	1
344	WRQ	y						X												foundation cracking	1
345	WRQ	y		X																general cracking	1
346	WRQ	n																			0
347	WRQ	y												X						pool cracks	1
348	WRQ	y					X					X								tile floor cracking, plaster cracking	2
349	WRQ	y	X																	general damage	1
350	WRQ	y			X						X					X				wall cracks, fissures on garage cement, pictures fallen off walls	3
351	WRQ	y	X																	general damage	1

352	WRQ	n																			0
353	WRQ	n																			0
354	WRQ	n																			0
355	WRQ	y		X																general cracking	1
356	WRQ	n																			0
357	WRQ	y		X																interior cracking	1
358	WRQ	n																			0
359	WRQ	y	X																	general damage	1
360	WRQ	y												X						pool cracks	1
361	WRQ	n																			0
Total Occurances			28	25	33	12	21	7	13	4	9	27	8	16	6	14	7	7	21		
% of Total Occurances			11%	10%	13%	5%	8%	3%	5%	2%	3%	10%	3%	6%	2%	5%	3%	3%	8%		
% Occurred in Complaints			19%	17%	22%	8%	14%	5%	9%	3%	6%	18%	5%	11%	4%	9%	5%	5%	14%		

APPENDIX E

RESPEC INSTRUMENTATION

APPENDIX E: RESPEC INSTRUMENTATION

The following section summarizes the locations and instrumentation setup used by RESPEC to independently monitor the blast vibrations and crack response at residences near the construction materials mines.

E.1 INSTRUMENTATION SETUP

Saul's Seismic was subcontracted to provide seismograph and crack monitoring services as a third-party operator under RESPEC's supervision. Nomis Mini-Supergraph seismographs were used for vibration monitoring. Geokon 4420-1-25 millimeters (mm), crack monitors were placed at select locations.

E.2 SEISMOGRAPH SETUP

Seismographs were set up according to the *ISEE Field Practice Guidelines for Blasting Seismographs* [ISEE, 2015]. Note that, in most cases, the regional FSFM inspectors were on hand to witness the seismograph setups and crack monitor installations.

The geophones were placed within 10 feet of each structure that was monitored. Sensors were spiked (Figure E-1) and placed in soil or bonded to a concrete pad if no soil was present that could be coupled to the geophone. The geophones were placed in holes that were no less than three times the height of the sensor or on bedrock if the topsoil was shallower than bedrock. Figure E-2 shows a hole that was dug for one of the geophones used in this study. Once dug, the soil at the bottom of the hole was compacted. Figure E-3 shows the placement of a spiked geophone at one of the seismograph locations. The geophones were pointed toward the general area of blasting. RESPEC was not privy to each blast location before each blast event, so the geophones could not be directed toward each blast. After each geophone was placed, soil was placed into the hole and tamped in lifts, which helped couple the seismograph. Figure E-4 shows the soil tamping process.

The final step of the seismograph setup is connecting the equipment together. Figure E-5 shows the wiring process while one of the seismographs was installed. Figure E-6 shows the final configurations of one of the installed seismographs. The seismographs were programmed to record 4,096 samples per second for 20 seconds. The ISEE recommends a minimum of 1,000 samples per second. RESPEC chose a higher sample rate so that the waveform data collected by the seismographs was more detailed.

E.3 CRACK MONITOR SETUP

Crack monitors were set up at residences that allowed RESPEC to place them. Crack monitors were mounted on visible cracks by using mechanical anchor bolts. The first step of crack monitor installation is drilling holes on either side of the selected visible crack to mount the mechanical anchor bolts, as illustrated in Figure E-7. Next, the bolts were mounted in the holes; an example is shown in Figure E-8. Finally, the crack monitor was mounted to the bolts as shown in Figure E-9 and connected to the data acquisition unit which was accessed remotely to download data during the study. Figure E-10 displays a completed crack monitor installation. The crack monitor setup was able to sample the relative crack width at 10 minute intervals. The data were used to determine the relative crack width before and after each blast event.

Figure E-1. Installing Spikes on a Geophone.

Figure E-2. Hole That Was Dug for Geophone Placement.

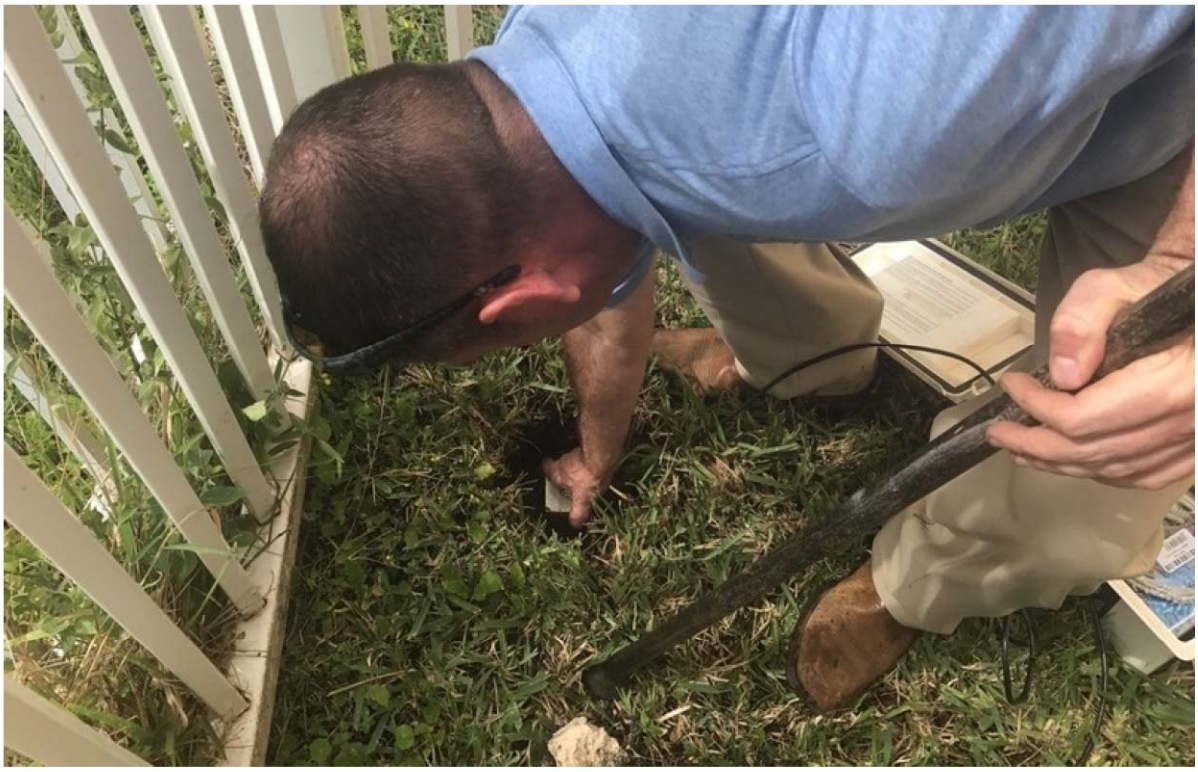


Figure E-3. Placing a Geophone.

Figure E-4. Tamping Soil on Top of a Geophone.

Figure E-5. Wiring a Seismograph Setup for Remote Monitoring. Note that the geophone in this photograph was bonded to the concrete because the yard did not have soil capable of coupling a geophone.

Figure E-6. Example of Completed Seismograph Installation.

Figure E-7. Drilling Holes to Mount the Mechanical Anchor Bolts.

Figure E-8. Mechanical Anchor Bolts Mounted on Either Side of a Visible Crack.

Figure E-9. Crack Monitor Mounted Over Visible Crack.

Figure E-10. Example of Completed Crack Monitor Installation.

APPENDIX F

RESPEC DATA SUMMARY

Branford Quarry East Seismograph

Sesmograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Unit Calibration	Comments
Branford Quarry East Seismograph	12805	28	11:35	2/21/2018	0.023	20.2		0.030	15.8		0.023	31.0		99.0	4.5	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	29	11:40	2/21/2018	0.020	17.5		0.015	15.7		0.015	28.8		106.0	2.5	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	68	11:36	3/8/2018	0.018	18.7		0.013	13.2		0.015	33.0		108.0	10.0	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	137	11:22	3/26/2018	0.343	7.3	2.2	0.120	14.9	2.2	0.283	9.3	2.0	115.0	3.9	0.01	117	12/13/2017	
Branford Quarry East Seismograph	12805	142	12:42	3/27/2018	0.025	16.5		0.040	15.3		0.020	23.8		99.0	1.3	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	143	12:56	3/27/2018	0.018	13.8		0.023	16.5		0.015	18.4		99.0	0.6	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	150	11:16	3/29/2018	0.173	8.7	3.0	0.083	18.6	3.0	0.160	18.7	3.0	116.0	7.5	0.01	117	12/13/2017	
Branford Quarry East Seismograph	12805	161	11:51	4/3/2018	0.020	22.2		0.020	17.9		0.018	29.6		108.0	8.6	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	197	13:06	4/16/2018	0.140	14.0	3.0	0.100	13.4	2.3	0.123	23.2	2.2	113.0	6.2	0.01	117	12/13/2017	
Branford Quarry East Seismograph	12805	198	13:11	4/16/2018	0.035	18.2		0.025	13.6		0.028	28.0		107.0	23.8	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	199	14:02	4/16/2018	0.020	17.3		0.023	15.5		0.018	28.0		102.0	12.0	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	200	14:13	4/16/2018	0.028	14.7		0.030	13.8		0.023	25.9		106.0	15.3	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	234	11:38	4/30/2018	0.180	10.6	3.0	0.085	14.8	2.2	0.163	29.2	2.2	111.0	1.4	0.01	117	12/13/2017	
Branford Quarry East Seismograph	12805	238	11:40	5/1/2018	0.028	22.2		0.015	16.0		0.025	28.8		102.0	4.3	0.01	117	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry East Seismograph	12805	246	12:00	5/4/2018	0.095	10.0	3.3	0.058	13.3	3.0	0.083	30.5	2.3	110.0	3.0	0.01	117	12/13/2017	
Branford Quarry East Seismograph	12805	258	11:09	5/8/2017	0.070	9.5	3.2	0.078	20.0	3.1	0.103	28.8	2.7	109.0	7.5	0.01	117	12/13/2017	

Branford Quarry North Seismograph

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Unit Calibration	Comments
Branford Quarry North Seismograph	12939	34	11:34	2/21/2018	0.033	22.5	4.1	0.048	22.0	3.7	0.030	31.5	2.8	104.0	5.5	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	35	11:39	2/21/2018	0.025	8.9		0.020	25.2		0.018	38.6		118.0	93.0	0.01	117	12/6/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry North Seismograph	12939	136	11:35	3/8/2018	0.030	22.2		0.023	27.3		0.020	37.2		107.0	10.3	0.01	117	12/6/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Branford Quarry North Seismograph	12939	462	11:22	3/26/2018	0.188	21.5	3.5	0.123	17.9	2.8	0.170	44.5	2.5	117.0	3.4	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	465	12:42	3/27/2018	0.033	5.9	4.5	0.045	17.2	3.3	0.023	17.2	2.2	104.0	1.9	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	503	11:16	3/29/2018	0.163	20.0	2.6	0.105	22.5	2.0	0.083	19.5	2.1	115.0	14.6	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	566	11:51	4/3/2018	0.025	21.5	2.4	0.028	25.9	2.5	0.023	9.7	2.1	110.0	9.5	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	721	13:06	4/16/2018	0.468	24.3	1.8	0.260	25.6	1.6	0.488	30.5	1.7	116.0	5.8	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	722	13:11	4/16/2018	0.065	18.7	2.8	0.055	21.7	2.0	0.038	30.5	1.9	115.0	4.6	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	723	14:01	4/16/2018	0.028	18.1	3.5	0.033	20.0	2.9	0.023	8.3	2.4	110.0	5.7	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	725	14:13	4/16/2018	0.030	8.0	3.8	0.050	4.3	3.4	0.028	3.6	2.6	109.0	2.1	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	769	11:38	4/30/2018	0.263	13.1	2.6	0.158	20.6	2.5	0.175	35.9	1.9	114.0	5.2	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	772	11:40	5/1/2018	0.028	29.6	2.3	0.025	34.1	2.1	0.023	36.5	1.7	108.0	5.0	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	779	12:00	5/4/2018	0.130	7.9	2.6	0.090	34.1	2.0	0.193	32.0	2.0	118.0	3.8	0.01	117	12/6/2017	
Branford Quarry North Seismograph	12939	788	11:08	5/8/2018	0.275	7.9	3.3	0.138	29.2	2.6	0.195	6.2	2.3	119.0	2.6	0.01	117	12/6/2017	

West Lakes Mine Southwest Seismograph

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mc (dB)	Unit Calibration	Comments
West Lakes Mine Southwest Seismograph	12920	6	9:16	2/14/2018	0.043	13.8	14.3	0.038	1.8	11.5	0.035	1.8	12.7	101.9	11.9	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	8	9:15	2/15/2018	0.045	7.7	11.2	0.045	1.7	10.0	0.048	2.0	10.0	100.0	1.9	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	10	9:42	2/16/2018	0.055	7.5	8.7	0.040	1.6	9.9	0.055	2.1	12.8	99.0	1.1	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	14	9:31	2/19/2018	0.048	8.0	8.5	0.025	4.8	11.6	0.033	2.3	10.5	99.0	1.6	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	23	10:52	2/26/2018	0.040	23.8	8.1	0.030	8.9	13.3	0.065	28.8	15.0	100.0	16.7	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	25	15:19	2/27/2018	0.053	4.4	12.1	0.045	2.0	13.5	0.068	16.7	14.5	100.0	32	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	35	11:10	3/6/2018	0.020	7.8		0.013	6.3		0.013	24.6		96.0	0.7	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	39	10:34	3/8/2018	0.020	24.0		0.013	14.6		0.015	28.4		100.0	8.6	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	42	15:17	3/9/2018	0.023	15.5		0.013	1.7		0.013	30.1		96.0	9.7	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	55	10:27	3/19/2018	0.015	15.1		0.013	1.9		0.015	22.7		96.0	0.9	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	59	10:23	3/22/2018	0.018	21.3		0.013	19.3		0.015	31.0		111.0	6.9	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	61	14:39	3/23/2018	0.025	16.9	10.6	0.015	1.6	11.4	0.023	2.1	11.5	98.0	9.0	0.01	120	1/12/2018	
West Lakes Mine Southwest Seismograph	12920	66	11:09	3/27/2018	0.023	20.0		0.015	1.2		0.018	2.5		102.0	1.7	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	75	11:28	4/2/2018	0.025	19.5		0.013	17.6		0.023	2.2		102.0	1.6	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	77	10:31	4/3/2018	0.010	8.4		0.013	8.2		0.005			96.0	2.2	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	79	11:46	4/4/2018	0.023	21.5		0.013	19.6		0.020	2.5		102.0	1.6	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
West Lakes Mine Southwest Seismograph	12920	105	10:47	4/24/2018	0.013	2.1		0.015	1.7		0.015	1.9		98.0	1.7	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated

White Rock Quarries East Seismograph

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Unit Calibration	Comments
White Rock Quarries East Seismograph	11131	8	13:15	2/13/2018	0.078	9.0	13.5	0.050	1.5	8.5	0.108	27.6	14.5	114.0	2.7	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	11	13:36	2/14/2018	0.025	5.8		0.018	7.3		0.025	28.8		94.0	8.5	0.01	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	148	11:29	2/16/2018	0.045	11.3	14.0	0.033	5.0	9.6	0.063	34.1	15.0	99.0	4.7	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	156	13:59	2/19/2018	0.093	19.6		0.055	8.8		0.105	33.5		100.0	13.8	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	158	13:15	2/20/2018	0.040	11.1		0.020	16.7		0.060	28.8		94.0	11.0	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	161	13:31	2/22/2018	0.083	20.0	13.0	0.053	15.1	9.8	0.115	24.6	12.6	101.0	13.2	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	174	13:59	2/26/2018	0.078	18.2	12.5	0.048	12.8	8.5	0.115	19.5	13.5	102.0	3.7	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	202	14:00	3/5/2018	0.075	9.9	12.0	0.043	7.0	10.7	0.085	24.3	14.3	99.0	8.0	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	206	11:36	3/7/2018	0.023	15.6		0.020	9.4		0.040	33.5		102.0	3.9	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	210	13:15	3/9/2018	0.068	4.4	12.3	0.050	6.9	11.0	0.083	3.2	13.6	98.0	10.3	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	227	14:19	3/19/2018	0.083	10.6	12.0	0.053	8.2	10.5	0.095	25.9	12.5	100.0	14.8	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	229	11:45	3/20/2018	0.045	19.3	14.9	0.035	17.6	12.2	0.080	23.2	16.1	103.0	5.4	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	234	13:15	3/23/2018	0.098	9.9	10.5	0.073	8.9	9.5	0.110	26.2	12.0	107.0	4.0	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	242	14:30	3/26/2018	0.053	5.8		0.038	8.9		0.068	4.3		99.0	6.9	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	251	11:30	3/30/2018	0.053	9.7		0.033	12.7		0.070	4.1		100.0	4.7	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	383	15:02	4/3/2018	0.055	14.3		0.040	9.2		0.060	22.0		100.0	4.9	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	386	14:00	4/5/2018	0.040	16.5		0.030	5.4		0.043	20.4		99.0	2.0	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	400	13:47	4/9/2018	0.013	7.5		0.008			0.030	40.9		94.0	3.8	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	404	14:00	4/10/2018	0.053	15.6		0.038	6.6		0.048	18.4		99.0	2.7	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	470	13:30	4/12/2018	0.048	16.7	14.0	0.040	7.4	11.0	0.063	24.9	15.1	98.0	1.7	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	473	11:31	4/13/2018	0.035	8.6	16.6	0.025	1.4	14.9	0.043	1.8	16.6	100.0	1.3	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	491	13:30	4/17/2018	0.048	15.5		0.028	5.8		0.063	23.5		99.0	3.9	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	494	13:30	4/19/2018	0.033	12.4		0.023	6.4		0.033	24.6		96.0	2.1	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	507	14:33	4/23/2018	0.043	15.1		0.030	8.0		0.045	14.3		98.0	2.4	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated

White Rock Quarries East Seismograph	12801	511	14:31	4/25/2018	0.035	11.5	17.3	0.025	6.3	12.0	0.043	23.2	17.5	99.0	6.1	0.02	120	1/12/2018	
White Rock Quarries East Seismograph	12801	561	15:01	4/30/2018	0.015	10.5		0.010	7.9		0.025	37.9		94.0	2.1	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	563	13:31	5/1/2018	0.055	8.5		0.028	5.8		0.028	17.2		101.0	2.7	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	566	14:31	5/2/2018	0.010	3.6		0.010	3.0		0.030	6.0		94.0	4.9	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	577	14:51	5/7/2018	0.010	4.1		0.010	3.0		0.028	40.9		94.0	1.8	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries East Seismograph	12801	581	13:32	5/8/2018	0.050	12.1		0.033	8.6		0.043	32.5		100.0	3.0	0.02	120	1/12/2018	Seismograph not capture beginning of vibration waveform, so displacement was not estimated

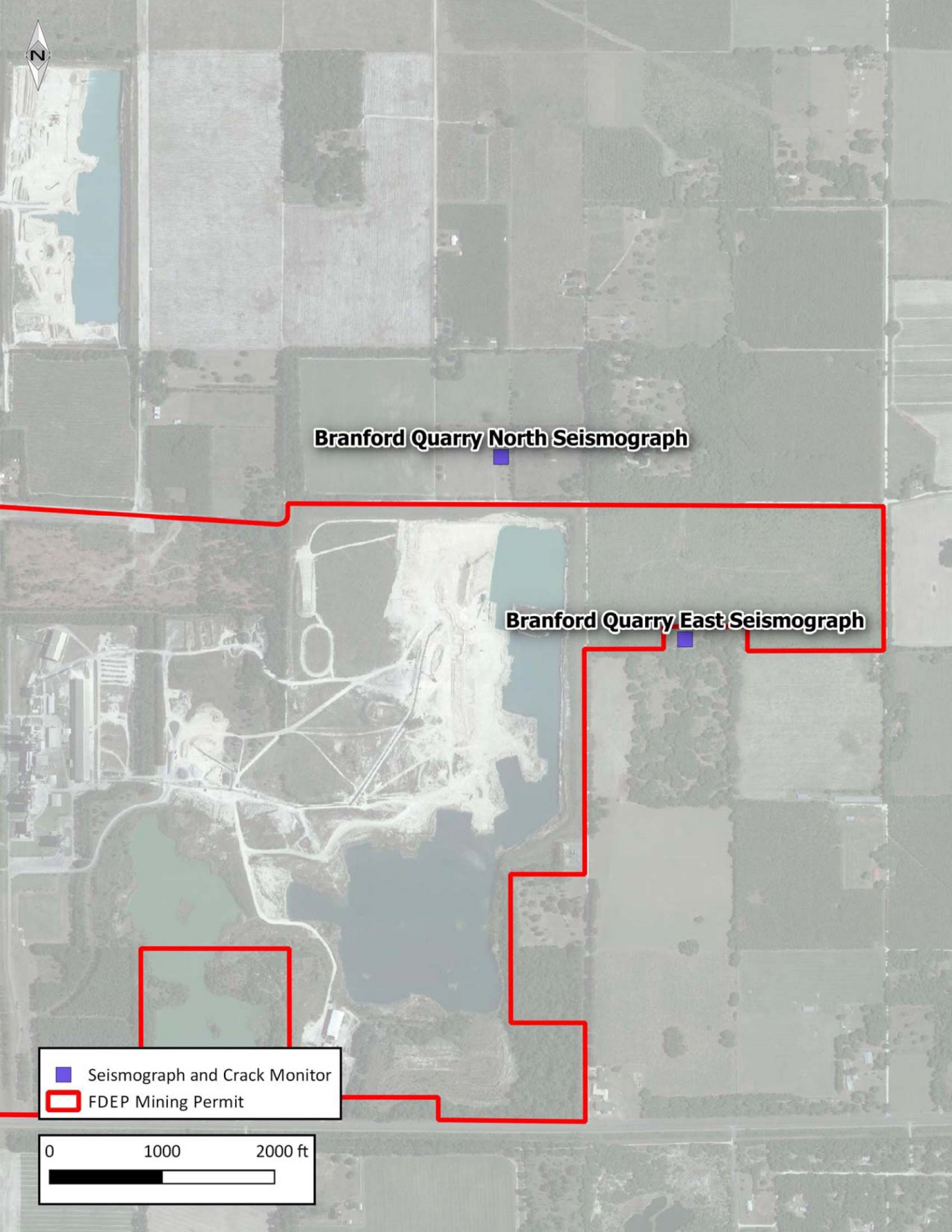
White Rock Quarries North Seismograph

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Unit Calibration	Comments
White Rock Quarries North Seismograph	13007	5	13:13	2/13/2018	0.075	9.3	13.3	0.035	8.5	6.7	0.070	1.7	16.6	112.0	8.6	0.05	120	12/13/2017	
White Rock Quarries North Seismograph	13007	9	11:29	2/16/2018	0.030	3.1		0.015			0.075	2.5		110.0	3.2	0.05	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	14	13:59	2/19/2018	0.050	13.8	11.4	0.030	6.1	6.3	0.045	9.7	16.3	107.0	4.9	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	16	13:14	2/20/2018	0.030	32.5	10.8	0.030	29.6	4.0	0.030	16.7	14.0	99.0	1.7	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	19	13:30	2/22/2018	0.045	11.9	9.7	0.045	6.2	6.8	0.060	7.2	13.3	107.0	5.2	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	24	13:59	2/26/2018	0.030	29.6	10.8	0.025	4.0	6.2	0.045	1.9	15.9	112.0	6.7	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	26	13:32	2/27/2018	0.025	24.3		0.025	2.3		0.030	15.5		98.0	2.4	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	34	13:59	3/5/2018	0.035	8.0	11.4	0.025	8.3	6.1	0.055	1.9	15.1	108.0	6.3	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	38	11:35	3/7/2018	0.020	33.0		0.025	26.5		0.025	18.2		104.0	3.2	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	44	13:15	3/9/2018	0.035	7.6		0.025	2.4		0.040	12.9		105.0	3.7	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	61	14:18	3/19/2018	0.040	17.3		0.035	6.4		0.065	7.7		108.0	9.1	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	63	11:44	3/20/2018	0.065	30.1	10.4	0.035	32.0	7.6	0.060	2.0	14.8	101.0	11.0	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	67	13:14	3/23/2018	0.090	23.8	8.8	0.050	6.2	5.2	0.080	2.3	11.4	104.0	9.8	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	71	14:29	3/26/2018	0.085	31.5	10.5	0.075	6.7	5.0	0.070	2.4	11.4	102.0	9.8	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	75	13:17	3/29/2017	0.040	28.0	10.5	0.055	5.3	3.4	0.040	11.1	14.0	104.0	6.9	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	78	11:30	3/30/2018	0.065	28.4	9.9	0.040	10.7	4.5	0.065	5.0	13.3	107.0	9.5	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	83	15:01	4/3/2018	0.100	40.1	8.2	0.050	40.9	5.5	0.080	3.6	10.5	104.0	4.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	87	13:59	4/5/2018	0.105	34.7	9.5	0.060	43.5	5.5	0.060	41.7	10.5	101.0	8.7	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	93	13:47	4/9/2018	0.100			0.100			0.025	1.7		101.0	4.9	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	95	14:00	4/10/2018	0.100	39.3	8.4	0.050	9.1	5.5	0.060	2.4	10.7	104.0	2.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	101	13:30	4/12/2018	0.070	31.0	8.6	0.040	28.8	4.8	0.075	3.6	9.7	105.0	6.1	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	103	11:30	4/13/2018	0.030	14.4		0.025	3.3		0.060	1.9		103.0	4.9	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	109	13:30	4/17/2018	0.115	39.3	10.4	0.055	28.4	4.8	0.045	19.8	11.5	101.0	11.3	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	111	13:16	4/18/2018	0.100			0.100			0.025	1.9		94.0		0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated

White Rock Quarries North Seismograph	13007	113	13:30	4/19/2018	0.070	44.5	9.8	0.045	27.3	5.3	0.045	7.1	10.8	100.0	9.0	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	120	14:32	4/23/2018	0.090	34.1	10.3	0.040	6.9	4.9	0.065	3.3	11.3	105.0	7.2	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	122	10:34	4/24/2018	0.100			0.100			0.025	1.8		98.0	68.2	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	124	14:30	4/25/2018	0.075	35.3	8.0	0.050	11.9	4.6	0.060	1.7	12.8	102.0	6.9	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	133	13:30	5/1/2018	0.035	11.6	12.0	0.030	5.5	4.7	0.035	5.1	13.9	105.0	6.5	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	135	14:31	5/2/2018	0.100			0.100			0.030	1.7		101.0	2.1	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
White Rock Quarries North Seismograph	13007	137	13:15	5/3/2018	0.040	8.1	11.0	0.025	6.6	5.5	0.055	2.9	13.3	107.0	5.8	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	144	13:31	5/8/2018	0.050	8.1	12.2	0.025	13.8	5.3	0.075	1.9	13.6	103.0	5.3	0.02	120	12/13/2017	

Krome Quarry East Seismograph

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mic (dB)	Unit Calibration	Comments
Krome Quarry East Seismograph	12759	32	10:35	3/5/2018	0.045	38.6	5.5	0.025	66.0	3.6	0.023	22.5	13.6	102.0	1.2	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	36	9:59	3/8/2018	0.040	44.5	5.5	0.035	66.0	4.0	0.023	49.9	14.0	104.0	4.4	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	67	12:33	3/13/2018	0.043	28.0	5.0	0.035	66.0	4.9	0.028	2.7	11.0	103.0	1.8	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	71	12:59	3/15/2018	0.045	51.2	5.0	0.035	2.8	4.5	0.030	2.6	14.5	102.0	2.5	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	86	10:17	3/20/2018	0.040	53.8		0.033	2.6		0.035	2.4		107.0	15.7	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Krome Quarry East Seismograph	12759	99	10:29	3/22/2018	0.023	48.7		0.015	2.9		0.015	3.0		101.0	1.2	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Krome Quarry East Seismograph	12759	106	11:30	3/26/2018	0.030	49.9	3.5	0.023	62.0	6.0	0.023	19.5	13.5	102.0	1.2	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	110	14:50	3/28/2018	0.043	39.3	4.7	0.025	60.2	5.5	0.025	24.3	12.0	98.0	1.4	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	117	10:34	4/3/2018	0.030	52.5	4.0	0.023	39.3	6.5	0.023	18.2	12.5	99.0	2.0	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	120	10:44	4/5/2018	0.043	38.6	5.0	0.023	44.5	4.9	0.023	21.3	12.0	100.0	1.7	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	126	10:31	4/10/2018	0.048	39.3	8.5	0.028	60.2	8.5	0.030	2.7	10.3	98.0	53.8	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	131	14:11	4/12/2018	0.038	40.9	5.5	0.028	68.2	5.0	0.020	24.9	13.5	99.0	2.1	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	139	10:30	4/19/2018	0.038	29.2		0.038	60.2		0.023	1.9		102.0	12.5	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated
Krome Quarry East Seismograph	12759	146	10:50	4/25/2018	0.043	30.5	13.0	0.025	8.8	9.5	0.025	17.6	15.0	109.0	9.3	0.02	120	12/13/2017	
Krome Quarry East Seismograph	12759	153	11:08	5/1/2018	0.053	37.2		0.033	12.0		0.030	24.0		100.0	1.8	0.02	120	12/13/2017	Seismograph not capture beginning of vibration waveform, so displacement was not estimated


N
Branford Quarry North Seismograph
Branford Quarry East Seismograph
Seismograph and Crack Monitor
FDEP Mining Permit
0
1000
2000 ft

Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

21-Feb-18 at 11:35:56 AM Event # 28

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.030**	**0.023**
Frequency (Hz)	**20.20**	**15.80**	**31.00**
Displacement (in)	**0.0002**	**0.0003**	**0.0001**
Acceleration (g's)	**0.0074**	**0.0077**	**0.0113**
Trigger >>> Peak	442.1	1059.3	858.2

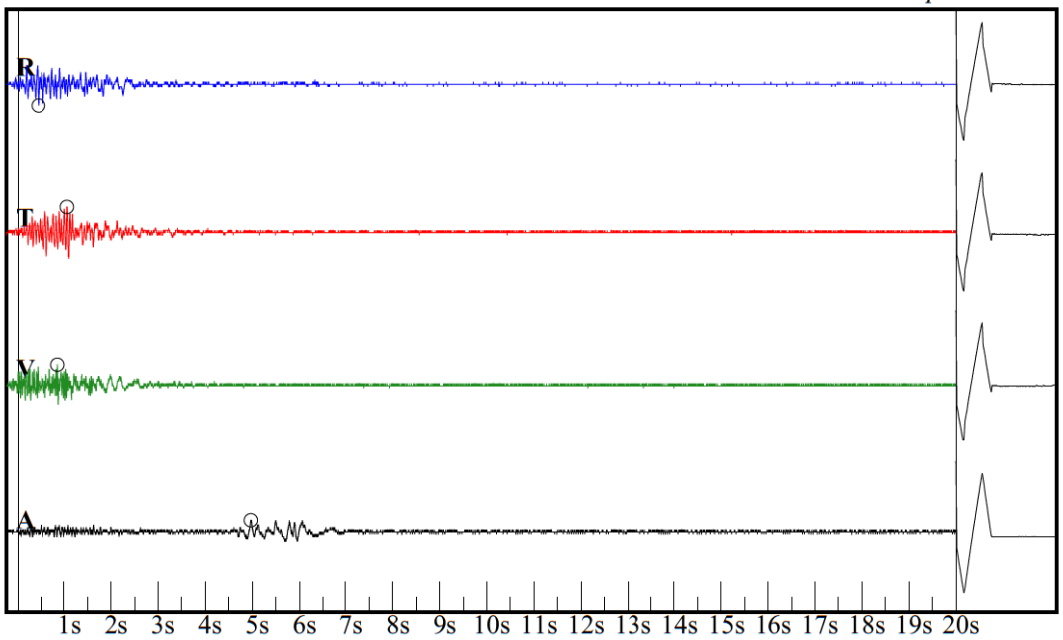
Air

Gain: 1 Trigger: 117 dBL

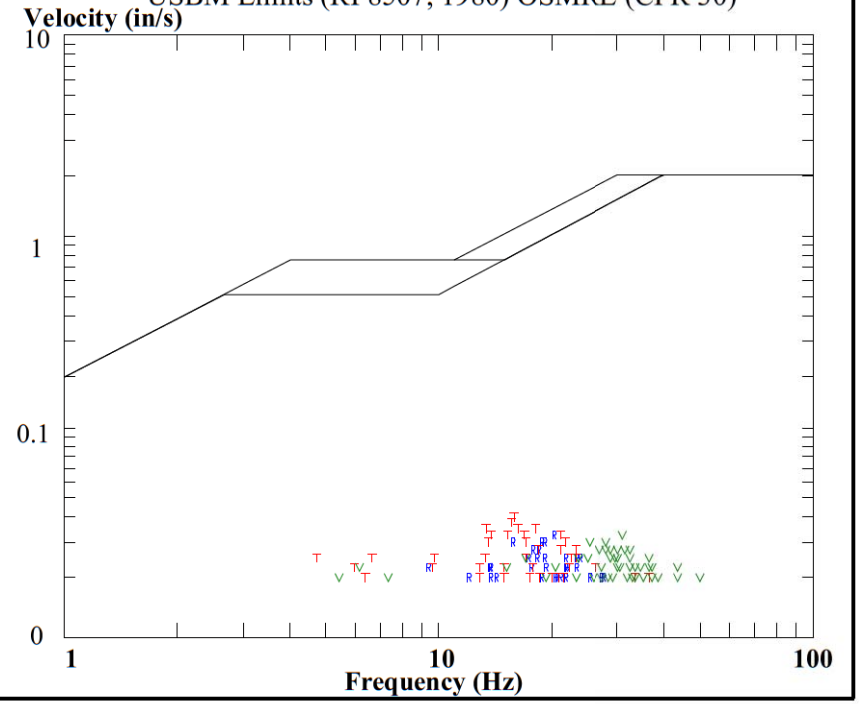
Measurement	Value	Trigger >>> Peak	
psi	.00025	4964.4	
dBL	**99**		
Hz	4.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

21-Feb-18 at 11:40:31 AM Event # 29

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.015**	**0.015**
Frequency (Hz)	**17.50**	**15.70**	**28.80**
Displacement (in)	**0.0002**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0057**	**0.0038**	**0.0070**
Trigger >>> Peak	190.2	373.8	3.4

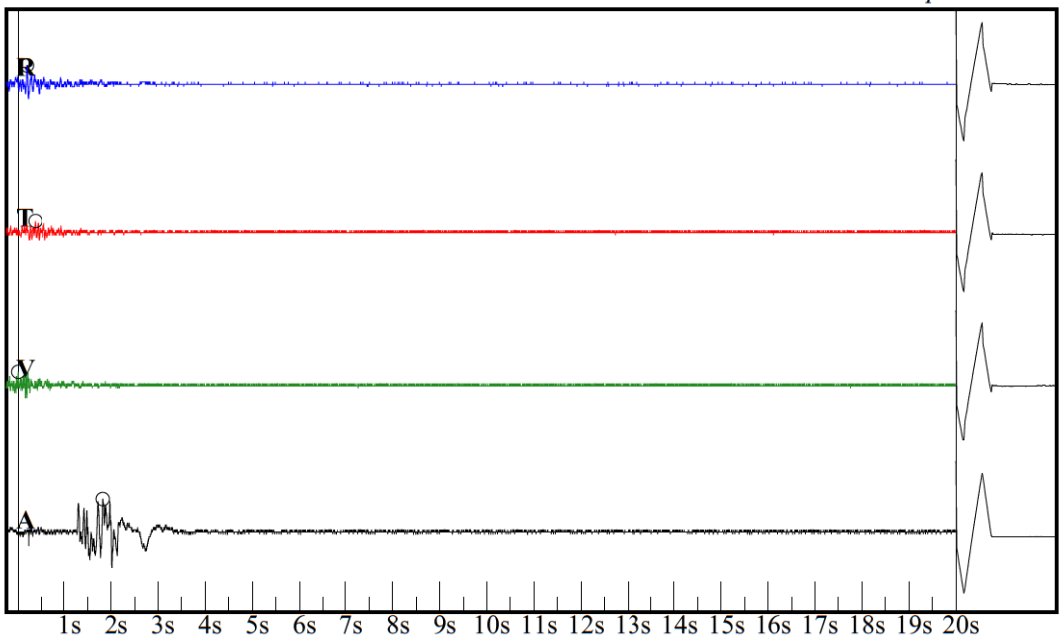
Air

Gain: 1 Trigger: 117 dBL

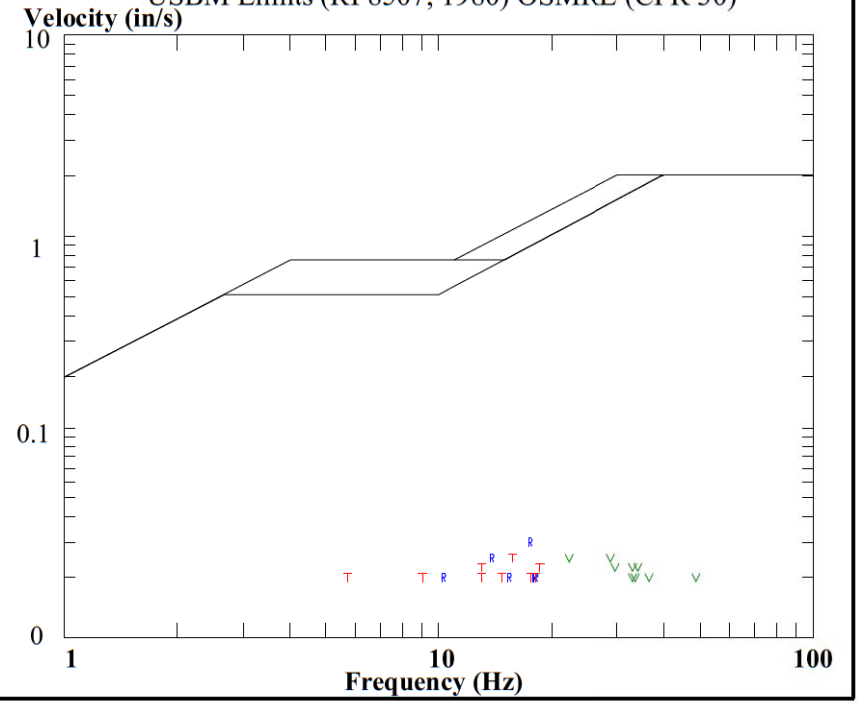
Measurement	Value	Trigger >>> Peak	
psi	.00058	1821.3	
dBL	**106**		
Hz	2.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

08-Mar-18 at 11:36:53 AM Event # 68

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.018**	**0.013**	**0.015**
Frequency (Hz)	**18.70**	**13.20**	**33.00**
Displacement (in)	**0.0001**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0053**	**0.0027**	**0.0080**
Trigger >>> Peak	617.9	522.7	64.5

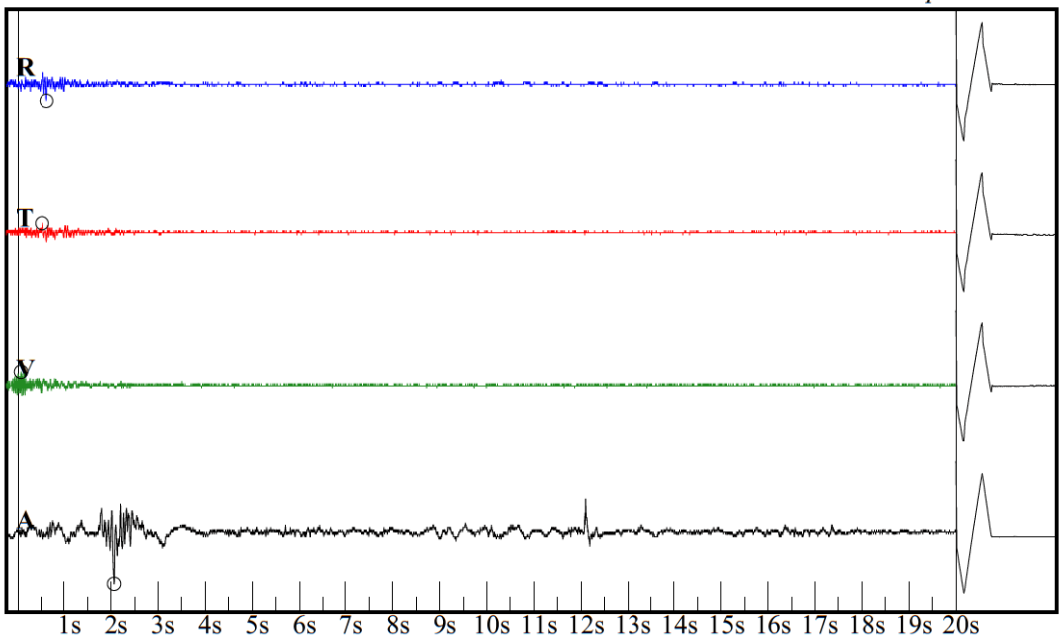
Air

Gain: 1 Trigger: 117 dBL

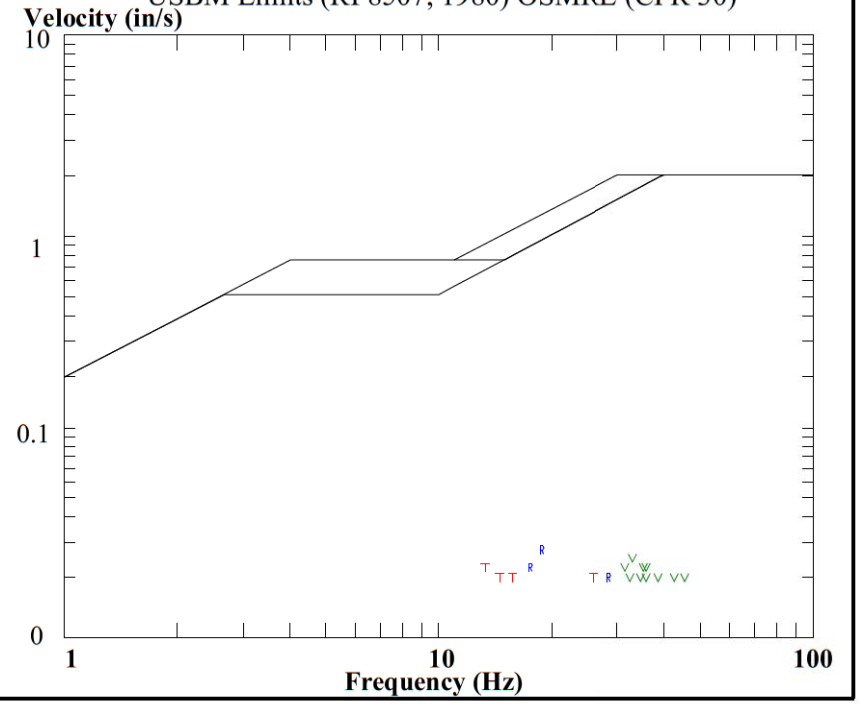
Measurement	Value	Trigger >>> Peak	
psi	.00073	2062	
dBL	**108**		
Hz	10		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

26-Mar-18 at 11:22:18 AM Event # 137

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.343**	**0.120**	**0.283**
Frequency (Hz)	**7.30**	**14.90**	**9.30**
Displacement (in)	**0.0075**	**0.0013**	**0.0048**
Acceleration (g's)	**0.0407**	**0.0291**	**0.0427**
Trigger >>> Peak	650.9	452.1	758.8

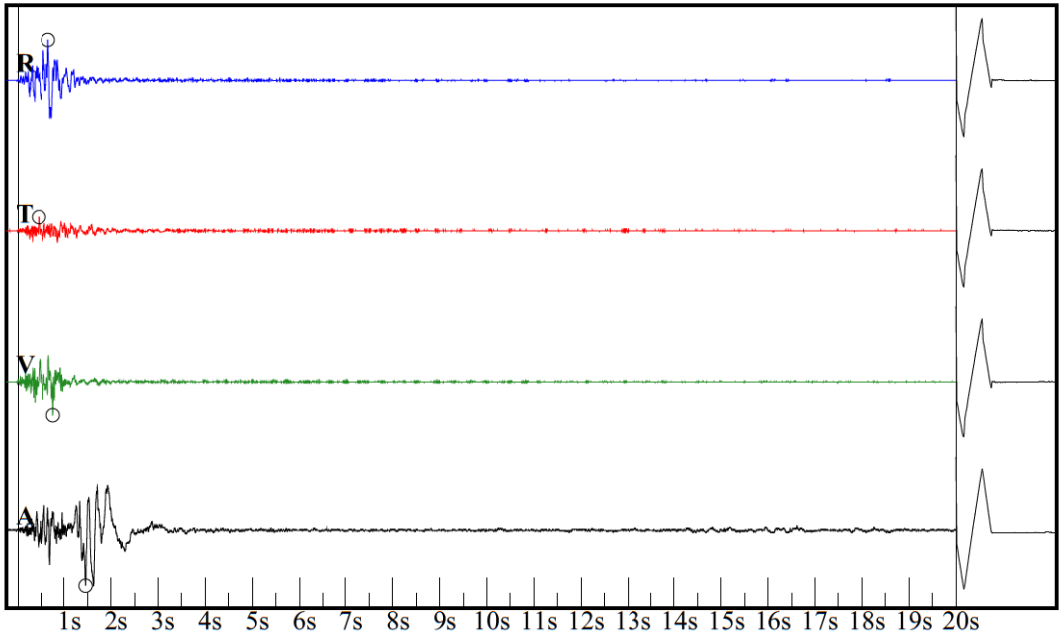
Air

Gain: 1 Trigger: 117 dBL

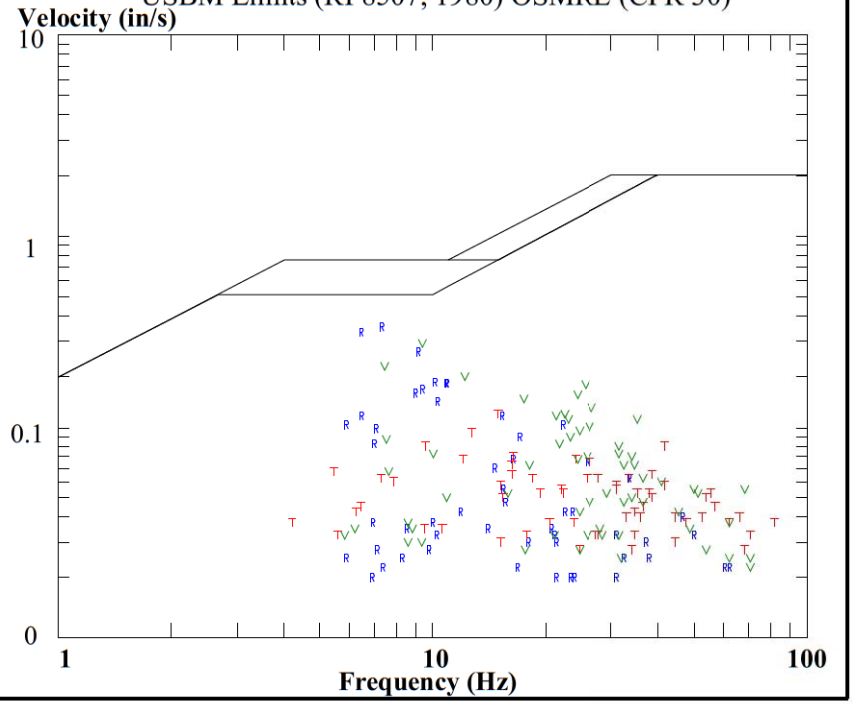
Measurement	Value	Trigger >>> Peak	
psi	.00163	1457	
dBL	**115**		
Hz	3.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.64 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

27-Mar-18 at 12:42:30 PM Event # 142

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.040**	**0.020**
Frequency (Hz)	**16.50**	**15.30**	**23.80**
Displacement (in)	**0.0002**	**0.0004**	**0.0001**
Acceleration (g's)	**0.0067**	**0.0100**	**0.0077**
Trigger >>> Peak	1100.8	969	135

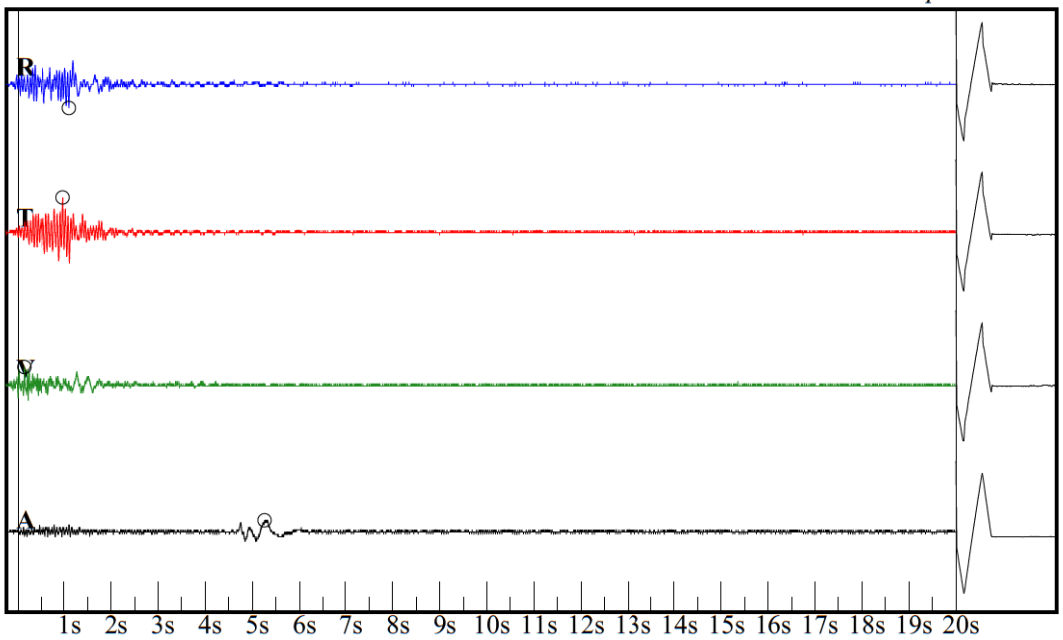
Air

Gain: 1 Trigger: 117 dBL

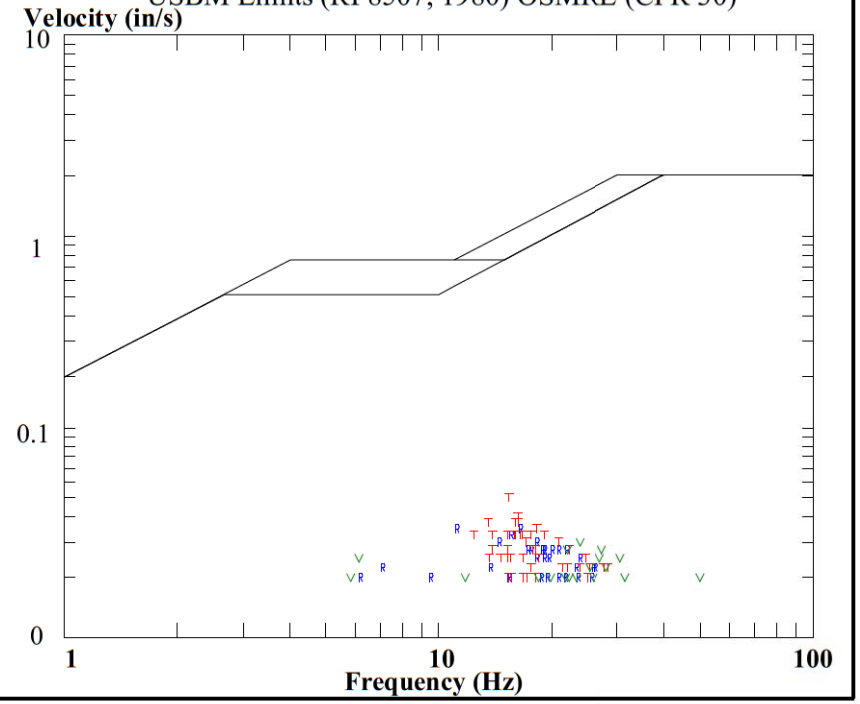
Measurement	Value	Trigger >>> Peak	
psi	.00025	5255.4	
dBL	**99**		
Hz	1.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

27-Mar-18 at 12:56:19 PM Event # 143

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.018**	**0.023**	**0.015**
Frequency (Hz)	**13.80**	**16.50**	**18.40**
Displacement (in)	**0.0002**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0039**	**0.0060**	**0.0045**
Trigger >>> Peak	403.3	588.4	261.7

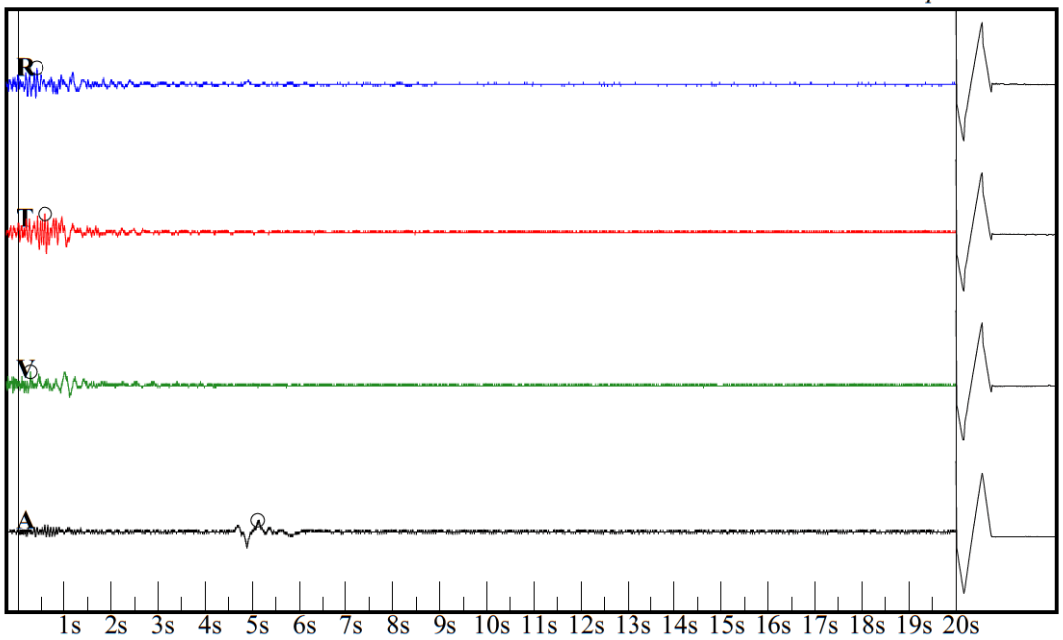
Air

Gain: 1 Trigger: 117 dBL

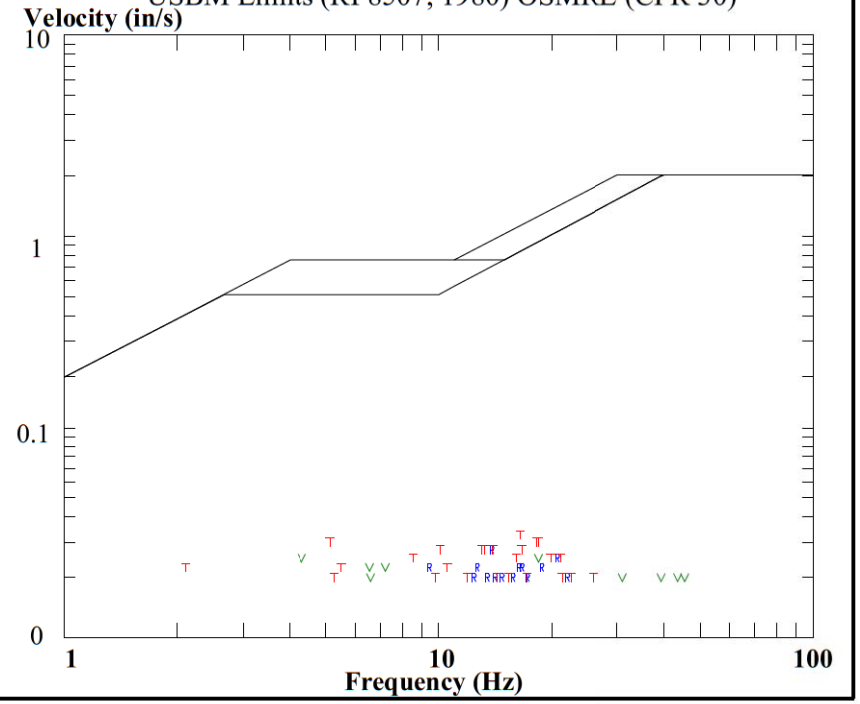
Measurement	Value	Trigger >>> Peak	
psi	.00025	5110.8	
dBL	**99**		
Hz	0.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

29-Mar-18 at 11:16:08 AM Event # 150

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.173**	**0.083**	**0.160**
Frequency (Hz)	**8.70**	**18.60**	**18.70**
Displacement (in)	**0.0032**	**0.0007**	**0.0014**
Acceleration (g's)	**0.0244**	**0.0250**	**0.0487**
Trigger >>> Peak	463.9	583.7	641.8

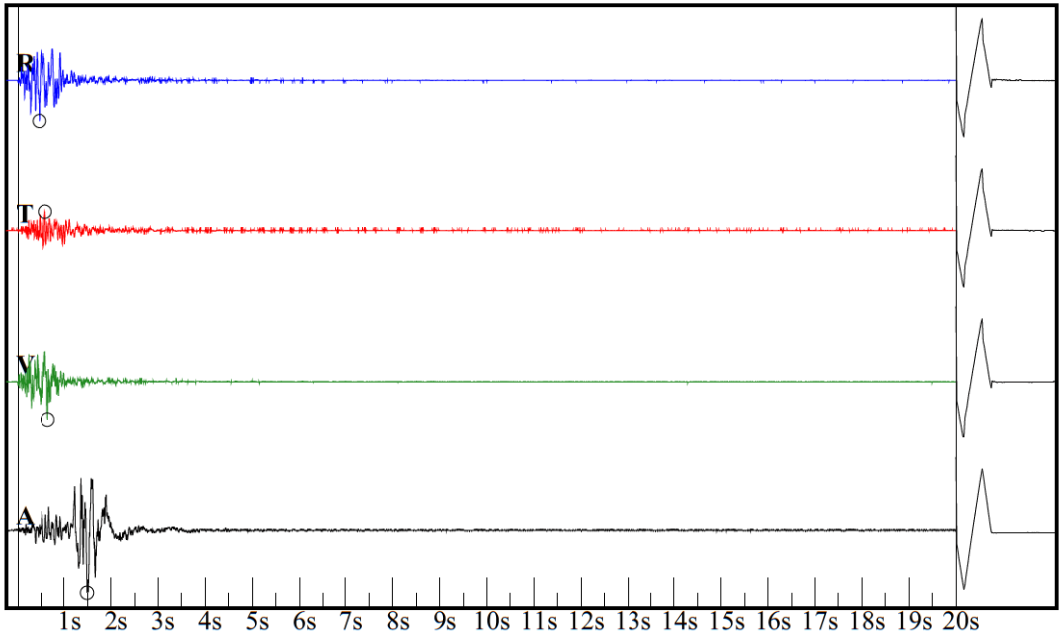
Air

Gain: 1 Trigger: 117 dBL

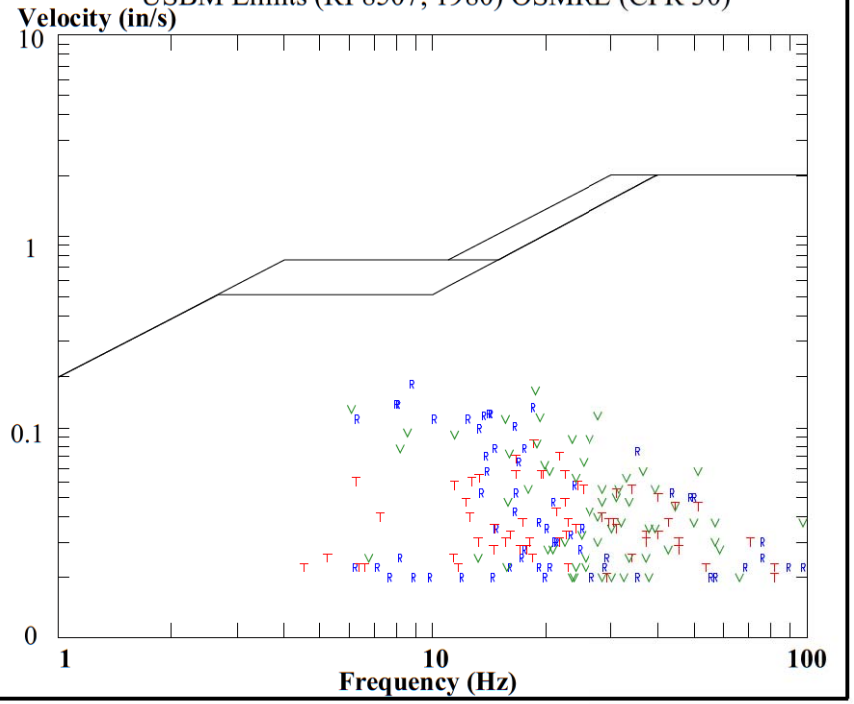
Measurement	Value	Trigger >>> Peak	
psi	.00185	1489.5	
dBL	**116**		
Hz	7.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

03-Apr-18 at 11:51:15 AM Event # 161

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.020**	**0.018**
Frequency (Hz)	**22.20**	**17.90**	**29.60**
Displacement (in)	**0.0001**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0072**	**0.0058**	**0.0084**
Trigger >>> Peak	220.9	604.5	414.1

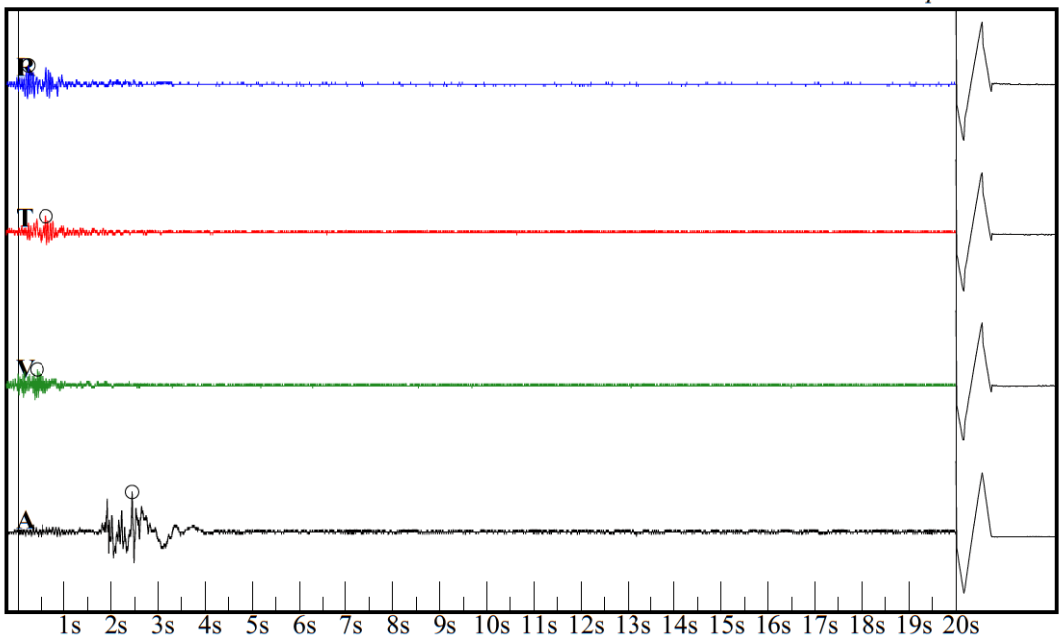
Air

Gain: 1 Trigger: 117 dBL

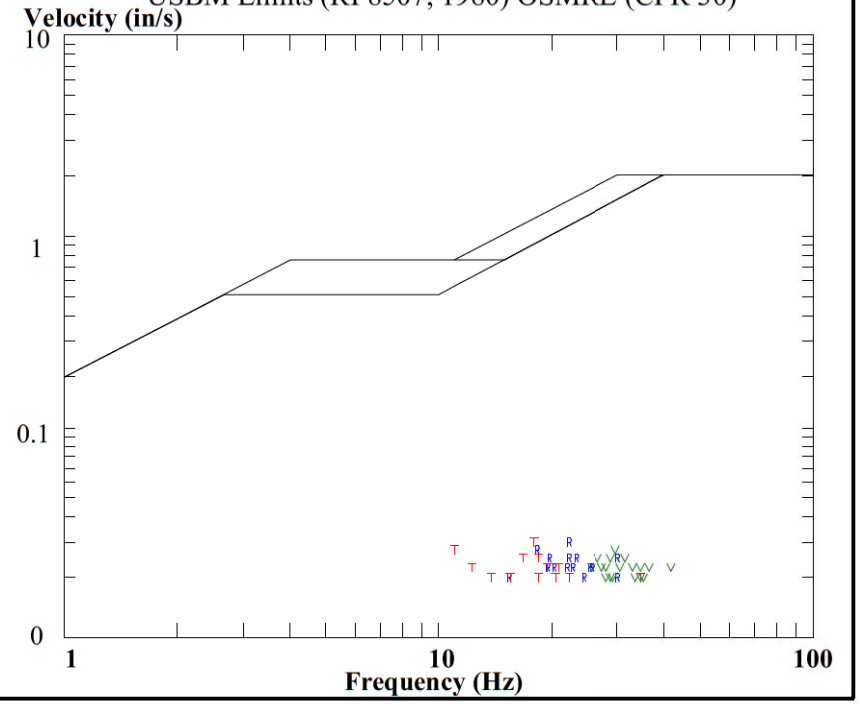
Measurement	Value	Trigger >>> Peak	
psi	.00069	2444.1	
dBL	**108**		
Hz	8.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

16-Apr-18 at 13:06:36 PM Event # 197

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.140**	**0.100**	**0.123**
Frequency (Hz)	**14.00**	**13.40**	**23.20**
Displacement (in)	**0.0016**	**0.0012**	**0.0008**
Acceleration (g's)	**0.0319**	**0.0218**	**0.0462**
Trigger >>> Peak	406.5	416.7	274.7

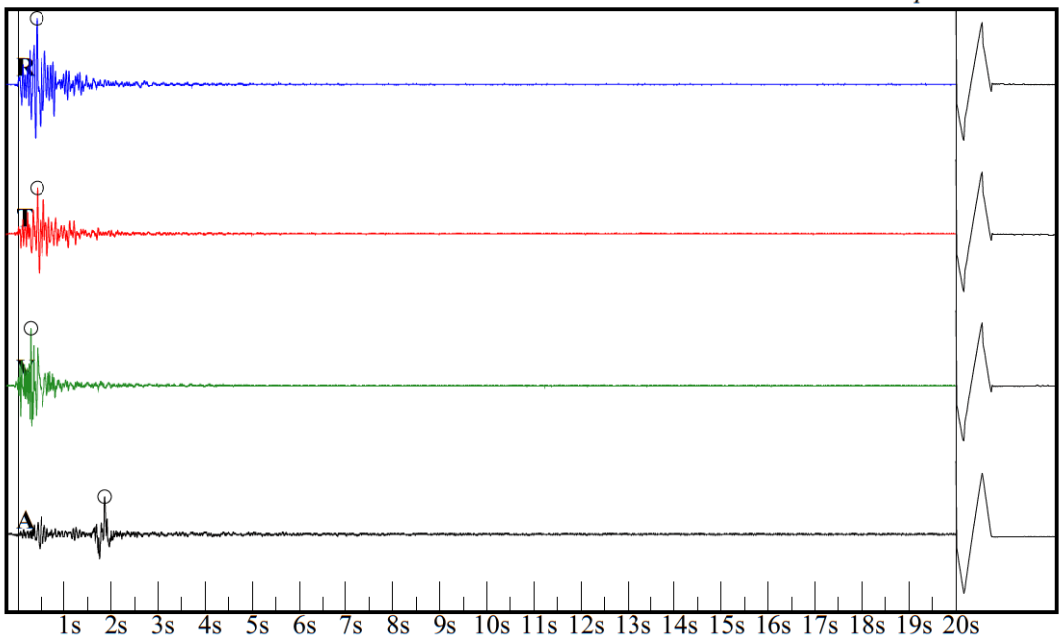
Air

Gain: 1 Trigger: 117 dBL

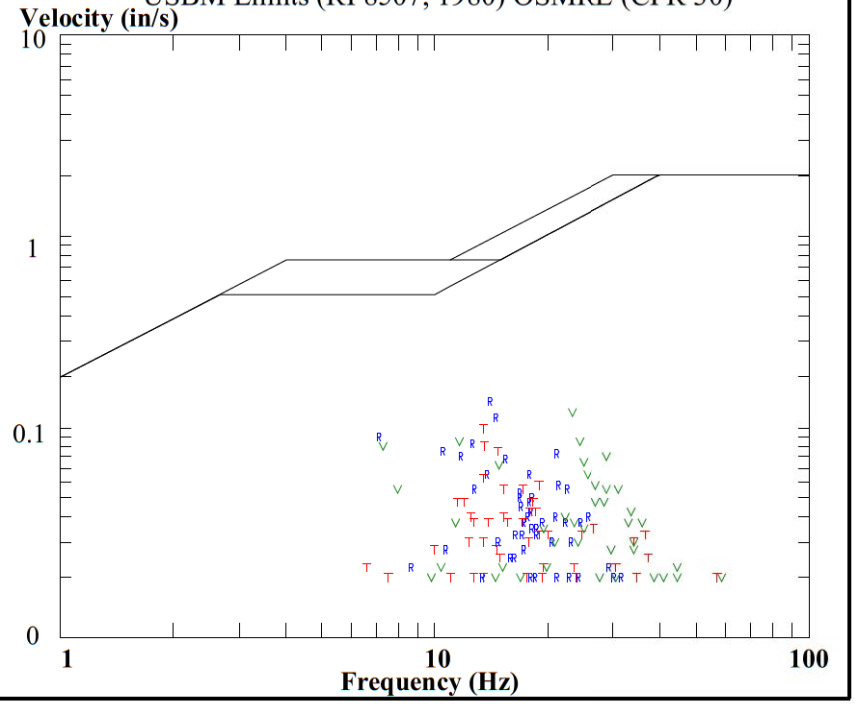
Measurement	Value	Trigger >>> Peak	
psi	.00123	1862.1	
dBL	**113**		
Hz	6.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

16-Apr-18 at 13:11:15 PM Event # 198

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.025**	**0.028**
Frequency (Hz)	**18.20**	**13.60**	**28.00**
Displacement (in)	**0.0003**	**0.0003**	**0.0002**
Acceleration (g's)	**0.0104**	**0.0055**	**0.0125**
Trigger >>> Peak	468	506.1	53

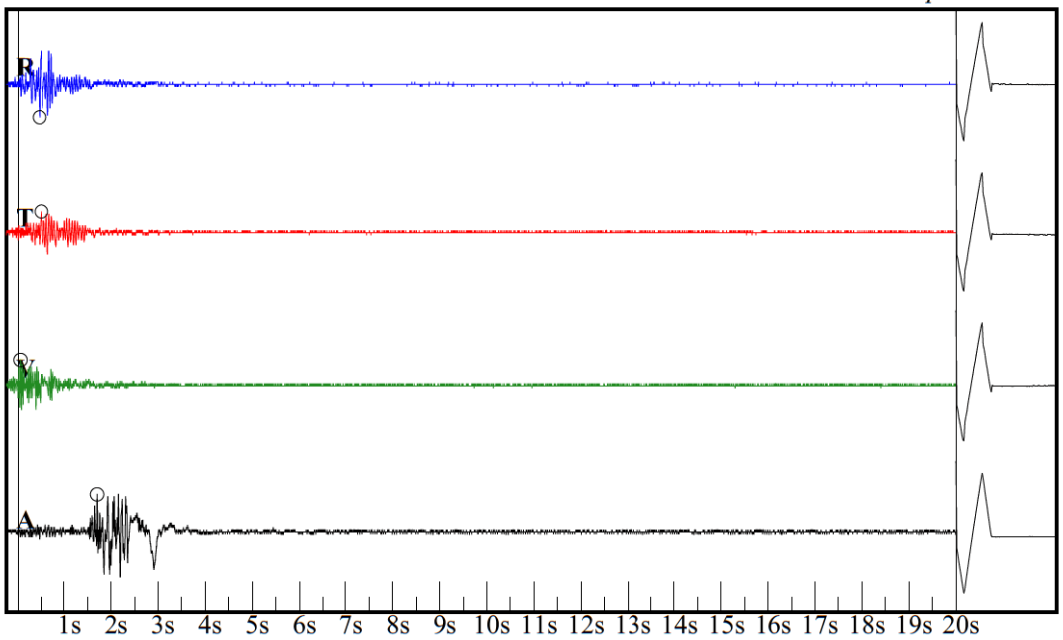
Air

Gain: 1 Trigger: 117 dBL

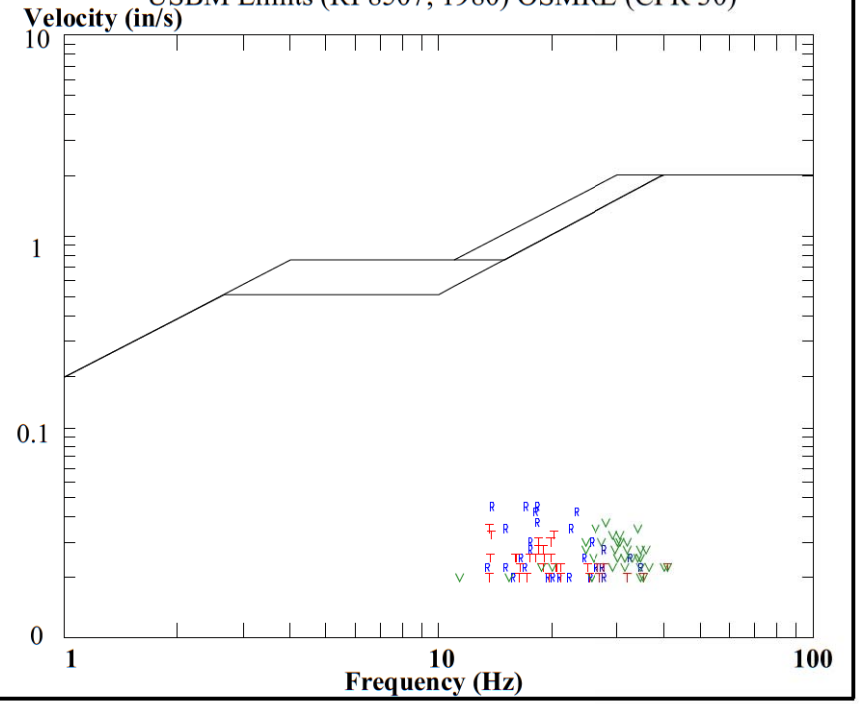
Measurement	Value	Trigger >>> Peak	
psi	.00065	1701.4	
dBL	**107**		
Hz	23.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

16-Apr-18 at 14:02:02 PM Event # 199

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.023**	**0.018**
Frequency (Hz)	**17.30**	**15.50**	**28.00**
Displacement (in)	**0.0002**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0056**	**0.0057**	**0.0080**
Trigger >>> Peak	516.6	953.6	177.5

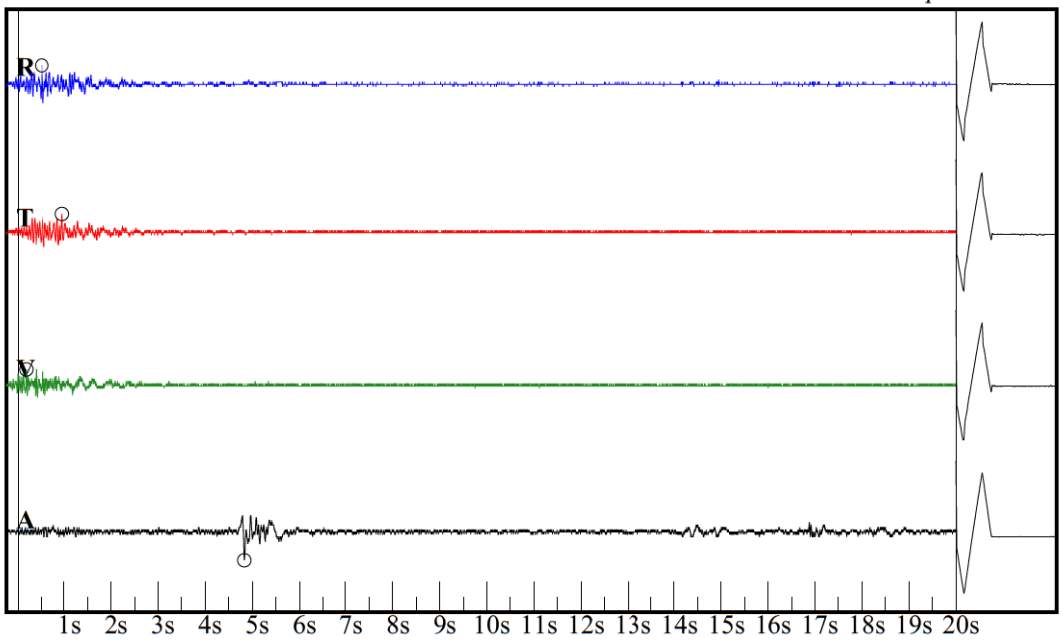
Air

Gain: 1 Trigger: 117 dBL

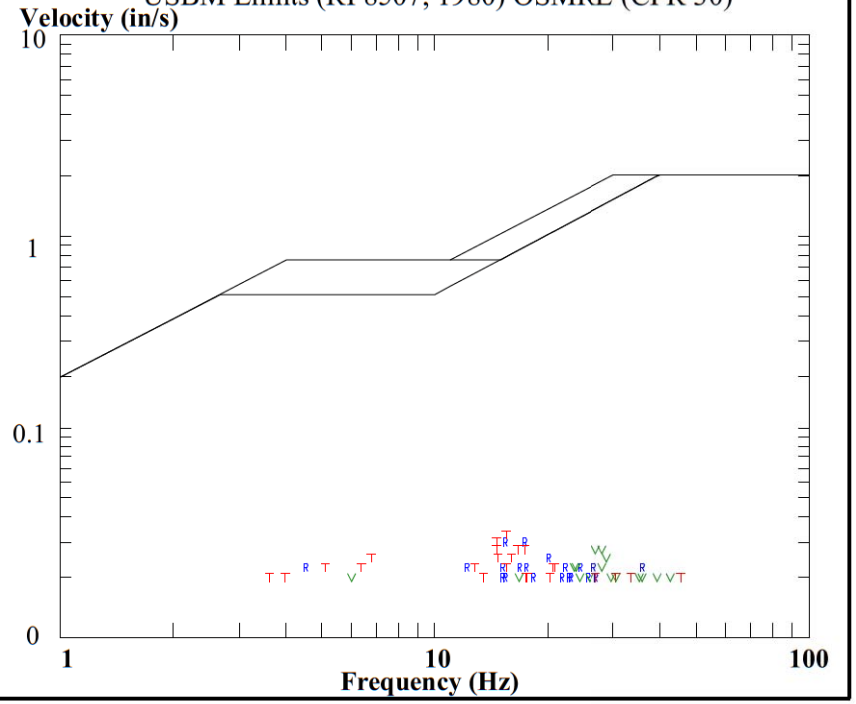
Measurement	Value	Trigger >>> Peak	
psi	.00036	4826.4	
dBL	**102**		
Hz	12		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

16-Apr-18 at 14:13:52 PM Event # 200

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.028**	**0.030**	**0.023**
Frequency (Hz)	**14.70**	**13.80**	**25.90**
Displacement (in)	**0.0003**	**0.0003**	**0.0001**
Acceleration (g's)	**0.0066**	**0.0067**	**0.0095**
Trigger >>> Peak	709.2	953.9	470.5

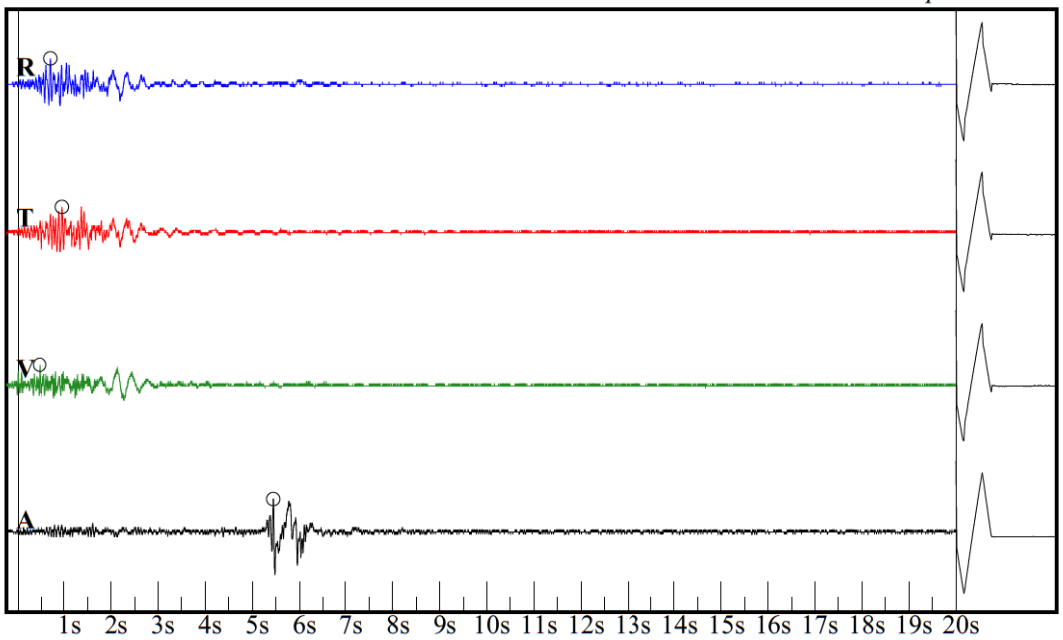
Air

Gain: 1 Trigger: 117 dBL

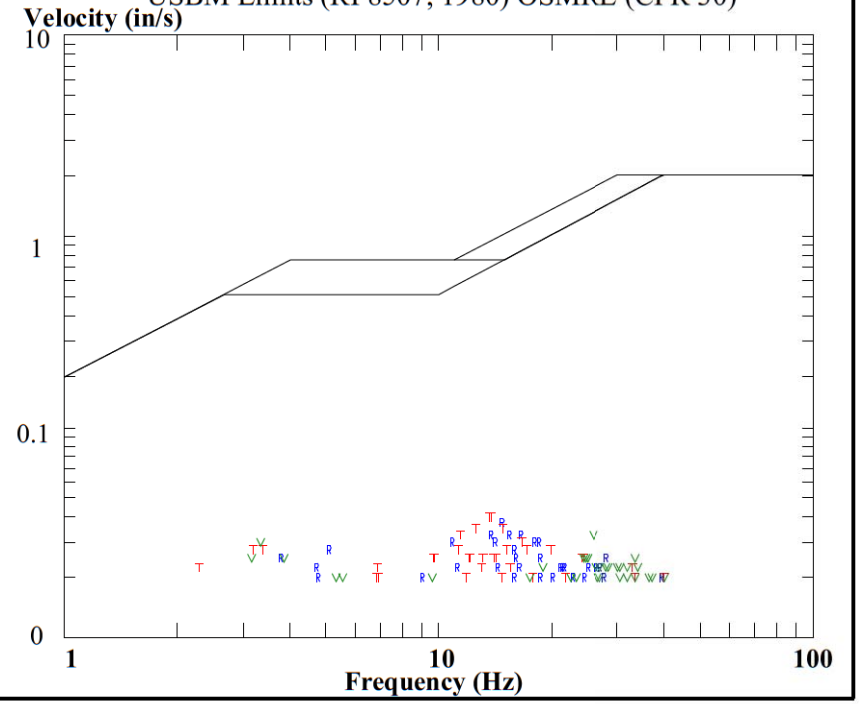
Measurement	Value	Trigger >>> Peak	
psi	.00058	5440.9	
dBL	**106**		
Hz	15.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

30-Apr-18 at 11:38:55 AM Event # 234

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.180**	**0.085**	**0.163**
Frequency (Hz)	**10.60**	**14.80**	**29.20**
Displacement (in)	**0.0027**	**0.0009**	**0.0009**
Acceleration (g's)	**0.0310**	**0.0205**	**0.0772**
Trigger >>> Peak	452.4	448.2	357.2

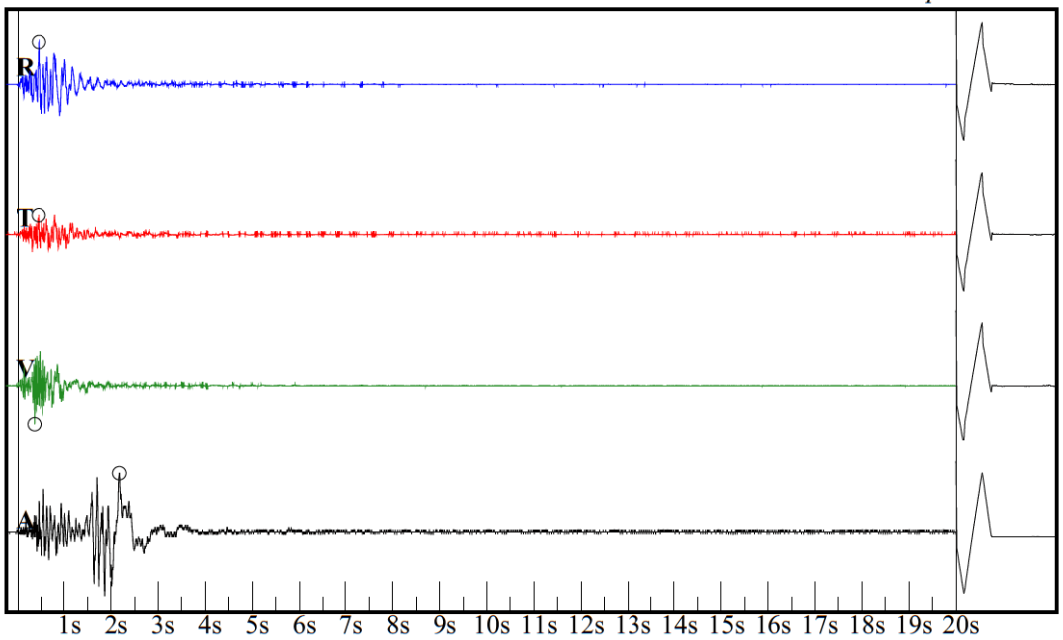
Air

Gain: 1 Trigger: 117 dBL

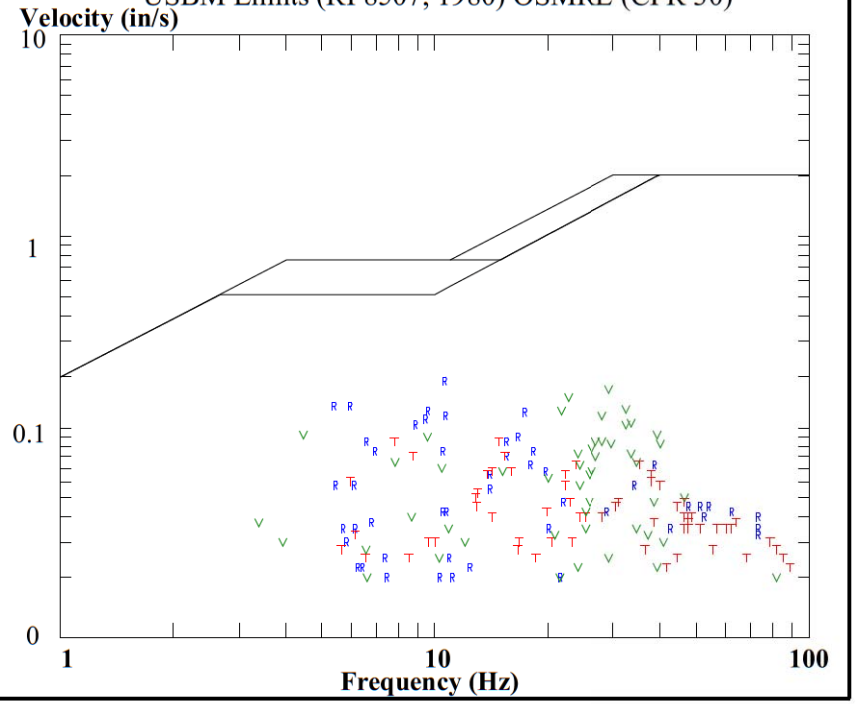
Measurement	Value	Trigger >>> Peak	
psi	.00098	2173.1	
dBL	**111**		
Hz	1.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

01-May-18 at 11:40:27 AM Event # 238

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.028**	**0.015**	**0.025**
Frequency (Hz)	**22.20**	**16.00**	**28.80**
Displacement (in)	**0.0002**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0099**	**0.0039**	**0.0117**
Trigger >>> Peak	259.3	148.7	266.4

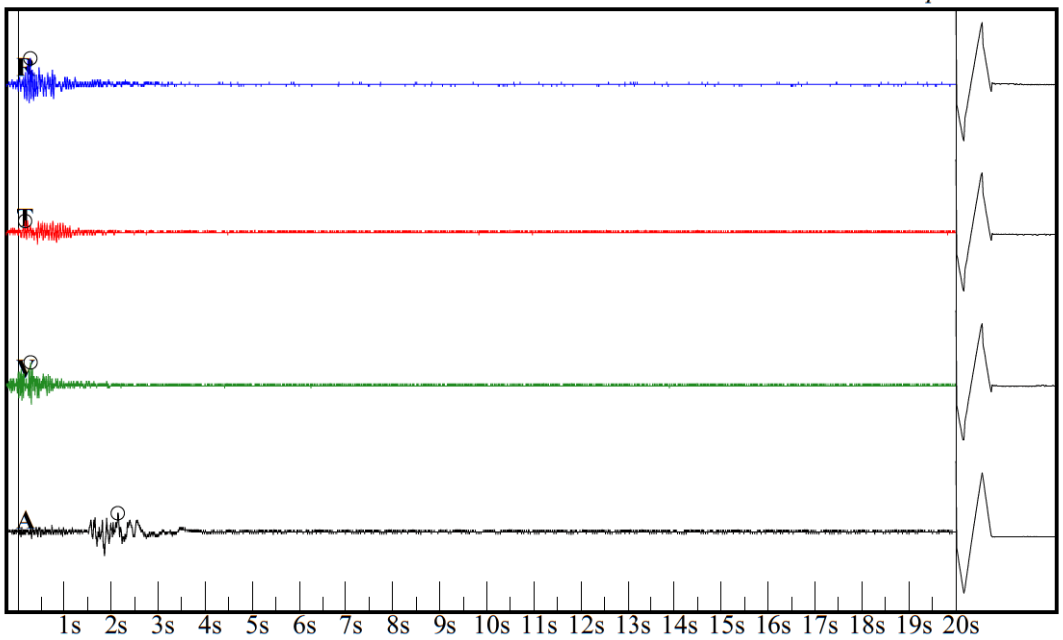
Air

Gain: 1 Trigger: 117 dBL

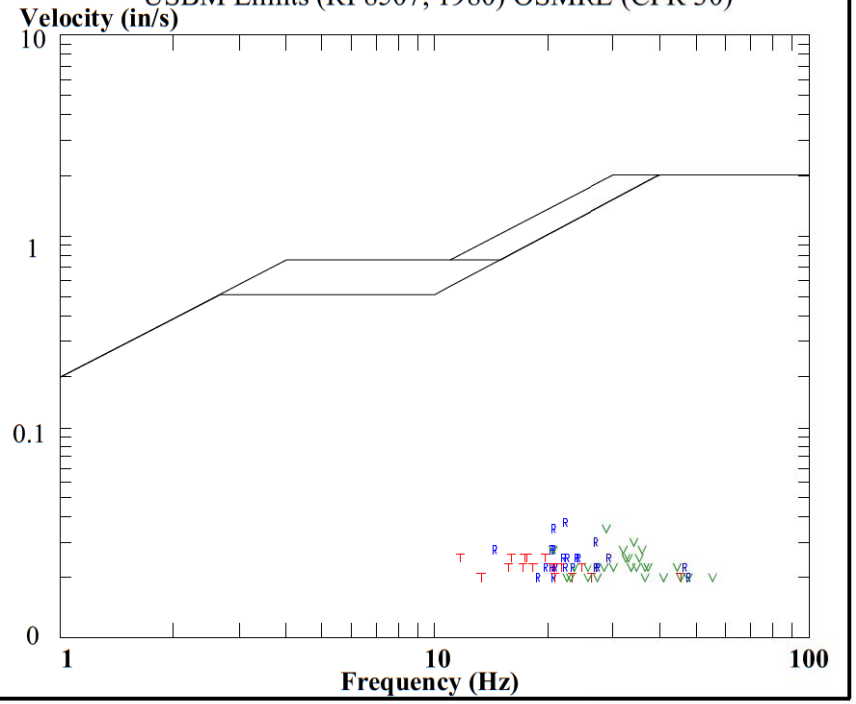
Measurement	Value	Trigger >>> Peak	
psi	.00036	2140.6	
dBL	**102**		
Hz	4.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

04-May-18 at 12:00:44 PM Event # 246

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.095**	**0.058**	**0.083**
Frequency (Hz)	**10.00**	**13.30**	**30.50**
Displacement (in)	**0.0015**	**0.0007**	**0.0004**
Acceleration (g's)	**0.0154**	**0.0124**	**0.0409**
Trigger >>> Peak	399.7	470.9	553.2

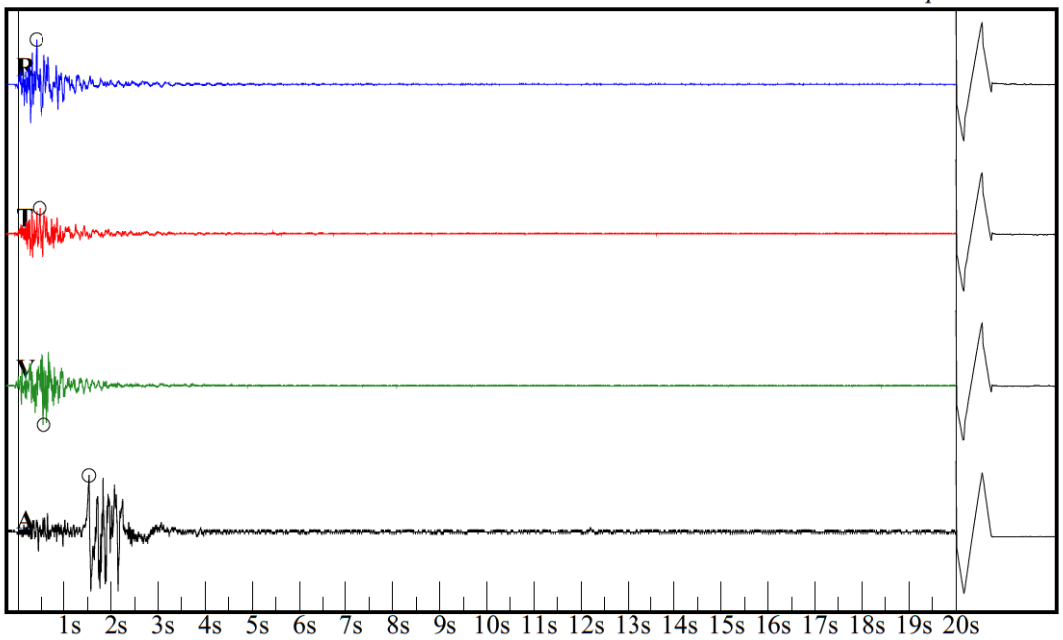
Air

Gain: 1 Trigger: 117 dBL

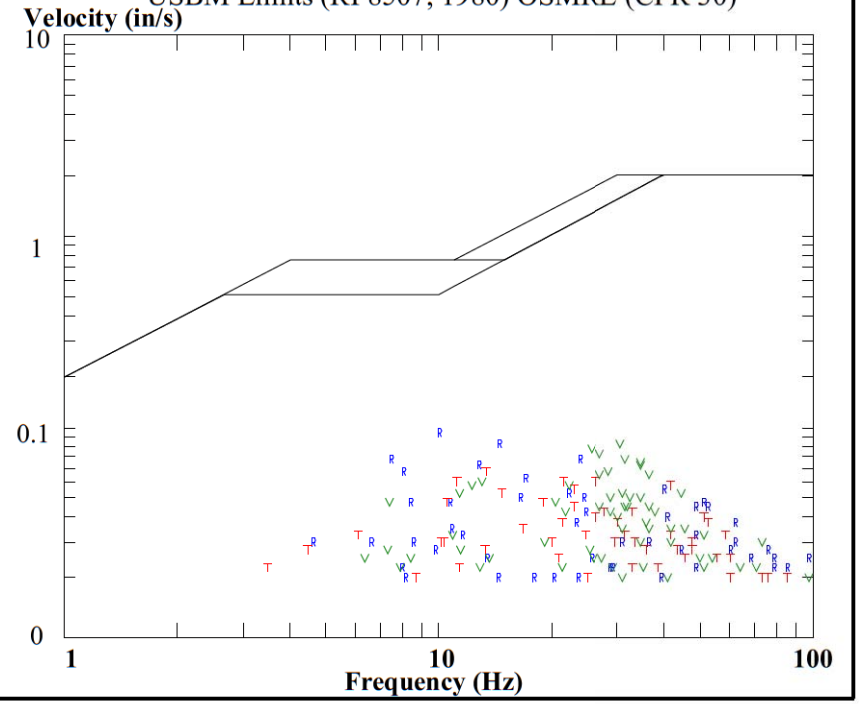
Measurement	Value	Trigger >>> Peak	
psi	.00094	1528.1	
dBL	**110**		
Hz	3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12805

08-May-18 at 11:09:00 AM Event # 258

Location: Branford Quarry East Seismograph

Operator: RESPEC

Notes: 29.96422368 -82.83273719

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.070**	**0.078**	**0.103**
Frequency (Hz)	**9.50**	**20.00**	**28.80**
Displacement (in)	**0.0012**	**0.0006**	**0.0006**
Acceleration (g's)	**0.0108**	**0.0252**	**0.0480**
Trigger >>> Peak	720	457.5	343.3

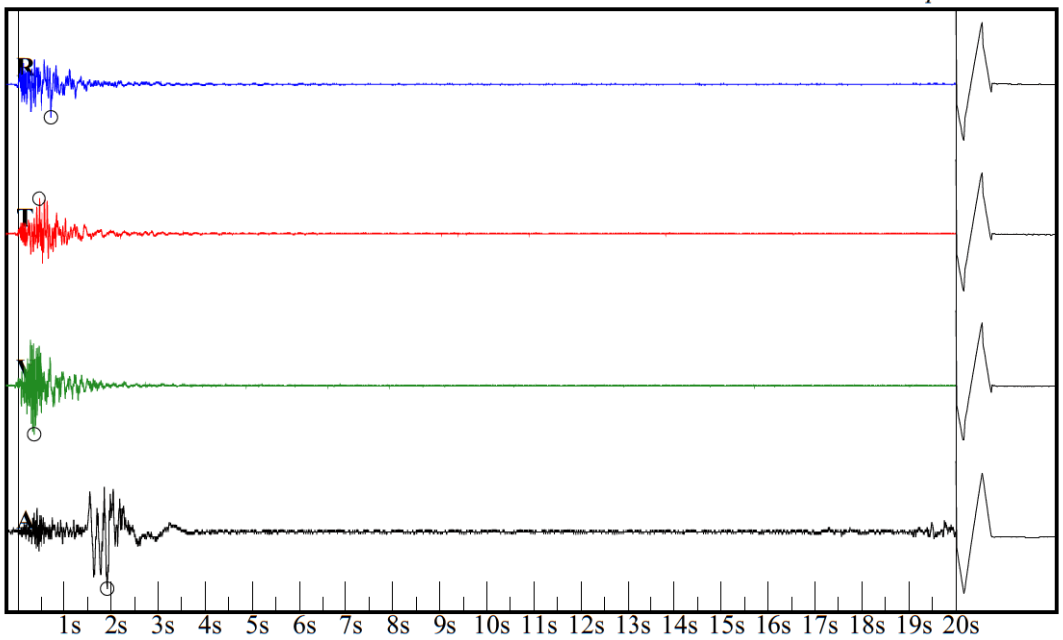
Air

Gain: 1 Trigger: 117 dBL

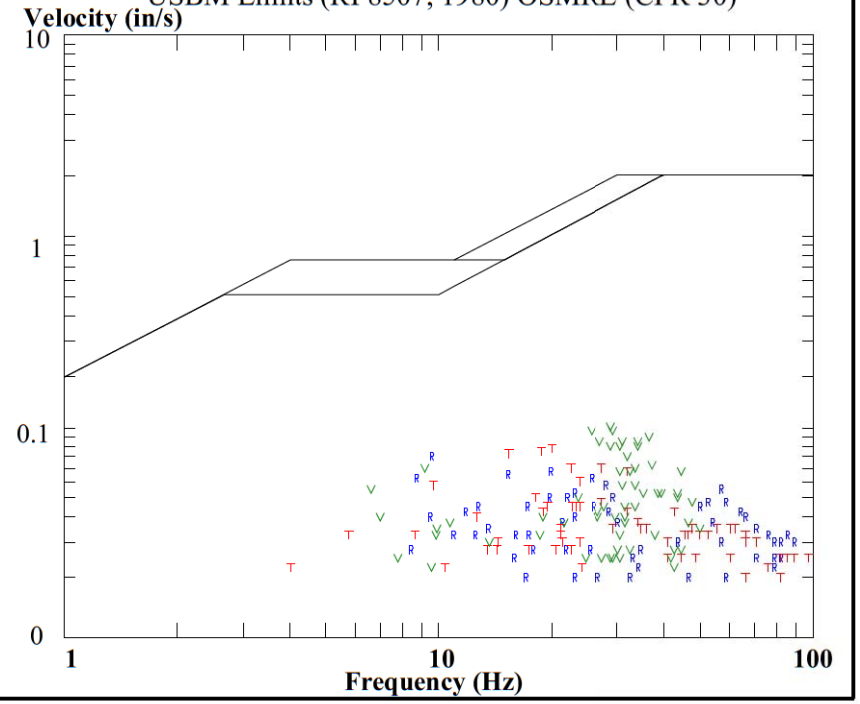
Measurement	Value	Trigger >>> Peak	
psi	.0008	1915.3	
dBL	**109**		
Hz	7.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

21-Feb-18 at 11:34:32 AM Event # 34

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.033**	**0.048**	**0.030**
Frequency (Hz)	**22.50**	**22.00**	**31.50**
Displacement (in)	**0.0002**	**0.0003**	**0.0002**
Acceleration (g's)	**0.0119**	**0.0170**	**0.0154**
Trigger >>> Peak	275.6	335.4	844

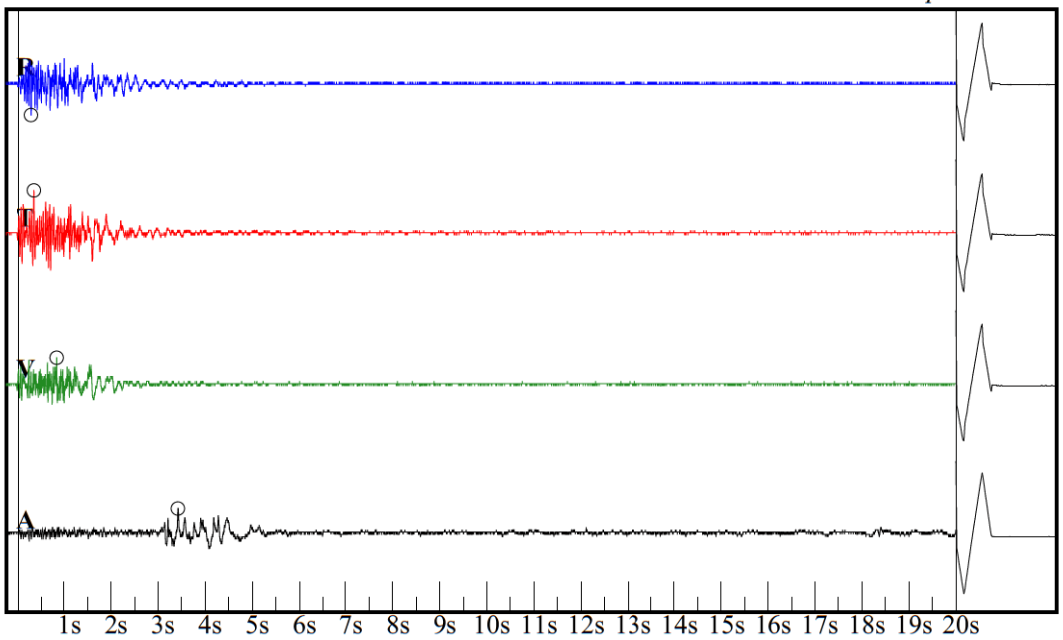
Air

Gain: 1 Trigger: 117 dBL

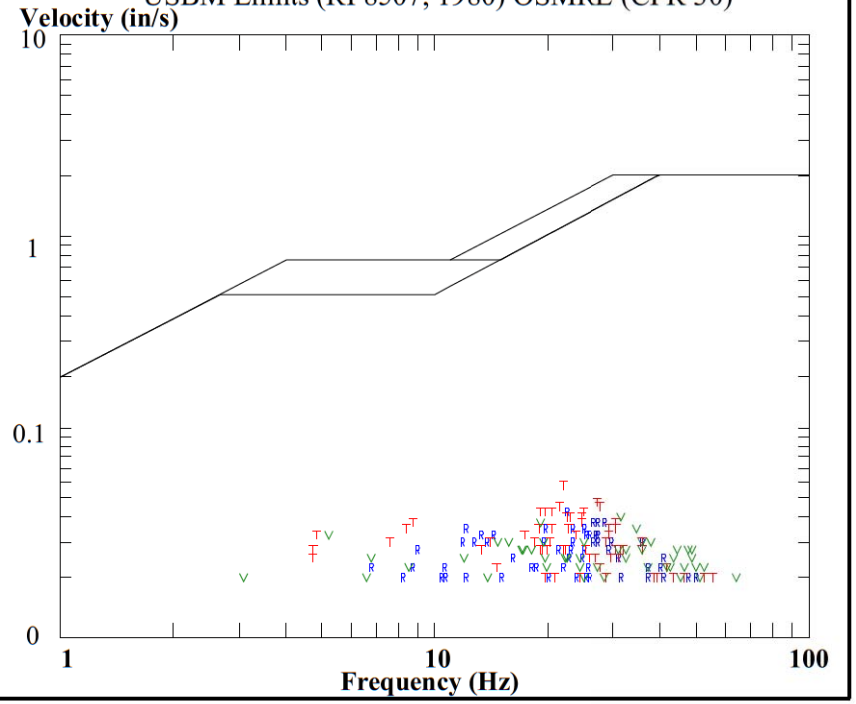
Measurement	Value	Trigger >>> Peak	
psi	.00044	3417.5	
dBL	**104**		
Hz	5.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

21-Feb-18 at 11:39:07 AM Event # 35

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.020**	**0.018**
Frequency (Hz)	**8.90**	**25.20**	**38.60**
Displacement (in)	**0.0004**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0036**	**0.0082**	**0.0110**
Trigger >>> Peak	738.8	497.1	451.4

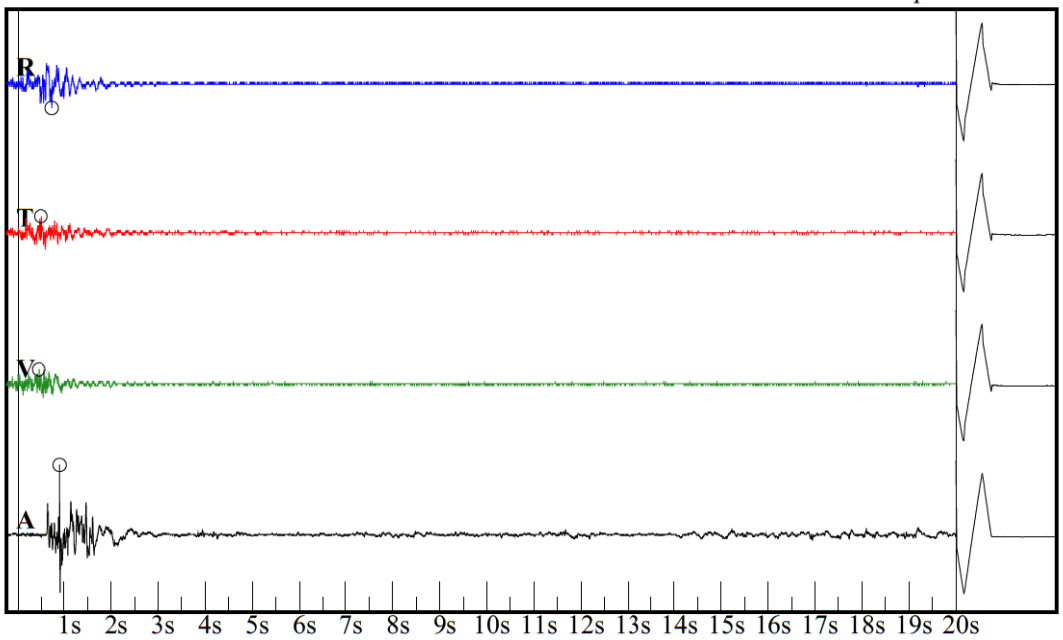
Air

Gain: 1 Trigger: 117 dBL

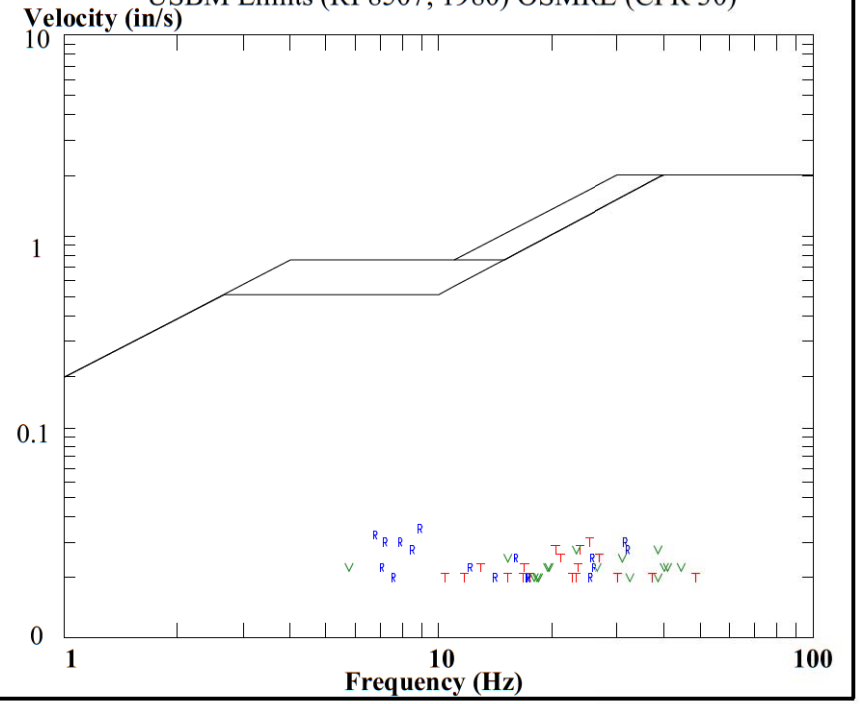
Measurement	Value	Trigger >>> Peak	
psi	.00221	904.3	
dBL	**118**		
Hz	93		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

08-Mar-18 at 11:35:27 AM Event # 136

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.023**	**0.020**
Frequency (Hz)	**22.20**	**27.30**	**37.20**
Displacement (in)	**0.0002**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0108**	**0.0100**	**0.0121**
Trigger >>> Peak	289.1	200.9	2.9

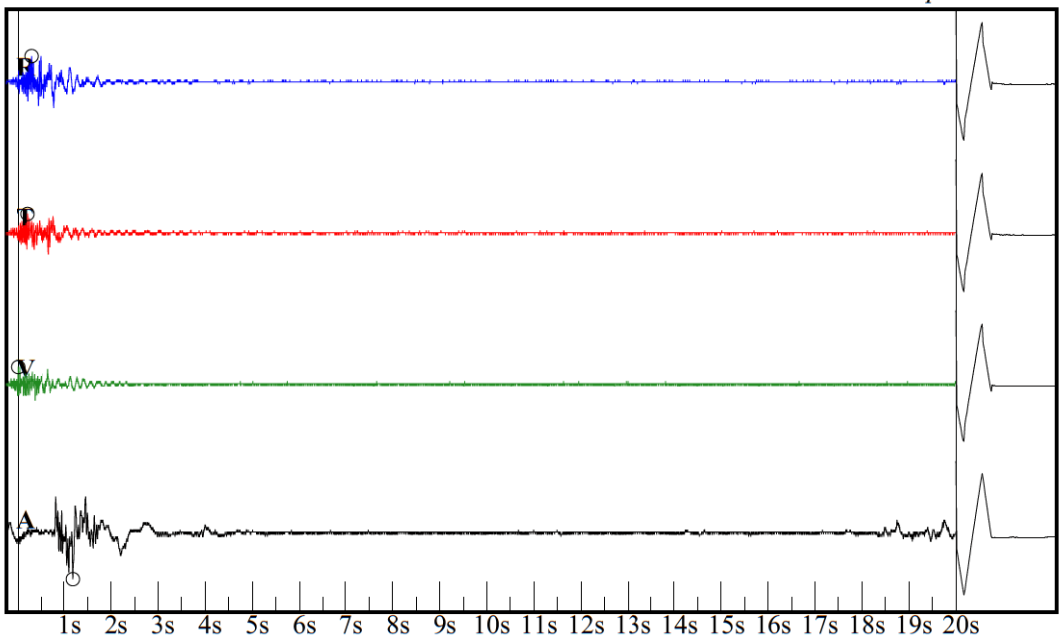
Air

Gain: 1 Trigger: 117 dBL

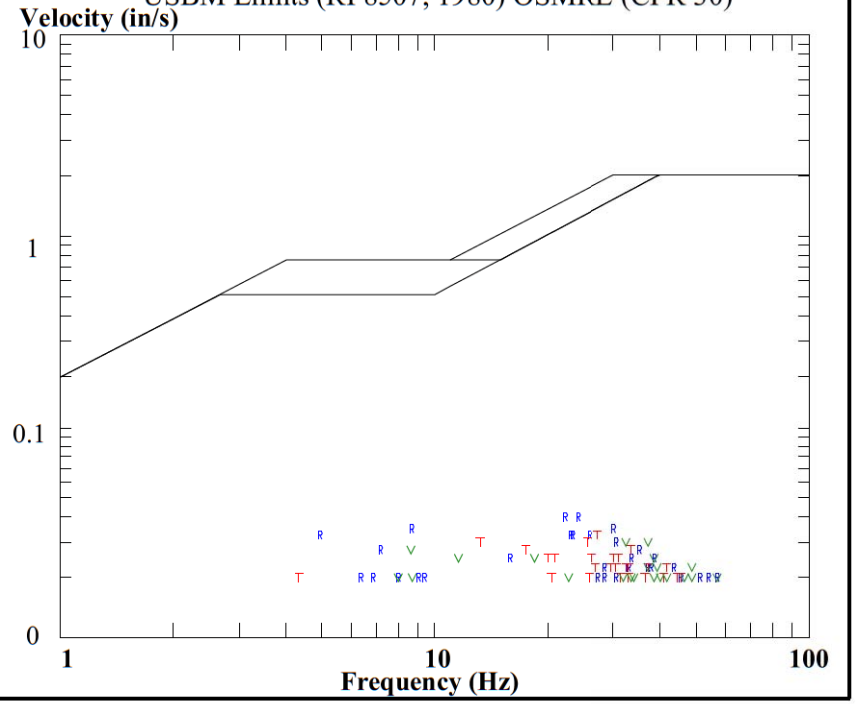
Measurement	Value	Trigger >>> Peak	
psi	.00065	1187	
dBL	**107**		
Hz	10.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

26-Mar-18 at 11:22:16 AM Event # 462

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.188**	**0.123**	**0.170**
Frequency (Hz)	**21.50**	**17.90**	**44.50**
Displacement (in)	**0.0014**	**0.0011**	**0.0006**
Acceleration (g's)	**0.0656**	**0.0357**	**0.1230**
Trigger >>> Peak	737.5	507.3	332.3

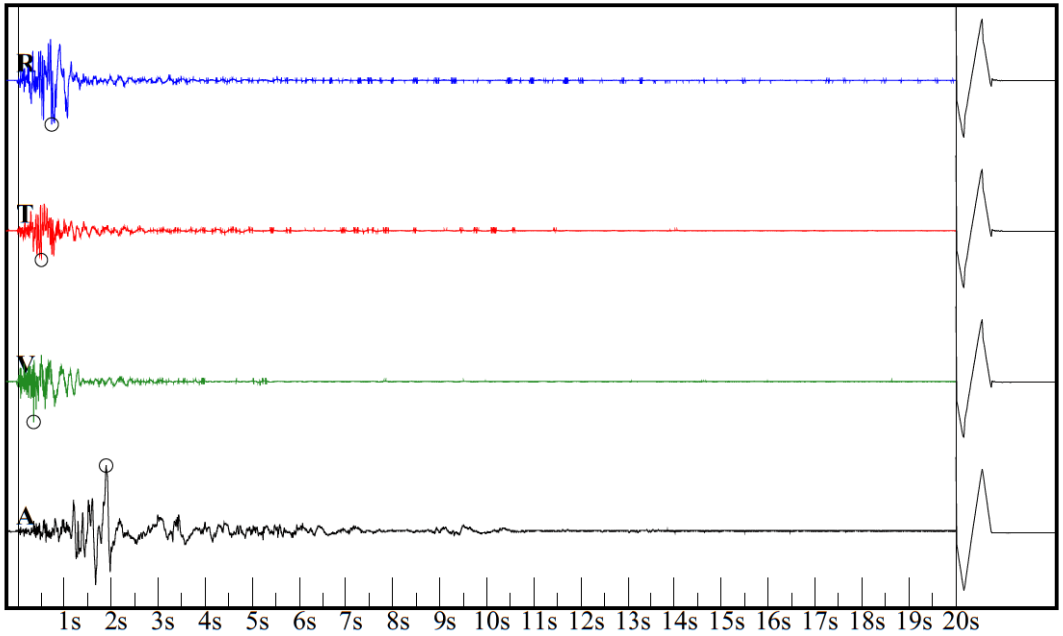
Air

Gain: 1 Trigger: 117 dBL

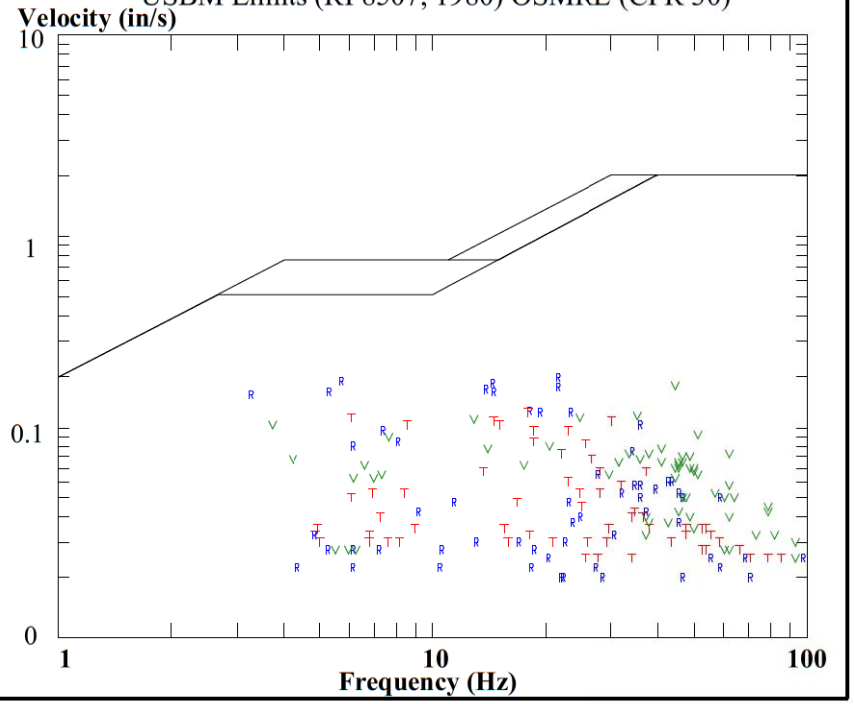
Measurement	Value	Trigger >>> Peak	
psi	.00207	1890.9	
dBL	**117**		
Hz	3.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

27-Mar-18 at 12:42:27 PM Event # 465

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.033**	**0.045**	**0.023**
Frequency (Hz)	**5.90**	**17.20**	**17.20**
Displacement (in)	**0.0009**	**0.0004**	**0.0002**
Acceleration (g's)	**0.0031**	**0.0126**	**0.0063**
Trigger >>> Peak	953.4	114.3	7.6

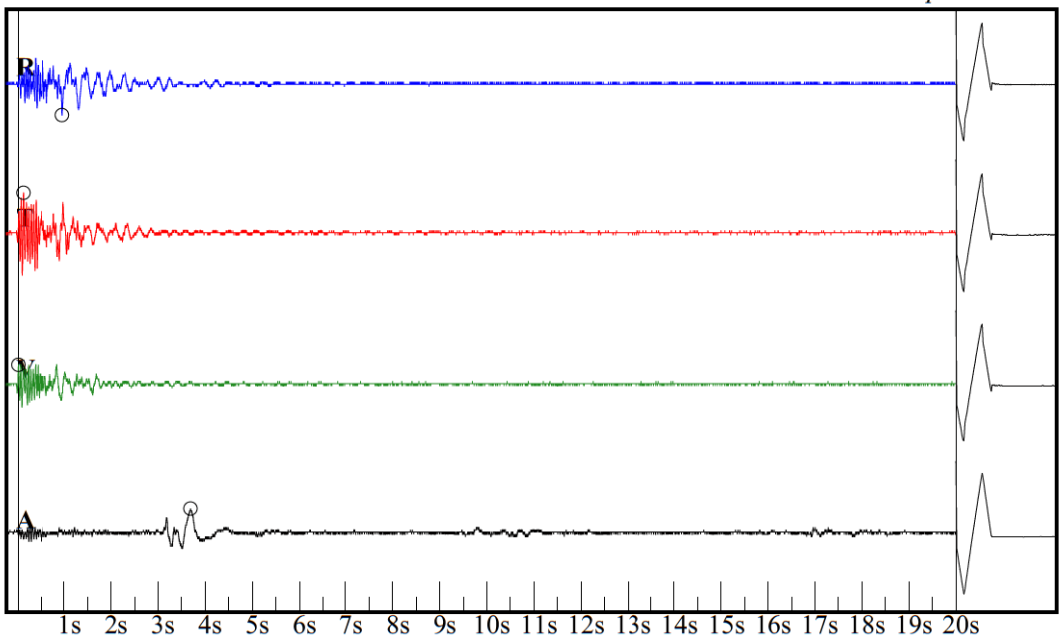
Air

Gain: 1 Trigger: 117 dBL

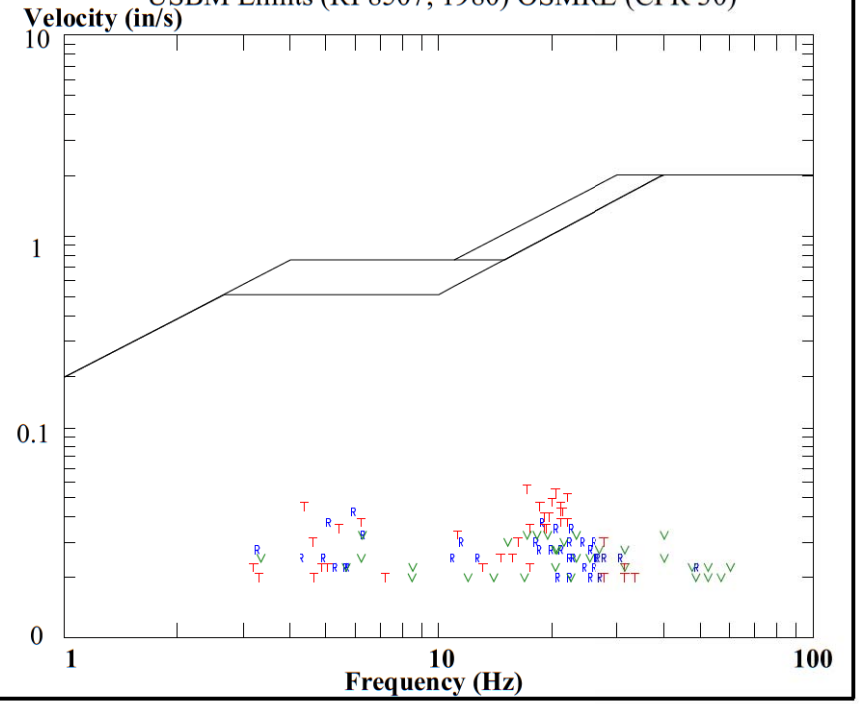
Measurement	Value	Trigger >>> Peak	
psi	.00044	3683.1	
dBL	**104**		
Hz	1.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

29-Mar-18 at 11:16:06 AM Event # 503

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.163**	**0.105**	**0.083**
Frequency (Hz)	**20.00**	**22.50**	**19.50**
Displacement (in)	**0.0013**	**0.0007**	**0.0007**
Acceleration (g's)	**0.0528**	**0.0384**	**0.0262**
Trigger >>> Peak	528.3	551	443.1

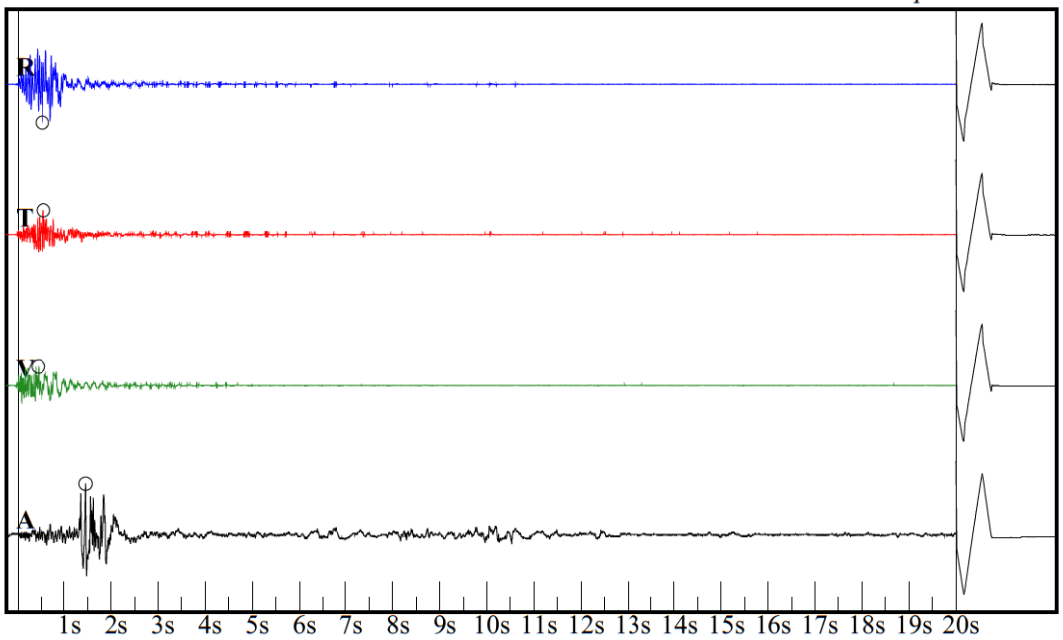
Air

Gain: 1 Trigger: 117 dBL

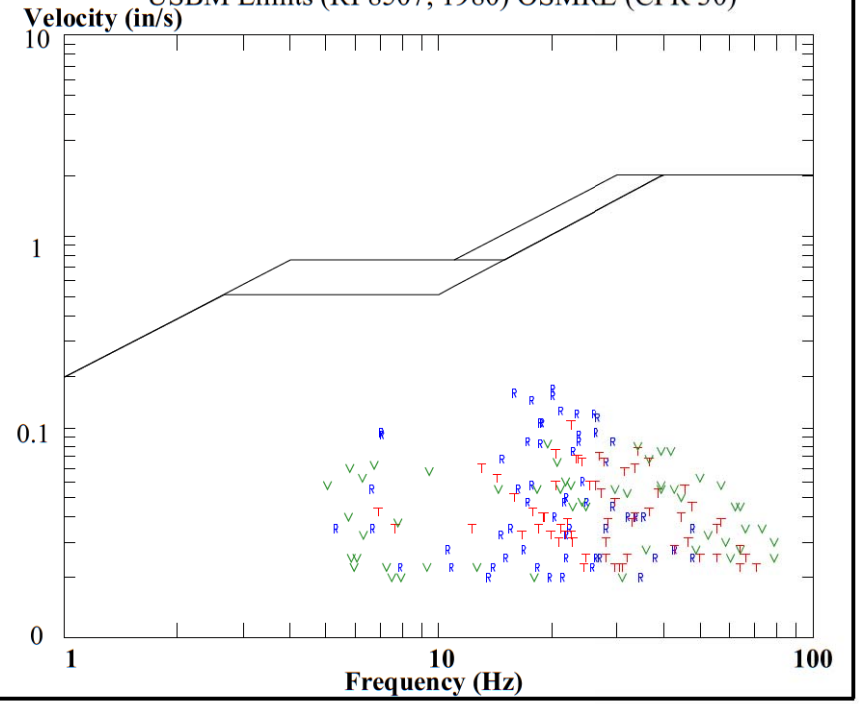
Measurement	Value	Trigger >>> Peak	
psi	.00163	1455.8	
dBL	**115**		
Hz	14.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

03-Apr-18 at 11:51:11 AM Event # 566

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.028**	**0.023**
Frequency (Hz)	**21.50**	**25.90**	**9.70**
Displacement (in)	**0.0002**	**0.0002**	**0.0004**
Acceleration (g's)	**0.0087**	**0.0116**	**0.0035**
Trigger >>> Peak	638.2	450.2	476.6

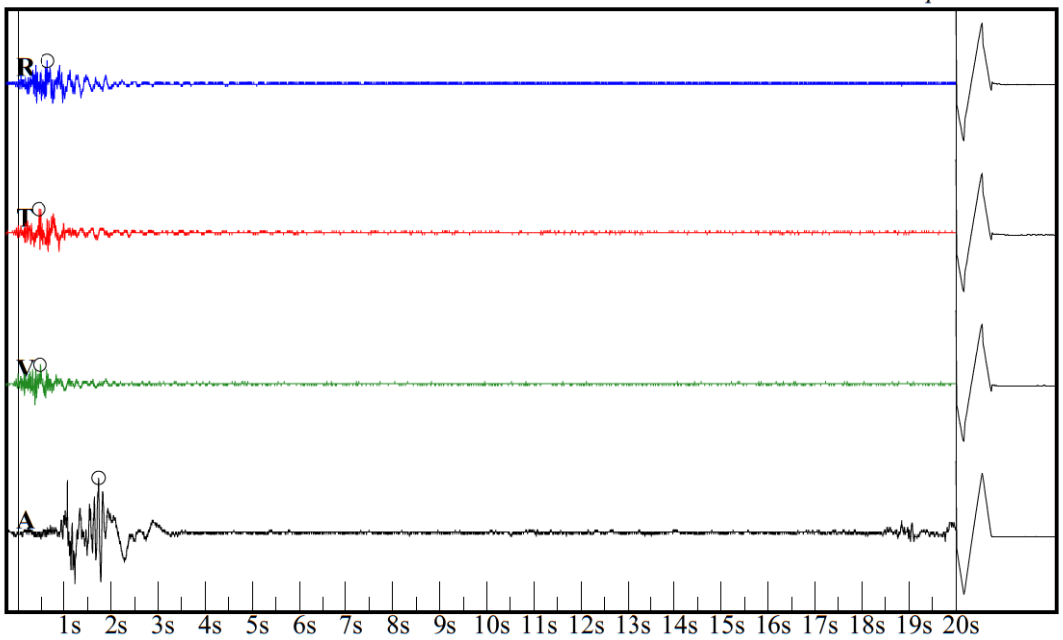
Air

Gain: 1 Trigger: 117 dBL

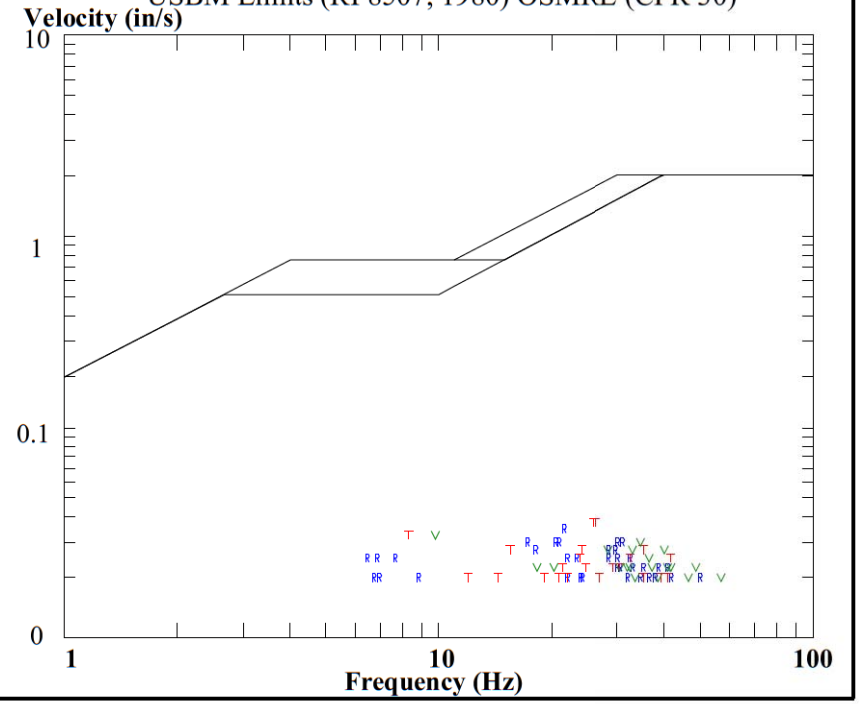
Measurement	Value	Trigger >>> Peak	
psi	.00091	1733.4	
dBL	**110**		
Hz	9.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

16-Apr-18 at 13:06:32 PM Event # 721

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.468**	**0.260**	**0.488**
Frequency (Hz)	**24.30**	**25.60**	**30.50**
Displacement (in)	**0.0031**	**0.0016**	**0.0025**
Acceleration (g's)	**0.1847**	**0.1082**	**0.2418**
Trigger >>> Peak	162.4	111.8	51

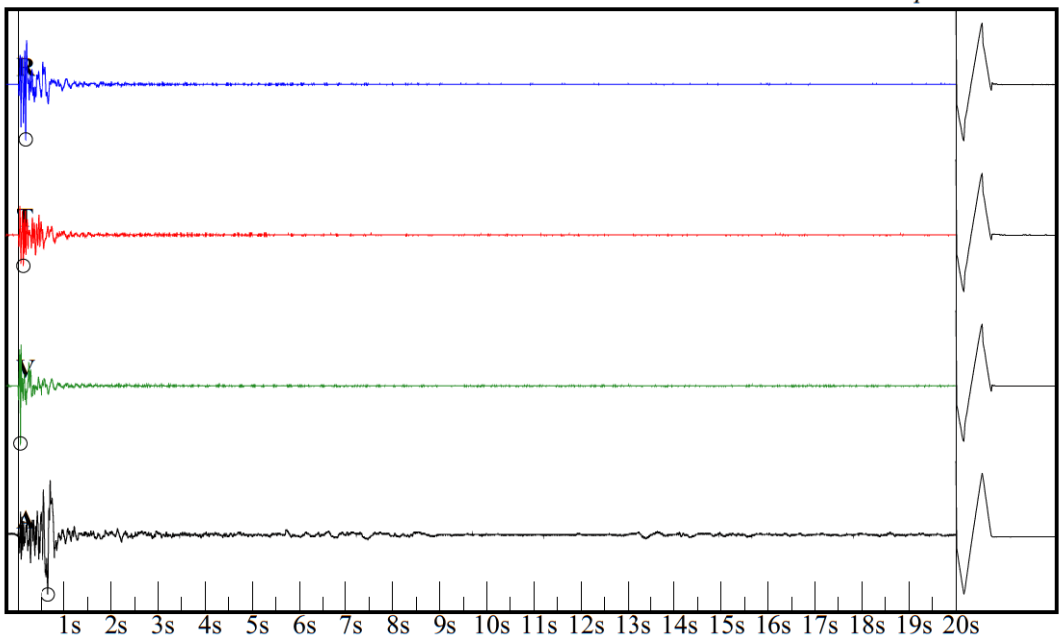
Air

Gain: 1 Trigger: 117 dBL

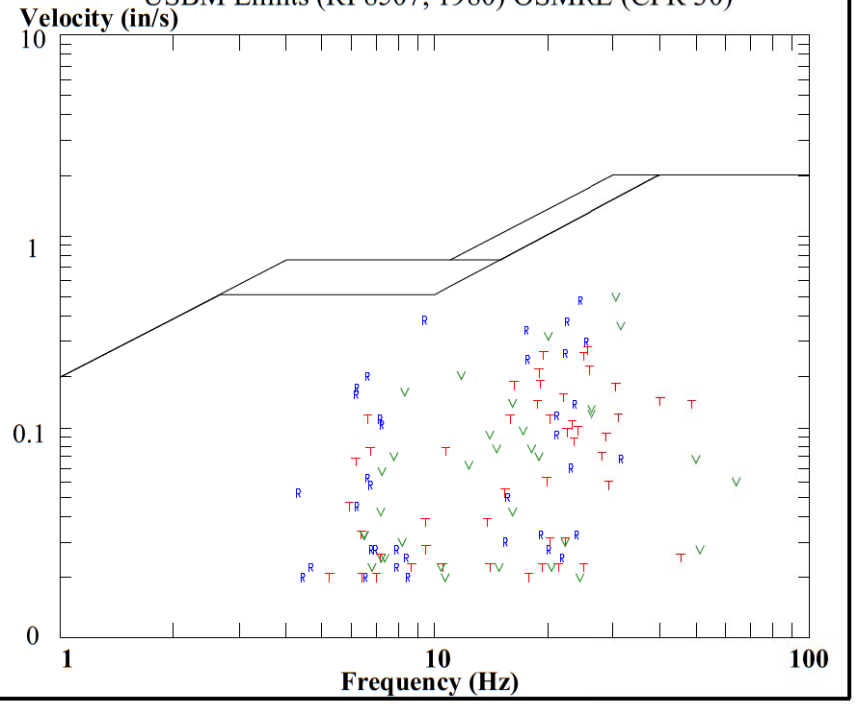
Measurement	Value	Trigger >>> Peak	
psi	.00178	652.1	
dBL	**116**		
Hz	5.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.64 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

16-Apr-18 at 13:11:11 PM Event # 722

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.065**	**0.055**	**0.038**
Frequency (Hz)	**18.70**	**21.70**	**30.50**
Displacement (in)	**0.0006**	**0.0004**	**0.0002**
Acceleration (g's)	**0.0198**	**0.0194**	**0.0186**
Trigger >>> Peak	570.8	497.6	321.5

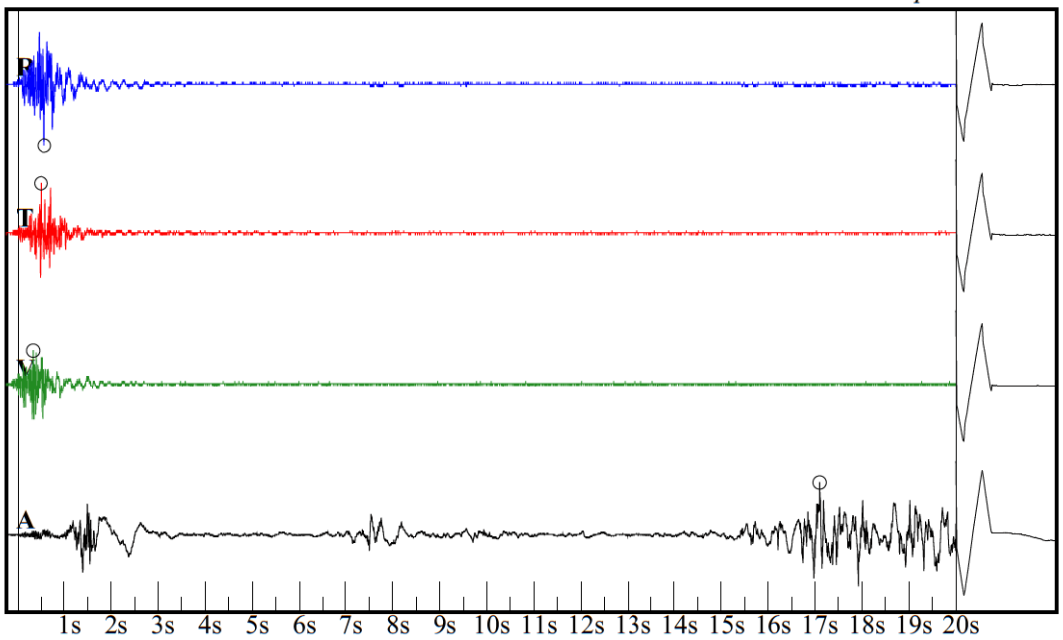
Air

Gain: 1 Trigger: 117 dBL

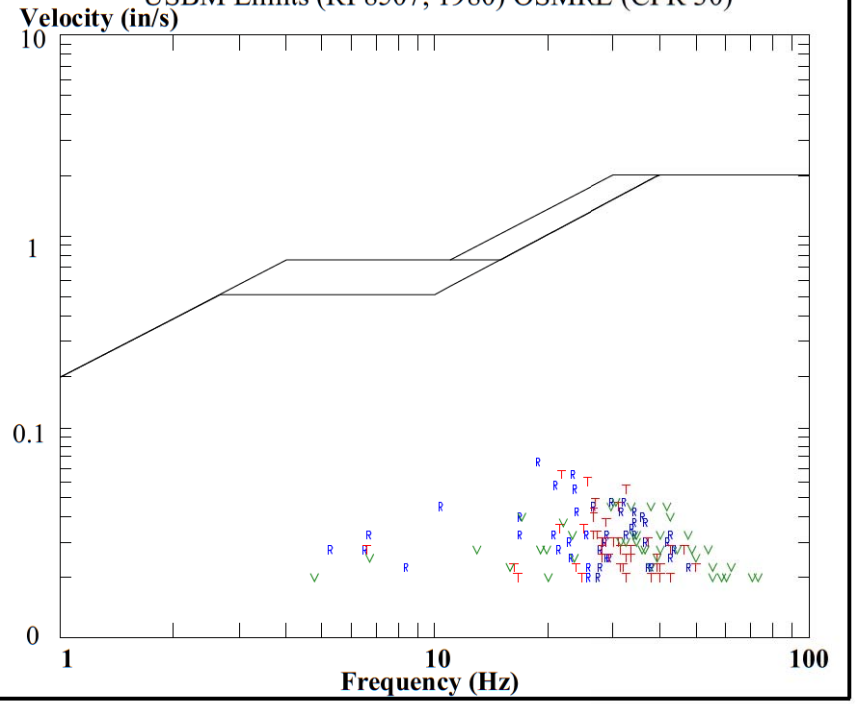
Measurement	Value	Trigger >>> Peak	
psi	.00167	17098.4	
dBL	**115**		
Hz	4.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

16-Apr-18 at 14:01:58 PM Event # 723

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.028**	**0.033**	**0.023**
Frequency (Hz)	**18.10**	**20.00**	**8.30**
Displacement (in)	**0.0002**	**0.0003**	**0.0004**
Acceleration (g's)	**0.0081**	**0.0106**	**0.0030**
Trigger >>> Peak	632.1	107.2	844.2

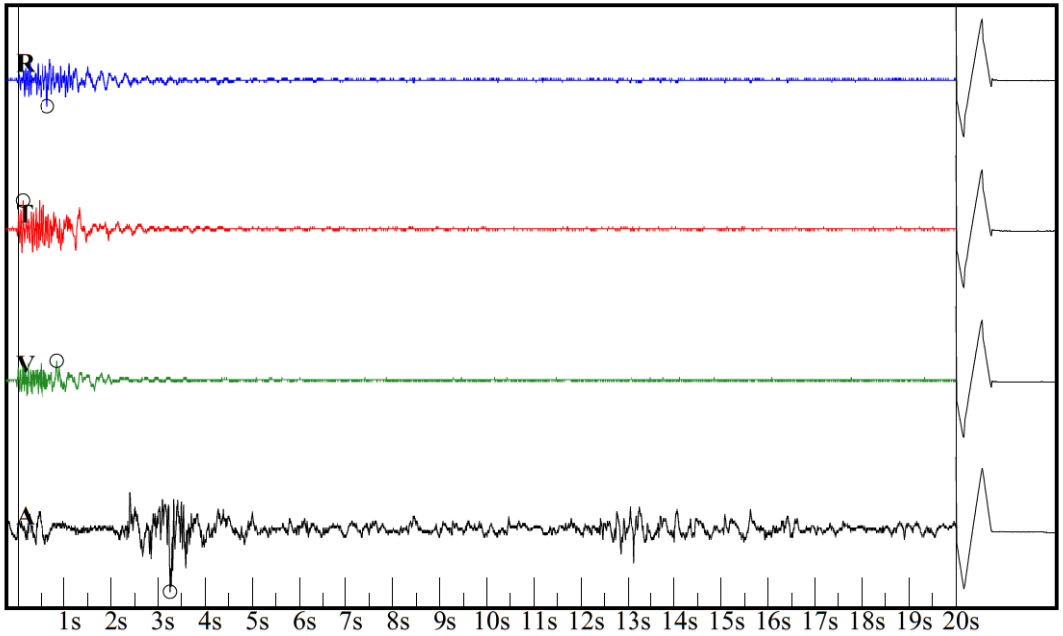
Air

Gain: 1 Trigger: 117 dBL

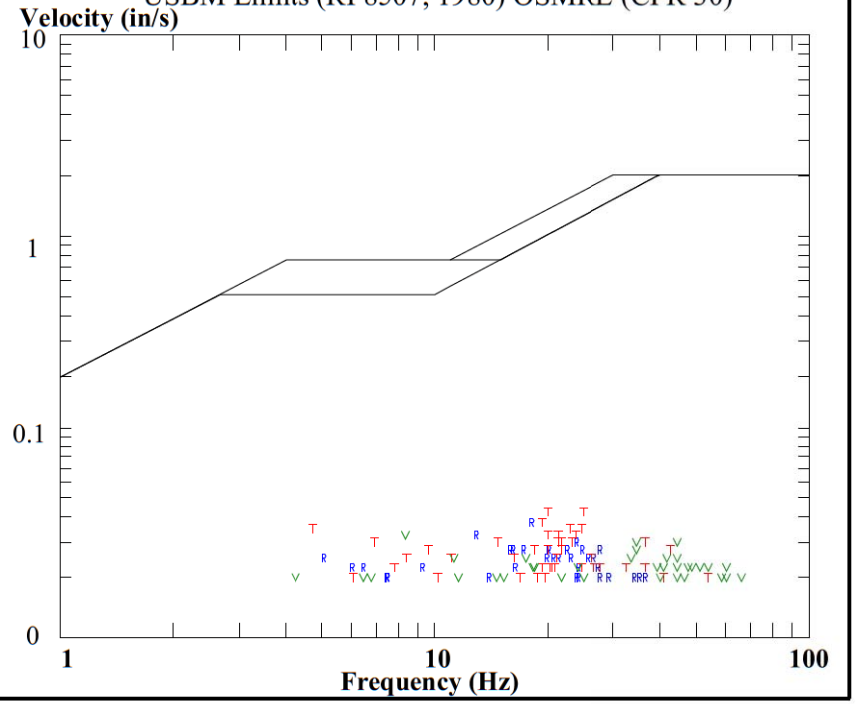
Measurement	Value	Trigger >>> Peak	
psi	.00091	3248	
dBL	**110**		
Hz	5.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

16-Apr-18 at 14:13:48 PM Event # 725

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.050**	**0.028**
Frequency (Hz)	**8.00**	**4.30**	**3.60**
Displacement (in)	**0.0006**	**0.0019**	**0.0012**
Acceleration (g's)	**0.0039**	**0.0035**	**0.0016**
Trigger >>> Peak	988.5	1382.6	1806.4

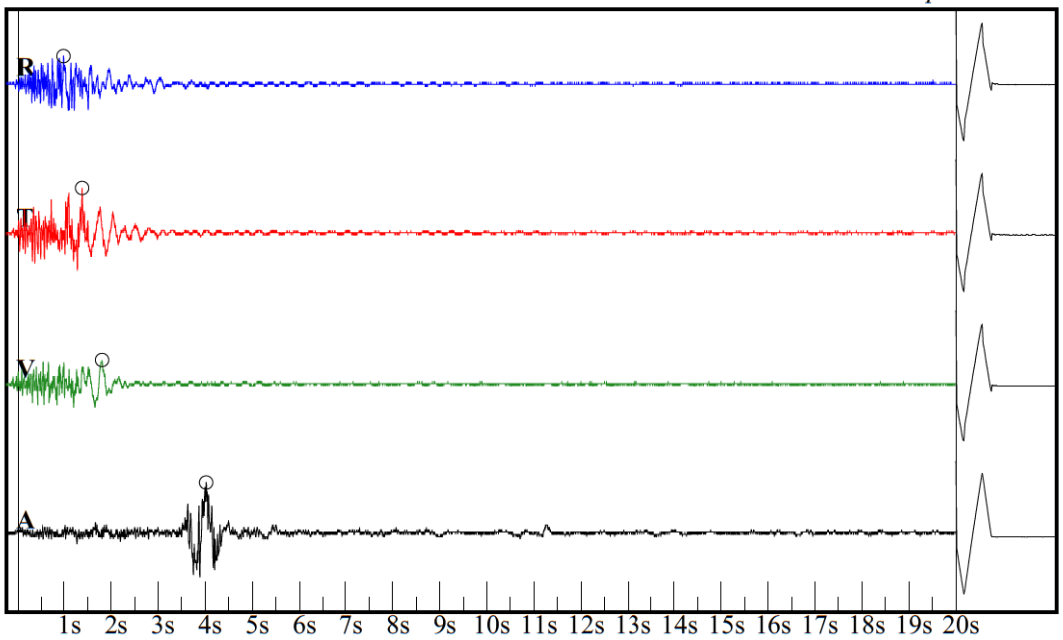
Air

Gain: 1 Trigger: 117 dBL

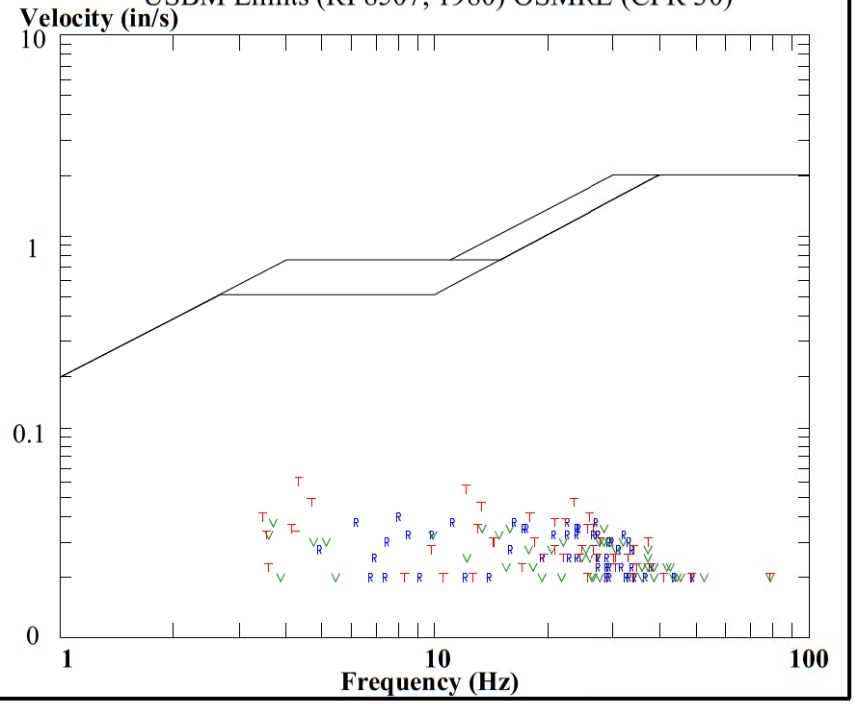
Measurement	Value	Trigger >>> Peak	
psi	.00083	4016.1	
dBL	**109**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

30-Apr-18 at 11:38:50 AM Event # 769

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.263**	**0.158**	**0.175**
Frequency (Hz)	**13.10**	**20.60**	**35.90**
Displacement (in)	**0.0032**	**0.0012**	**0.0008**
Acceleration (g's)	**0.0559**	**0.0528**	**0.1022**
Trigger >>> Peak	604.5	623.8	85.9

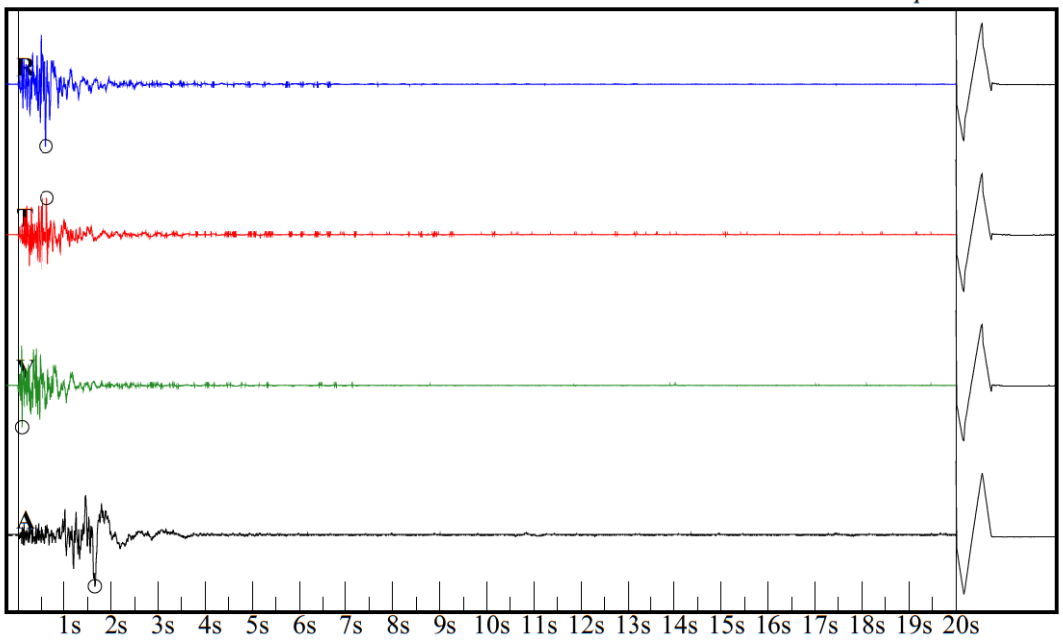
Air

Gain: 1 Trigger: 117 dBL

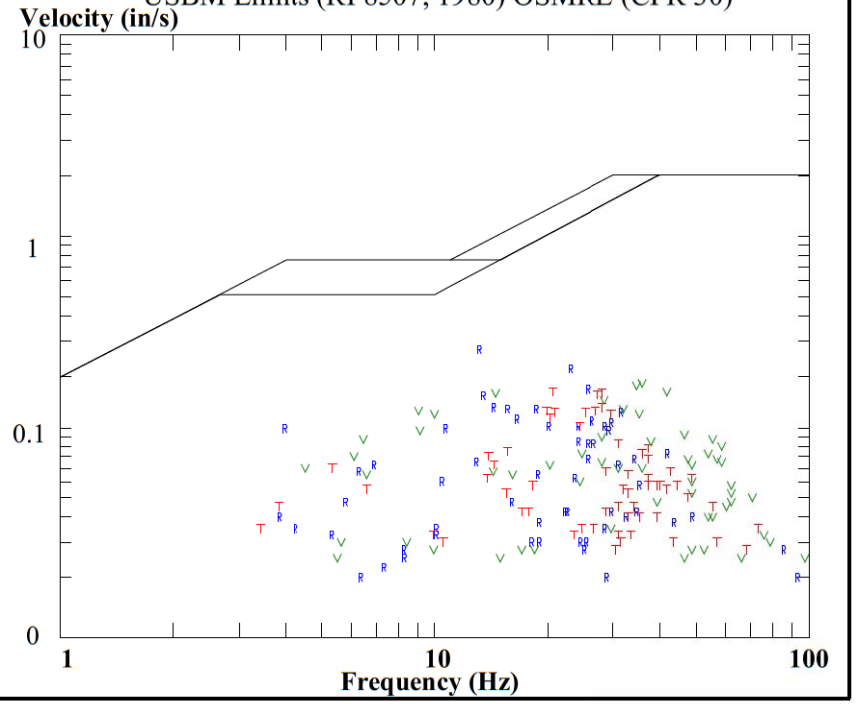
Measurement	Value	Trigger >>> Peak	
psi	.00152	1654.1	
dBL	**114**		
Hz	5.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

01-May-18 at 11:40:22 AM Event # 772

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N | *Wgt. Per Delay: N* | *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.028**	**0.025**	**0.023**
Frequency (Hz)	**29.60**	**34.10**	**36.50**
Displacement (in)	**0.0001**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0132**	**0.0139**	**0.0134**
Trigger >>> Peak	258.8	458	249

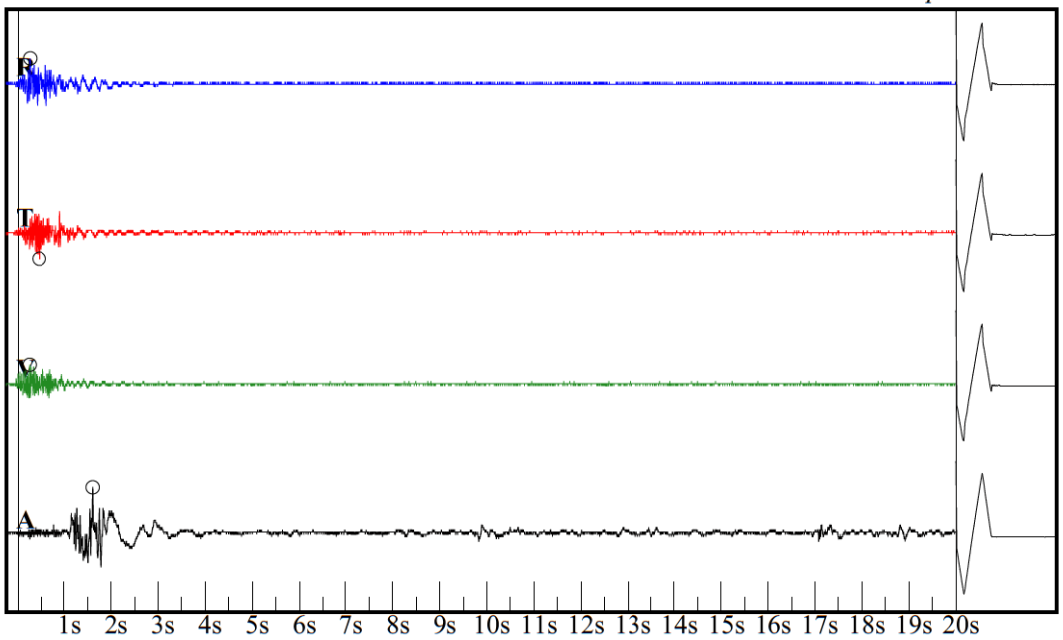
Air

Gain: 1 Trigger: 117 dBL

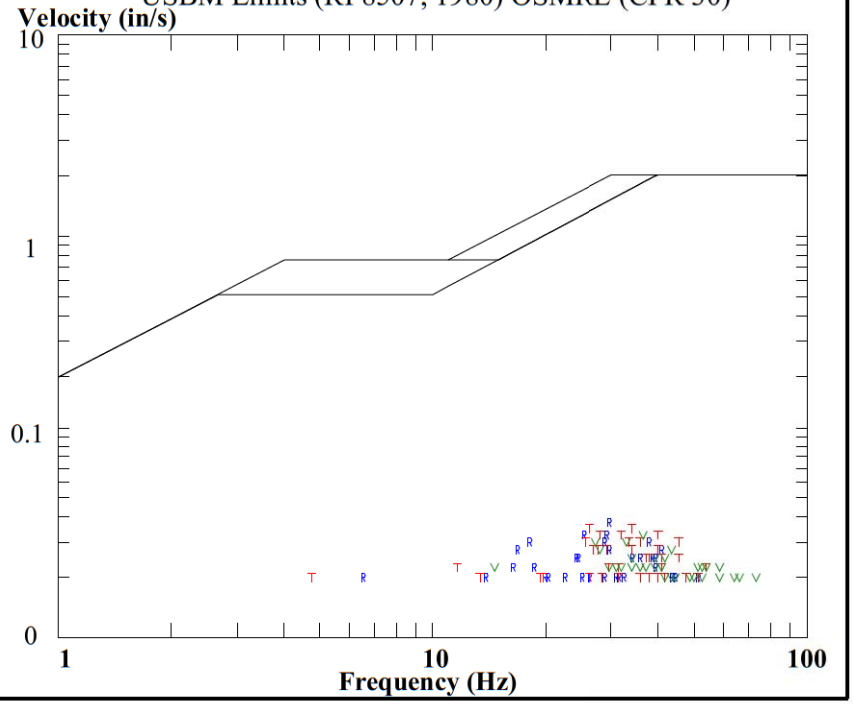
Measurement	Value	Trigger >>> Peak	
psi	.00076	1607.7	
dBL	**108**		
Hz	5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

04-May-18 at 12:00:37 PM Event # 779

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.130**	**0.090**	**0.193**
Frequency (Hz)	**7.90**	**34.10**	**32.00**
Displacement (in)	**0.0026**	**0.0004**	**0.0010**
Acceleration (g's)	**0.0167**	**0.0499**	**0.1002**
Trigger >>> Peak	277.1	589.6	311.8

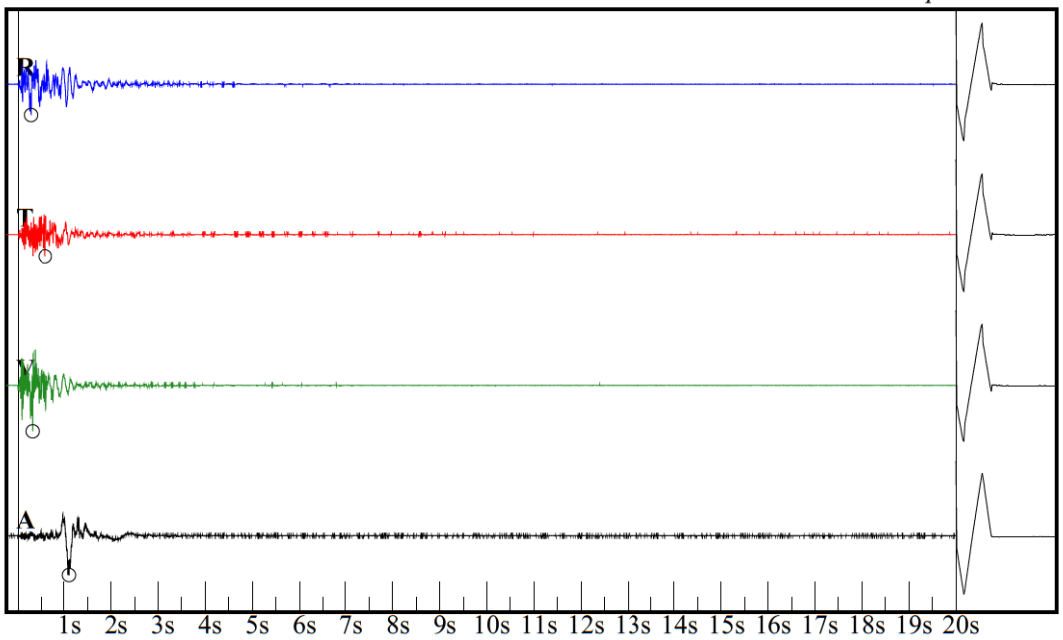
Air

Gain: 1 Trigger: 117 dBL

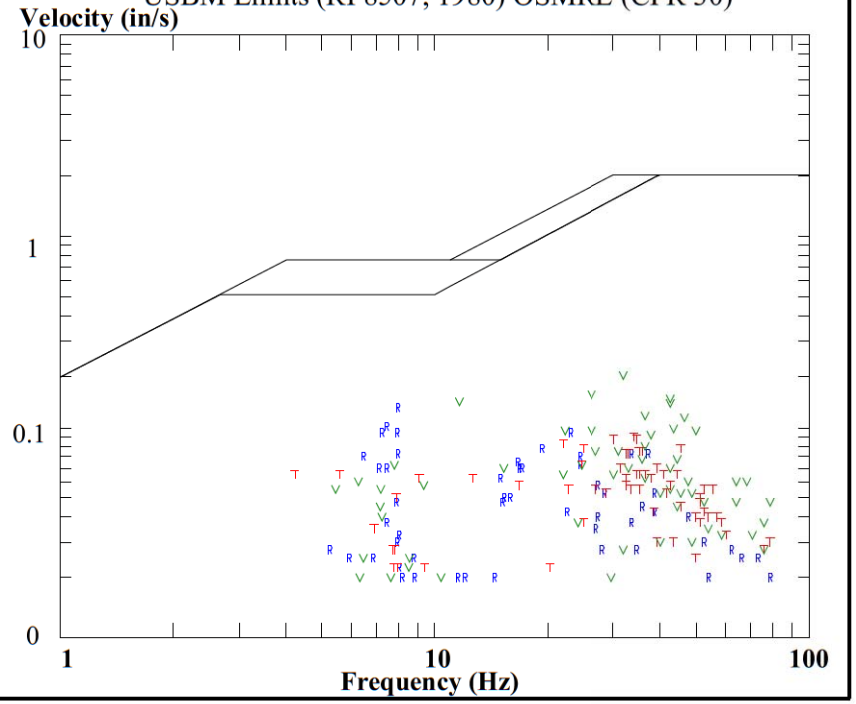
Measurement	Value	Trigger >>> Peak	
psi	.00236	1105.5	
dBL	**118**		
Hz	3.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .00461 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12939

08-May-18 at 11:08:53 AM Event # 788

Location: Branford Quarry North Seismograph

Operator: RESPEC

Notes: 29.96865632, -82.83793967

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 06Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.275**	**0.138**	**0.195**
Frequency (Hz)	**7.90**	**29.20**	**6.20**
Displacement (in)	**0.0055**	**0.0007**	**0.0050**
Acceleration (g's)	**0.0353**	**0.0653**	**0.0197**
Trigger >>> Peak	425	377.2	619.4

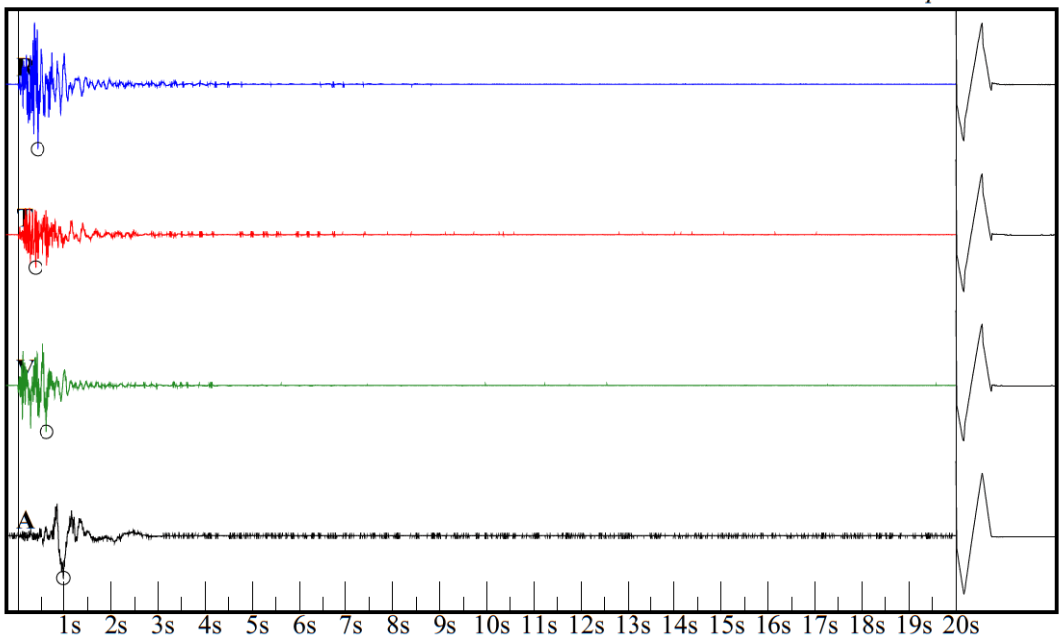
Air

Gain: 1 Trigger: 117 dBL

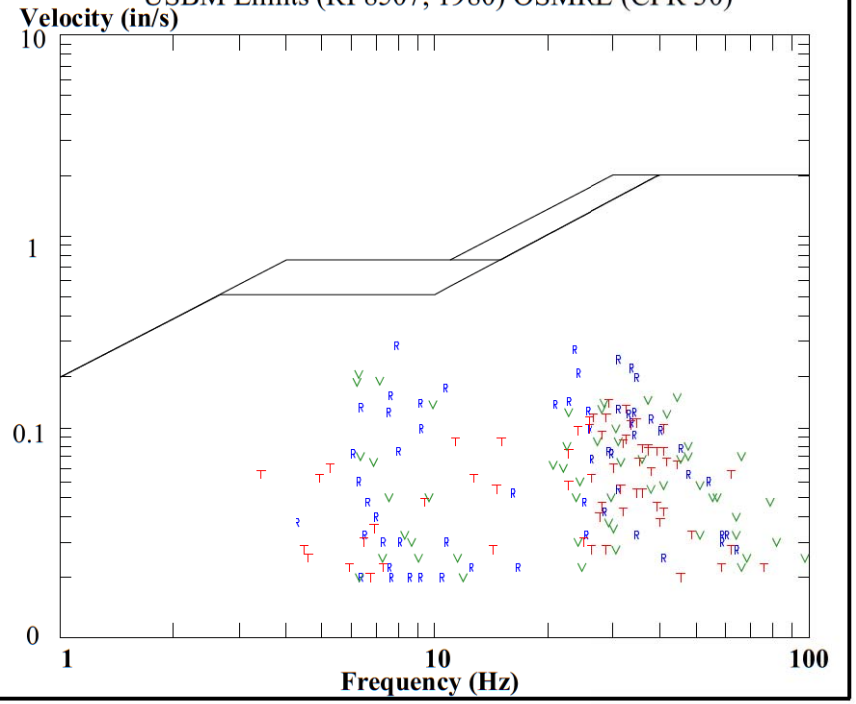
Measurement	Value	Trigger >>> Peak	
psi	.00254	984.1	
dBL	**119**		
Hz	2.6		

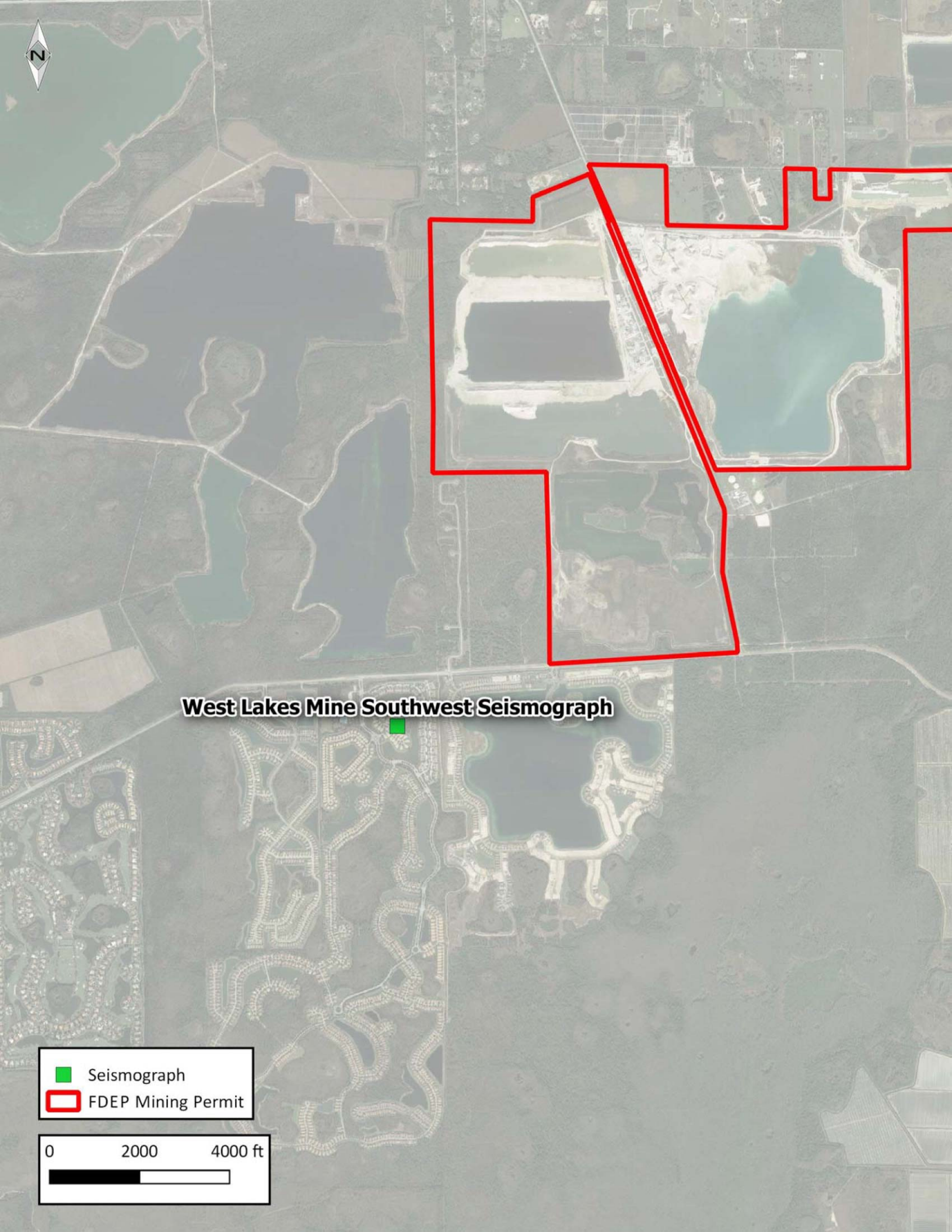
Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.32 in/s/div. *Air Scale: .00461 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)




N
West Lakes Mine Southwest Seismograph
Seismograph
FDEP Mining Permit
0
2000
4000 ft

Version 4.1.1
Executable Date: 17Dec2015

Nomis Seismographs, Inc.

SuperGraphics - Report

Telephone: (205)592-2488 x 23

Company: RESPEC

Unit #: 12920

2/14/2018 at 09:16:47 Event # 6

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N | Wgt. Per Delay: N | Scaled Distance: 0.0

Seismic

Gain: 2 Trigger: .01 in/s ▽ Vector Sum: 0.05 in/s @ 6.61 Hz

Channel	Radial	Transverse	Vertical
○ Velocity (in/s)	0.043	0.038	0.035
Frequency (Hz)	13.80	1.80	1.80
Trigger >>> Peak	643.3	1958.5	5744.9

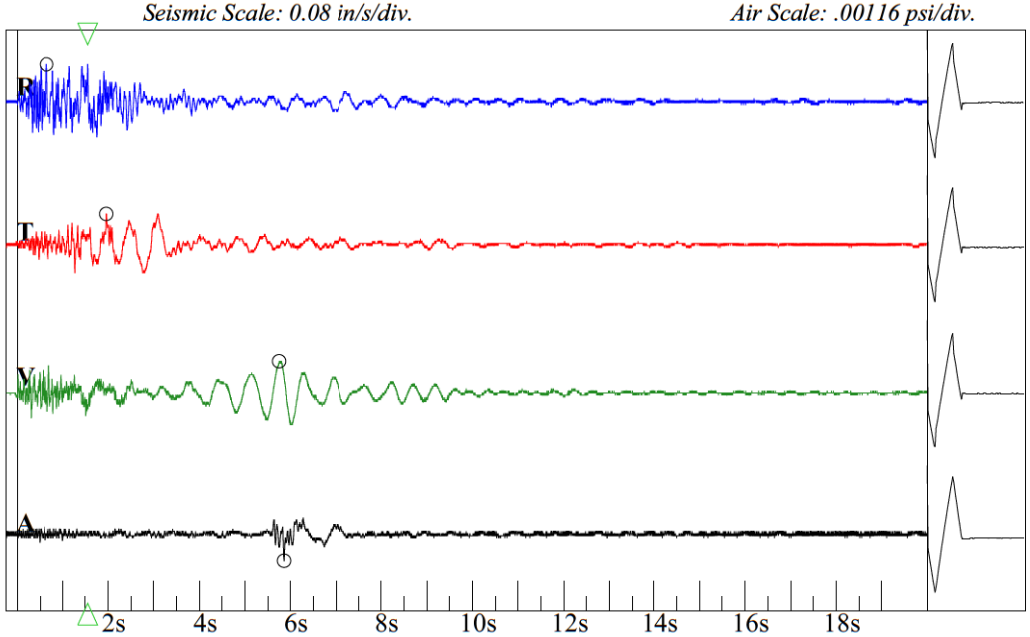
Air

Gain: 1 Air Trigger: 120 dBL

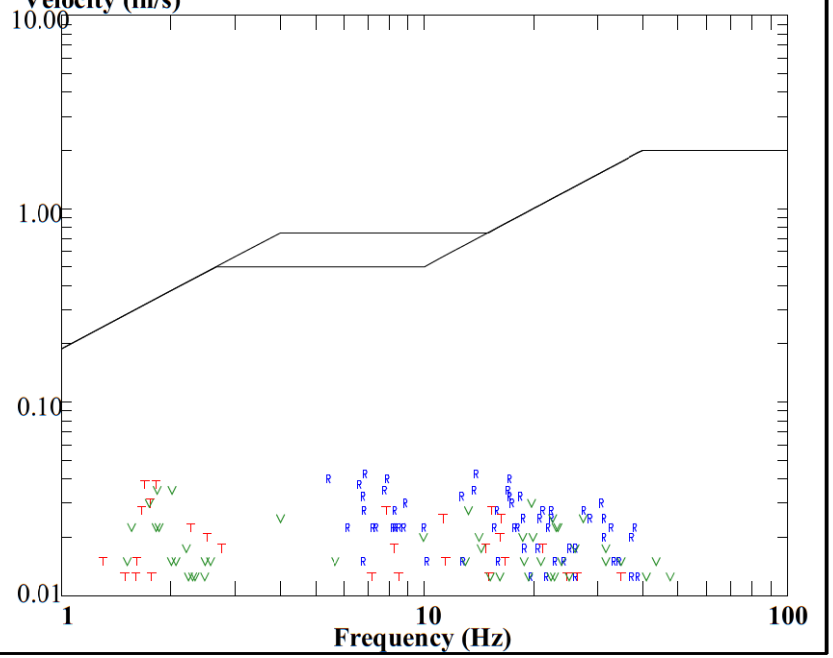
Measurement	Value	Trigger >>> Peak	
		5853.3	
psi	.0003627		
dBL	101.9		
Hz	11.9		

Waveform Analysis / Frequency Plot

Seismic Scale: 0.08 in/s/div. Air Scale: .00116 psi/div.



USBM Limits (RI 8507, 1980)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

15-Feb-18 at 09:15:59 AM Event # 8

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.045**	**0.048**
Frequency (Hz)	**7.70**	**1.70**	**2.00**
Displacement (in)	**0.0009**	**0.0042**	**0.0038**
Acceleration (g's)	**0.0056**	**0.0012**	**0.0015**
Trigger >>> Peak	901.4	3019.5	5986.6

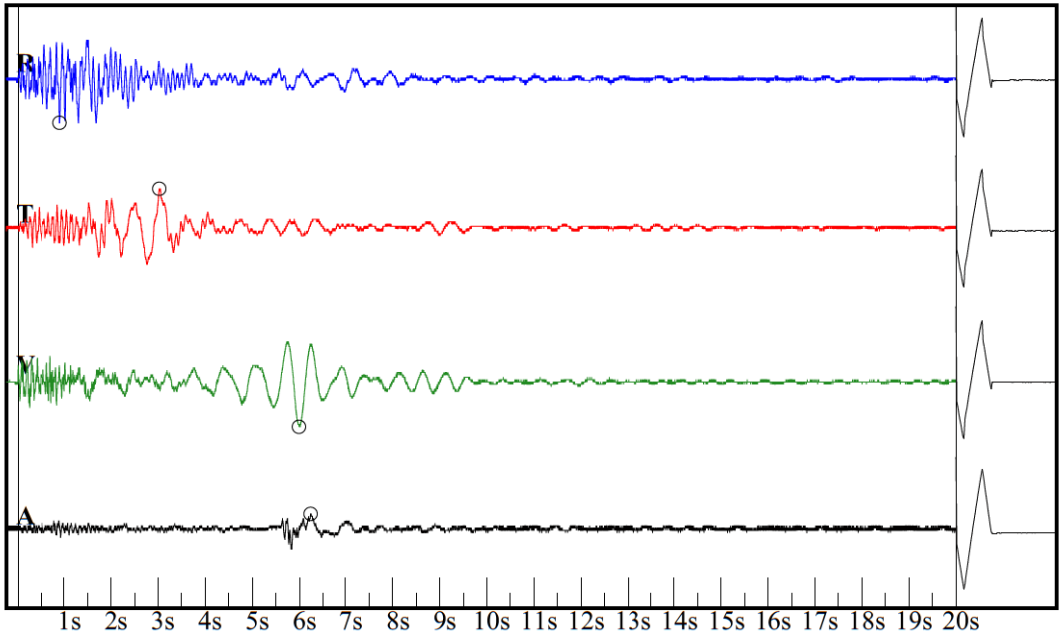
Air

Gain: 1 Trigger: 120 dBL

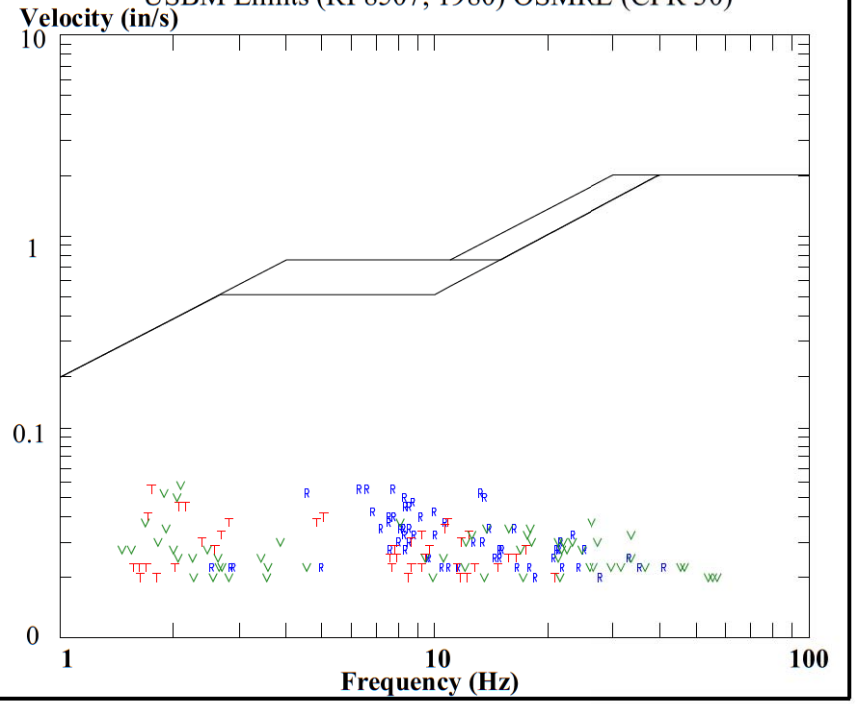
Measurement	Value	Trigger >>> Peak	
psi	.00029	6233.6	
dBL	**100**		
Hz	1.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

16-Feb-18 at 09:42:14 AM Event # 10

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.055**	**0.040**	**0.055**
Frequency (Hz)	**7.50**	**1.60**	**2.10**
Displacement (in)	**0.0012**	**0.0040**	**0.0042**
Acceleration (g's)	**0.0067**	**0.0010**	**0.0019**
Trigger >>> Peak	1698	3021	6011.5

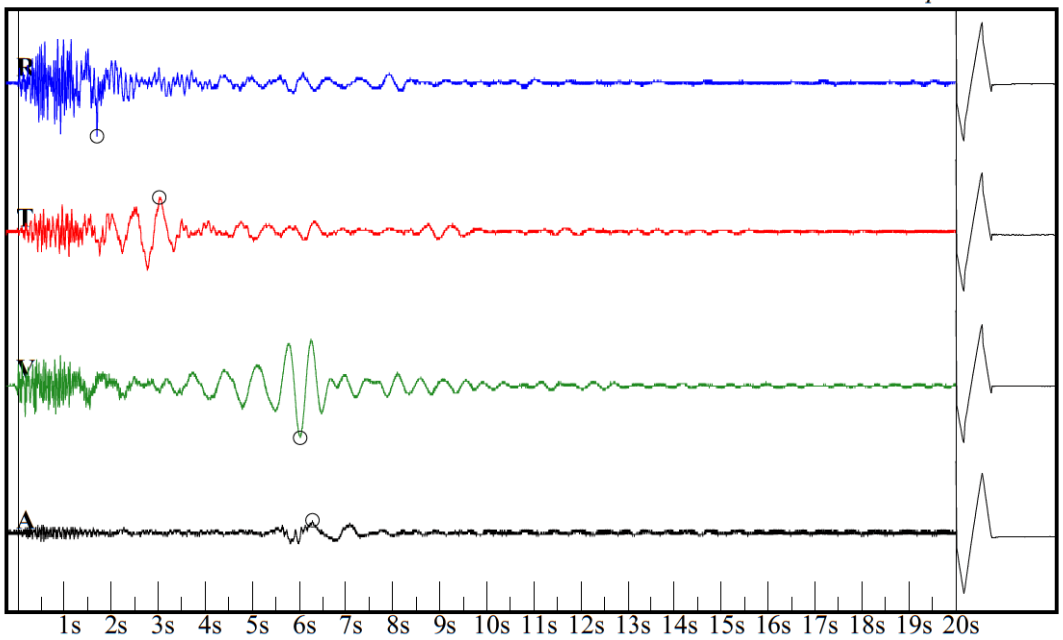
Air

Gain: 1 Trigger: 120 dBL

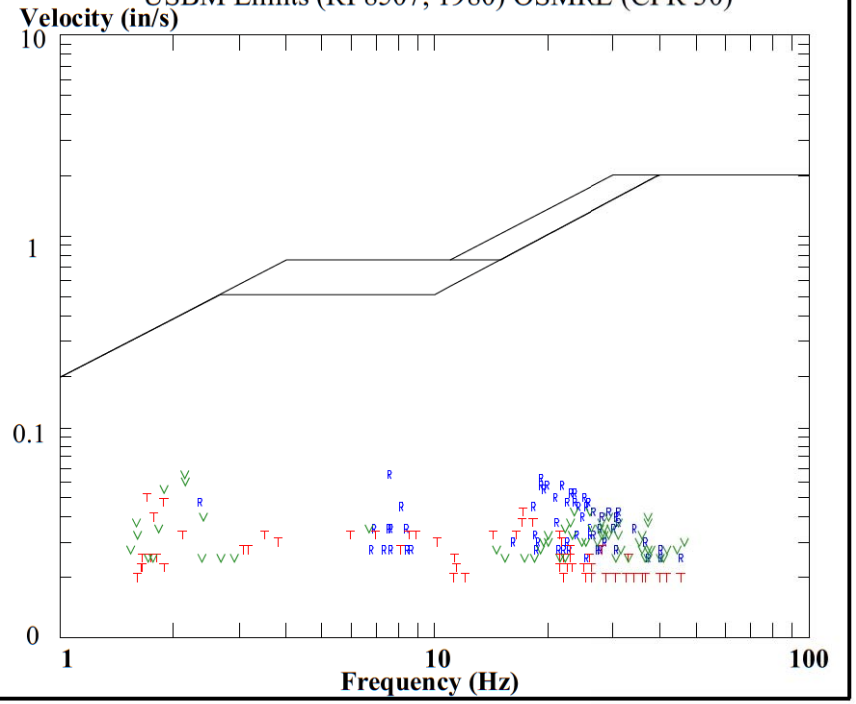
Measurement	Value	Trigger >>> Peak	
psi	.00025	6274.4	
dBL	**99**		
Hz	1.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

19-Feb-18 at 09:31:50 AM Event # 14

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.048**	**0.025**	**0.033**
Frequency (Hz)	**8.00**	**4.80**	**2.30**
Displacement (in)	**0.0009**	**0.0008**	**0.0022**
Acceleration (g's)	**0.0062**	**0.0020**	**0.0012**
Trigger >>> Peak	1157.7	1845.9	6523.2

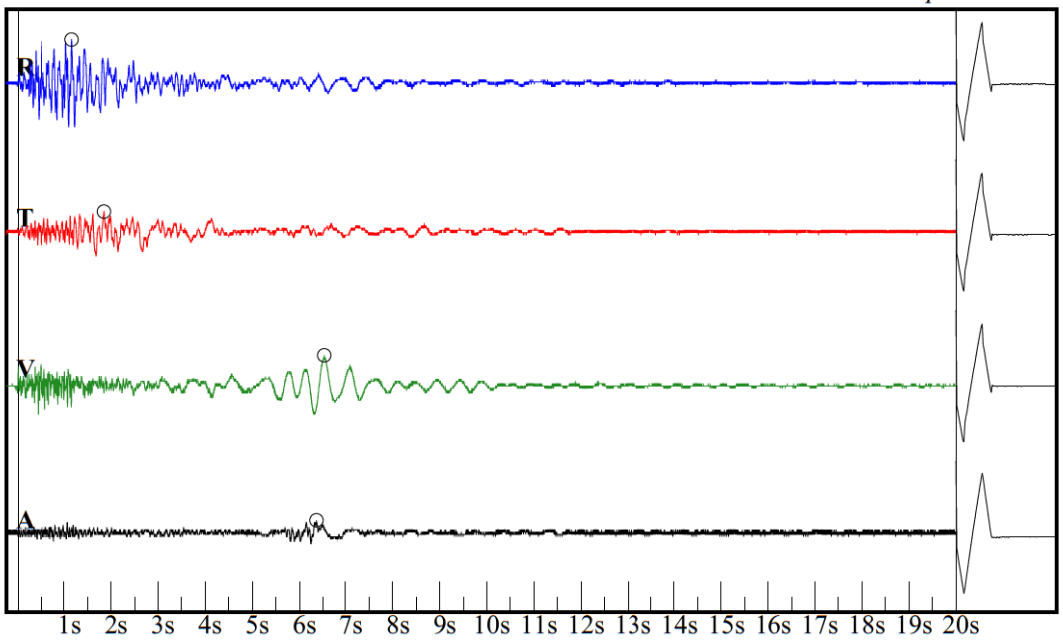
Air

Gain: 1 Trigger: 120 dBL

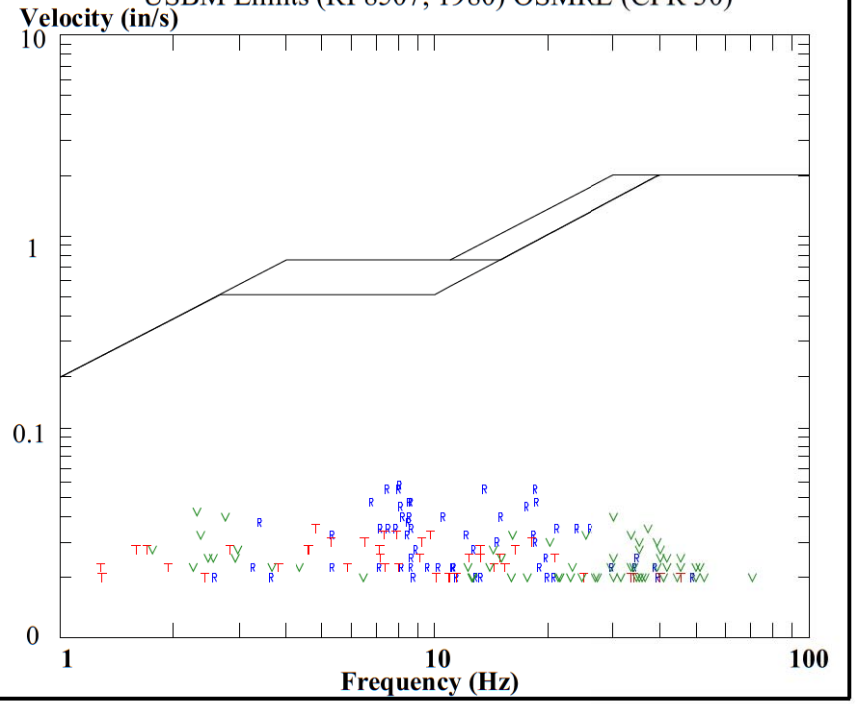
Measurement	Value	Trigger >>> Peak	
psi	.00025	6359.6	
dBL	**99**		
Hz	1.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

26-Feb-18 at 10:52:32 AM Event # 23

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.030**	**0.065**
Frequency (Hz)	**23.80**	**8.90**	**28.80**
Displacement (in)	**0.0003**	**0.0005**	**0.0004**
Acceleration (g's)	**0.0155**	**0.0043**	**0.0304**
Trigger >>> Peak	242.9	241.7	400.6

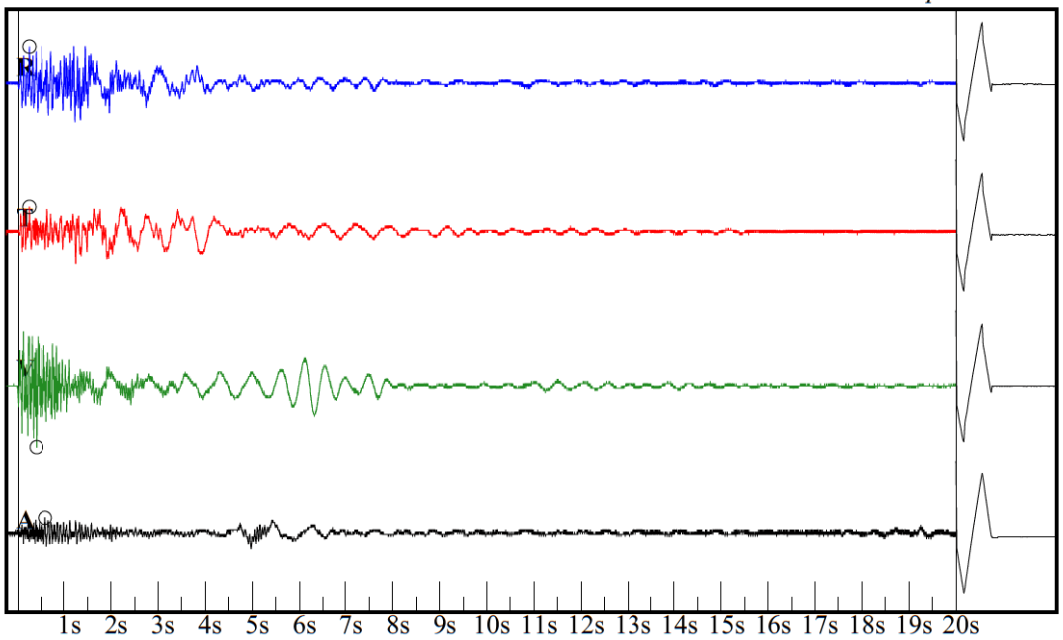
Air

Gain: 1 Trigger: 120 dBL

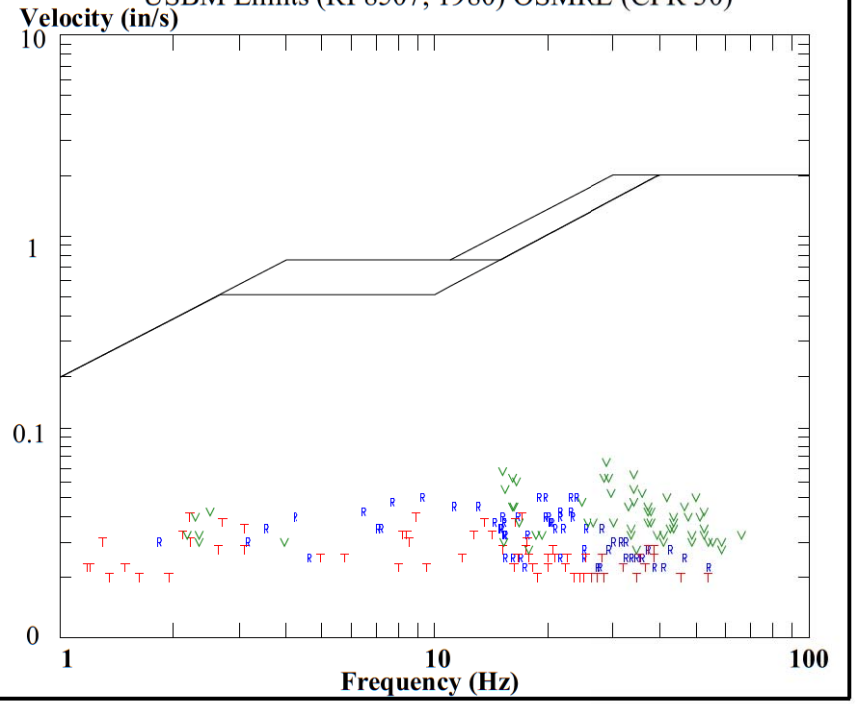
Measurement	Value	Trigger >>> Peak	
psi	.00029	585.9	
dBL	**100**		
Hz	16.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

27-Feb-18 at 15:19:27 PM Event # 25

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.053**	**0.045**	**0.068**
Frequency (Hz)	**4.40**	**2.00**	**16.70**
Displacement (in)	**0.0019**	**0.0036**	**0.0006**
Acceleration (g's)	**0.0038**	**0.0015**	**0.0183**
Trigger >>> Peak	1661.9	1971.7	223.4

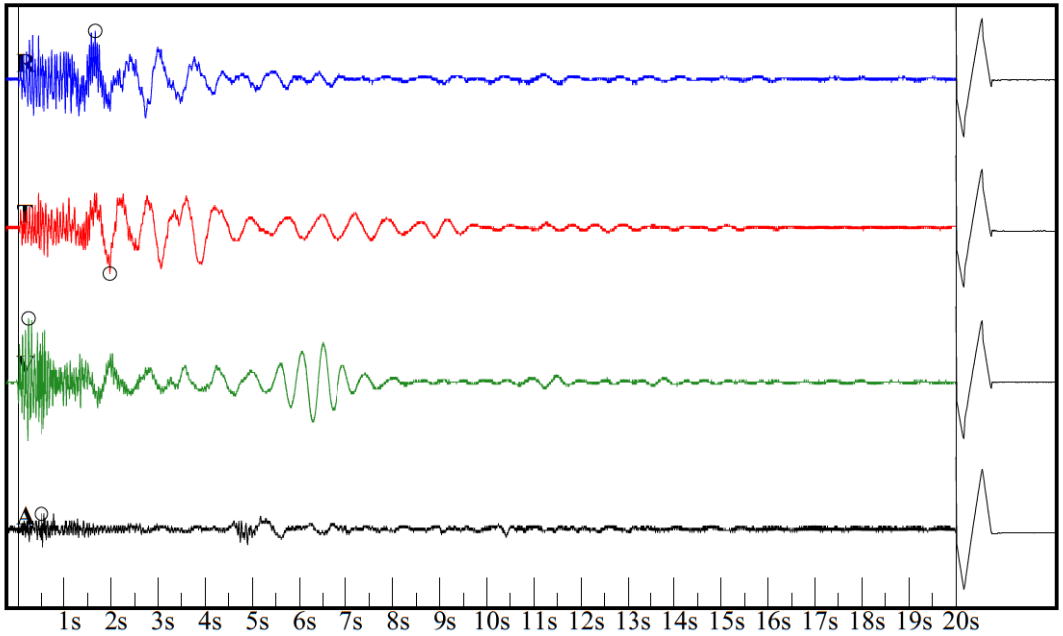
Air

Gain: 1 Trigger: 120 dBL

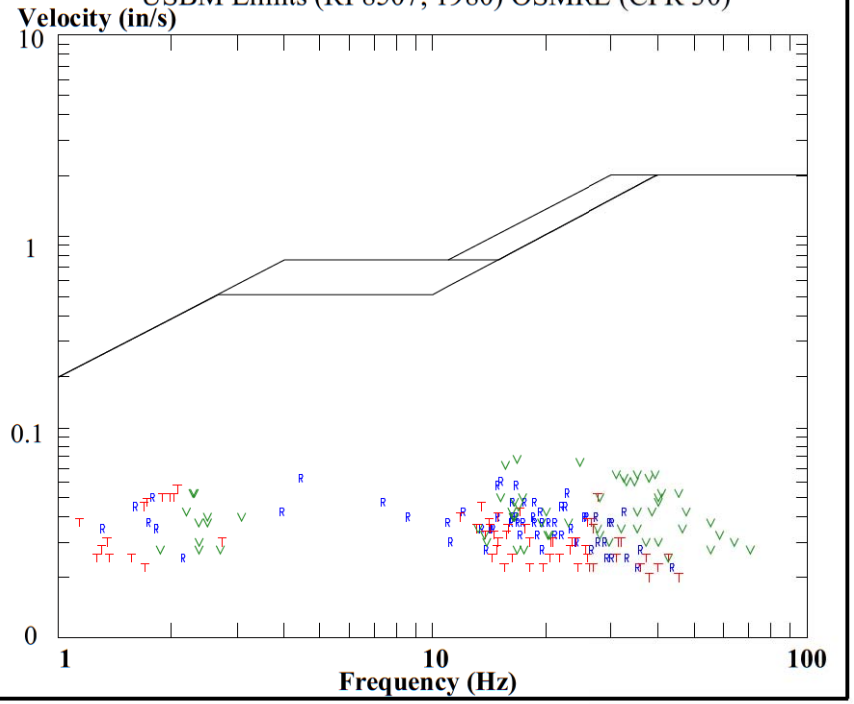
Measurement	Value	Trigger >>> Peak	
psi	.00029	507.8	
dBL	**100**		
Hz	32		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

06-Mar-18 at 11:10:01 AM Event # 35

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.013**	**0.013**
Frequency (Hz)	**7.80**	**6.30**	**24.60**
Displacement (in)	**0.0004**	**0.0003**	**0.0001**
Acceleration (g's)	**0.0025**	**0.0013**	**0.0050**
Trigger >>> Peak	454.6	3154.8	0

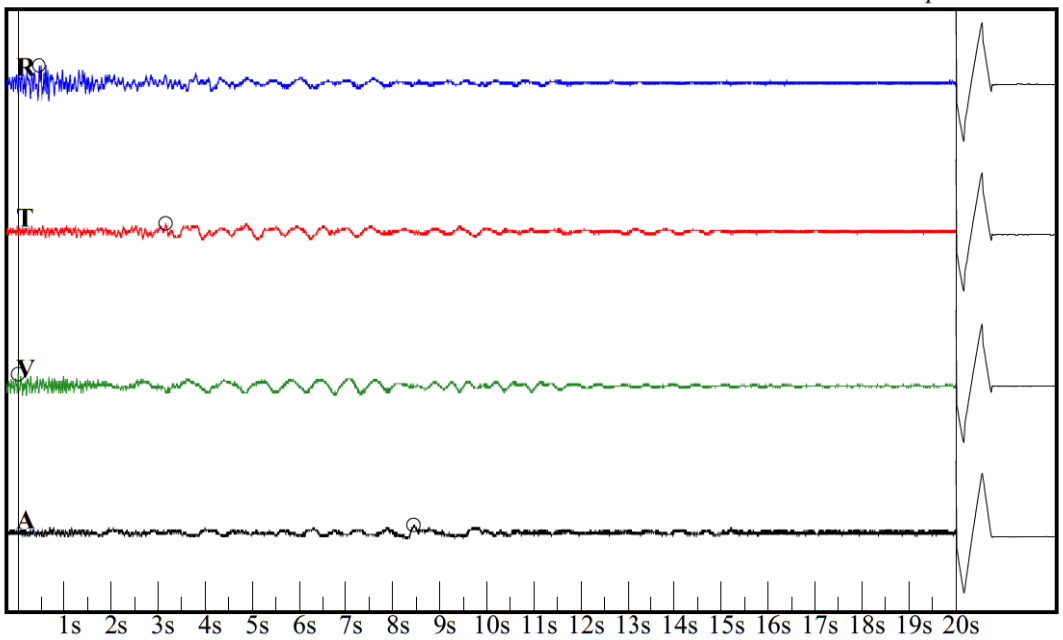
Air

Gain: 1 Trigger: 120 dBL

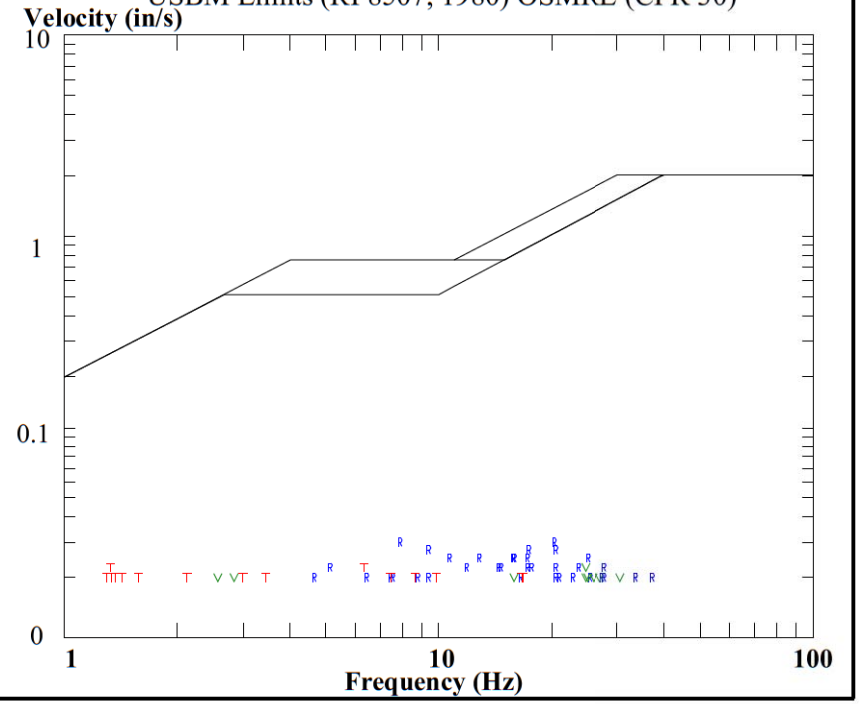
Measurement	Value	Trigger >>> Peak	
psi	.00018	8439.2	
dBL	**96**		
Hz	0.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

08-Mar-18 at 10:34:06 AM Event # 39

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.013**	**0.015**
Frequency (Hz)	**24.00**	**14.60**	**28.40**
Displacement (in)	**0.0001**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0078**	**0.0030**	**0.0069**
Trigger >>> Peak	628.9	1053.2	2.4

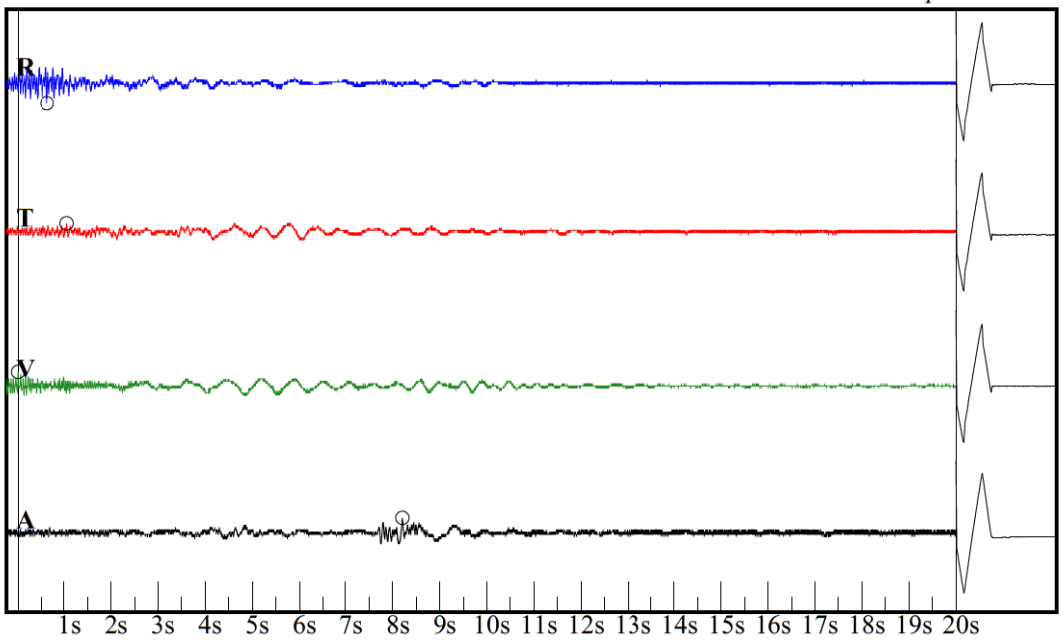
Air

Gain: 1 Trigger: 120 dBL

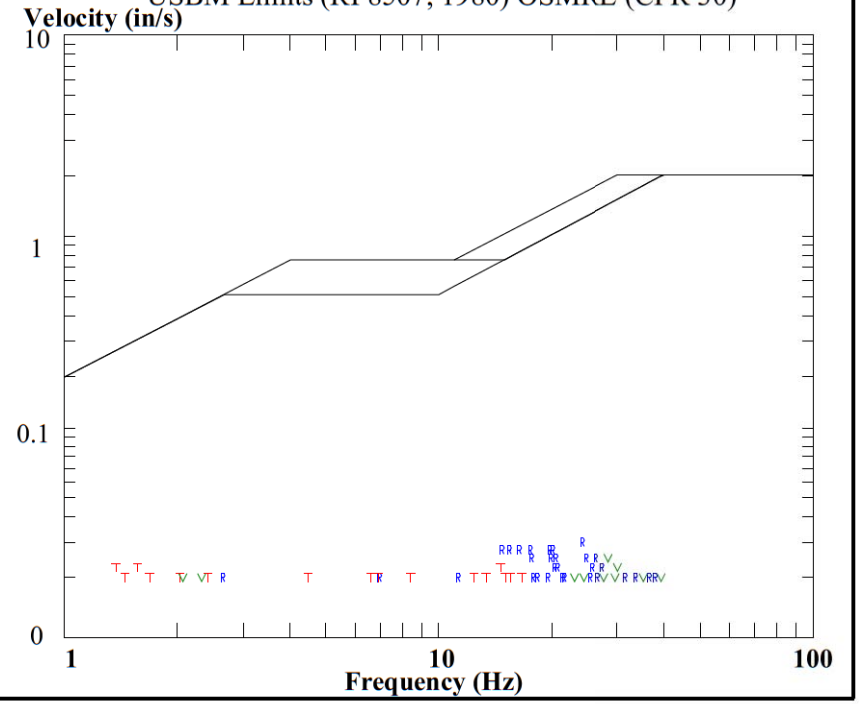
Measurement	Value	Trigger >>> Peak	
psi	.00029	8204.1	
dBL	**100**		
Hz	8.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

09-Mar-18 at 15:17:40 PM Event # 42

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.013**	**0.013**
Frequency (Hz)	**15.50**	**1.70**	**30.10**
Displacement (in)	**0.0002**	**0.0012**	**0.0001**
Acceleration (g's)	**0.0057**	**0.0003**	**0.0061**
Trigger >>> Peak	549.8	2042.5	0

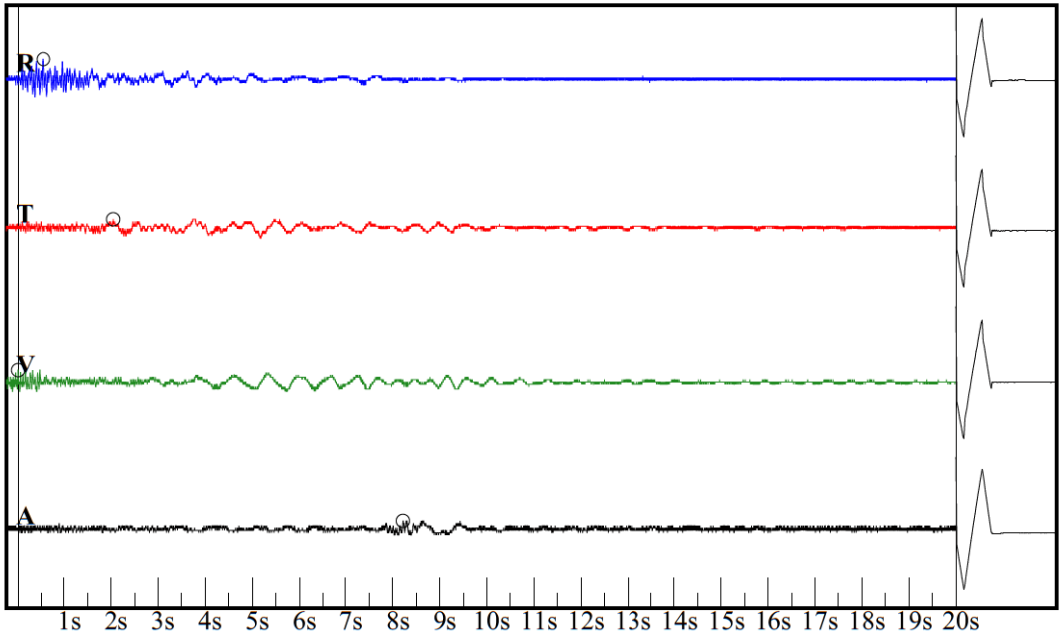
Air

Gain: 1 Trigger: 120 dBL

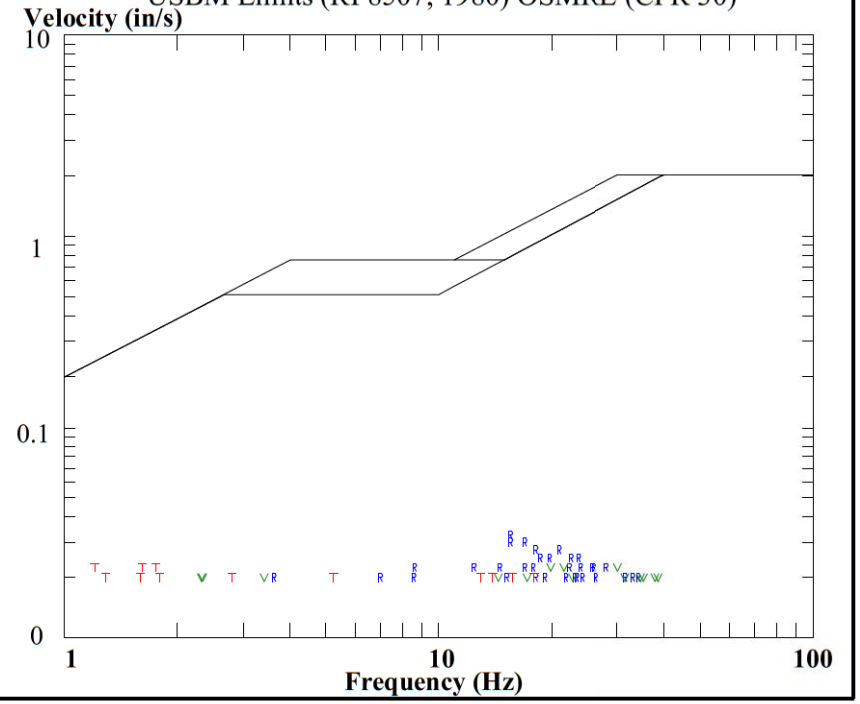
Measurement	Value	Trigger >>> Peak	
psi	.00018	8216.6	
dBL	**96**		
Hz	9.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

19-Mar-18 at 10:27:32 AM Event # 55

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.015**	**0.013**	**0.015**
Frequency (Hz)	**15.10**	**1.90**	**22.70**
Displacement (in)	**0.0002**	**0.0010**	**0.0001**
Acceleration (g's)	**0.0037**	**0.0004**	**0.0055**
Trigger >>> Peak	718.8	2051.3	269

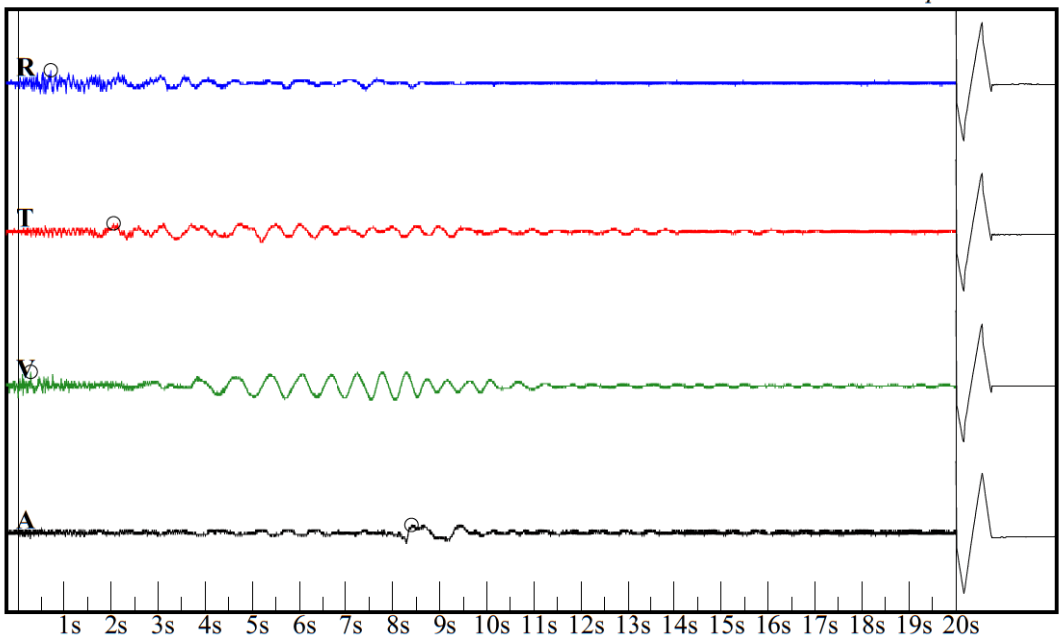
Air

Gain: 1 Trigger: 120 dBL

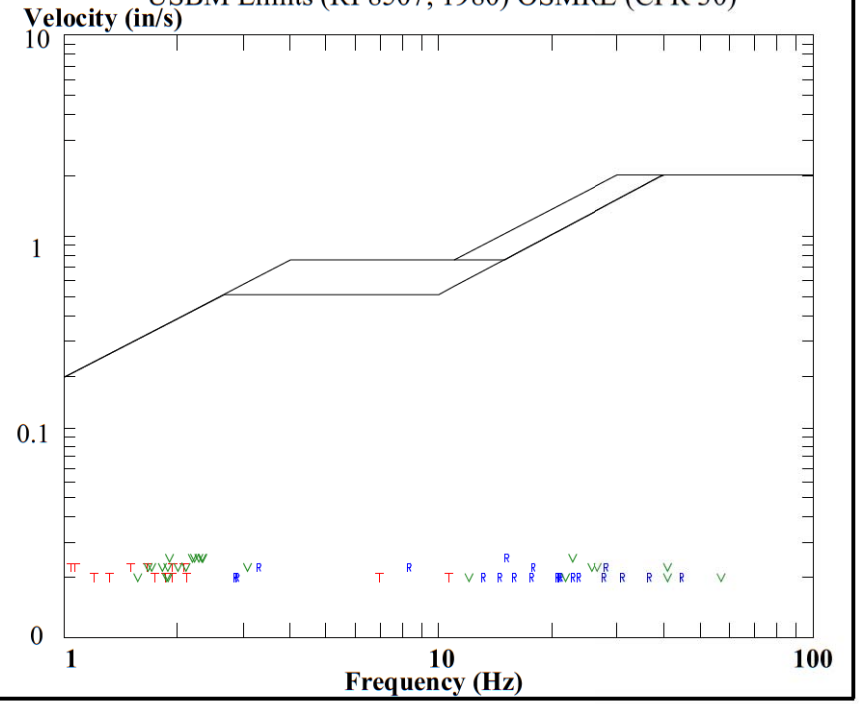
Measurement	Value	Trigger >>> Peak	
psi	.00018	8397.9	
dBL	**96**		
Hz	0.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

22-Mar-18 at 10:23:24 AM Event # 59

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.018**	**0.013**	**0.015**
Frequency (Hz)	**21.30**	**19.30**	**31.00**
Displacement (in)	**0.0001**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0061**	**0.0039**	**0.0076**
Trigger >>> Peak	229.2	1112.1	103.8

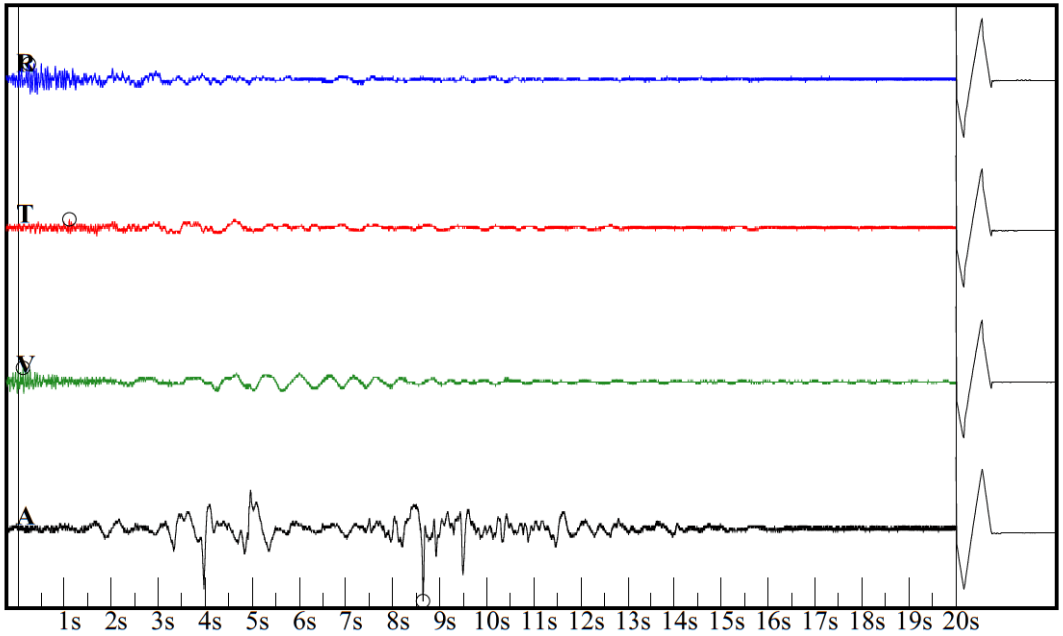
Air

Gain: 1 Trigger: 120 dBL

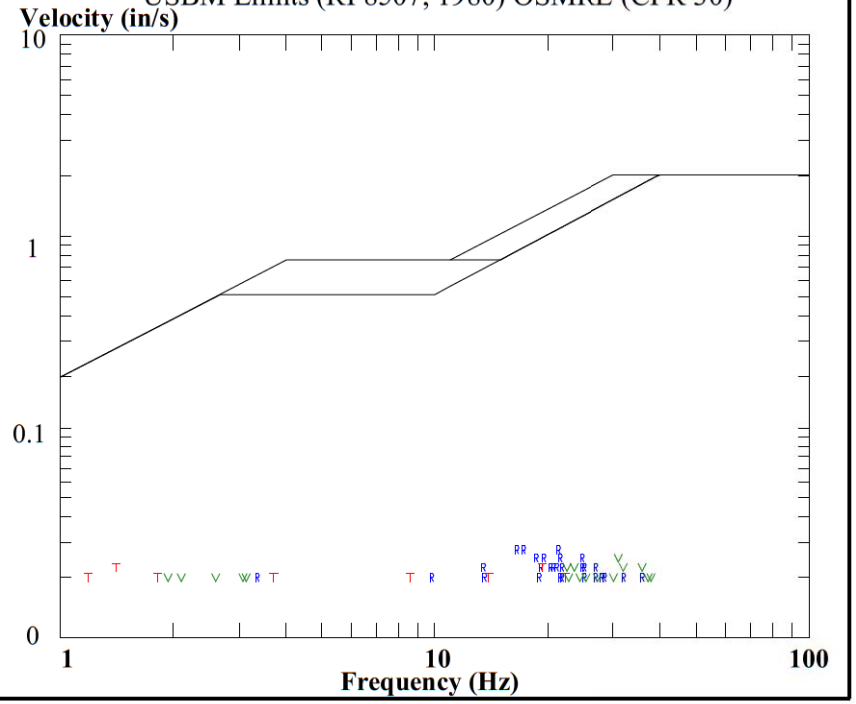
Measurement	Value	Trigger >>> Peak	
psi	.00105	8642.8	
dBL	**111**		
Hz	6.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

23-Mar-18 at 14:39:14 PM Event # 61

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.015**	**0.023**
Frequency (Hz)	**16.90**	**1.60**	**2.10**
Displacement (in)	**0.0002**	**0.0015**	**0.0017**
Acceleration (g's)	**0.0069**	**0.0004**	**0.0008**
Trigger >>> Peak	303.7	4532	7948

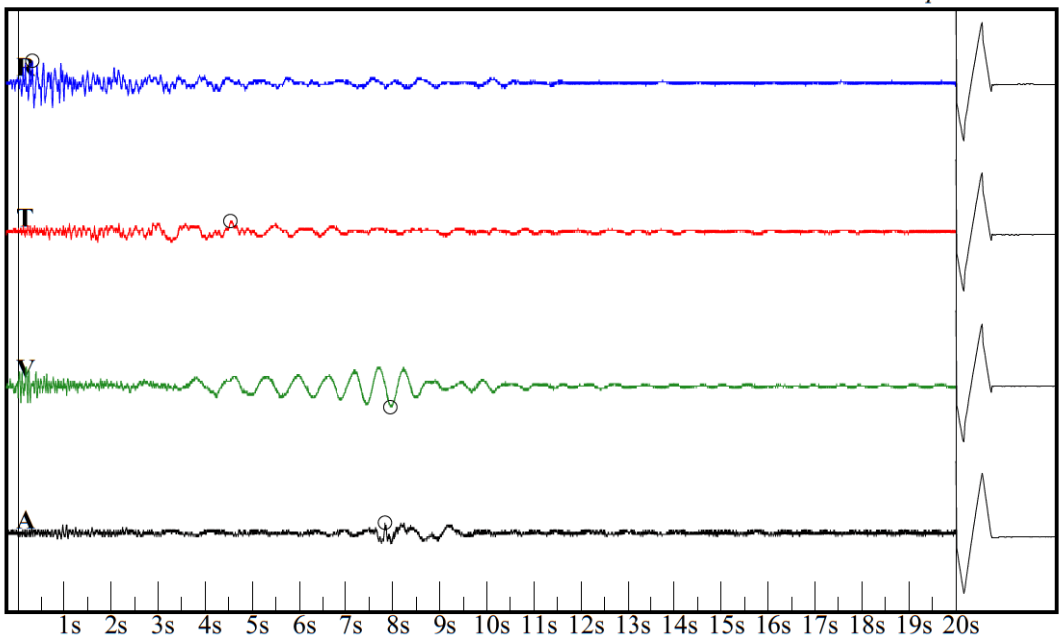
Air

Gain: 1 Trigger: 120 dBL

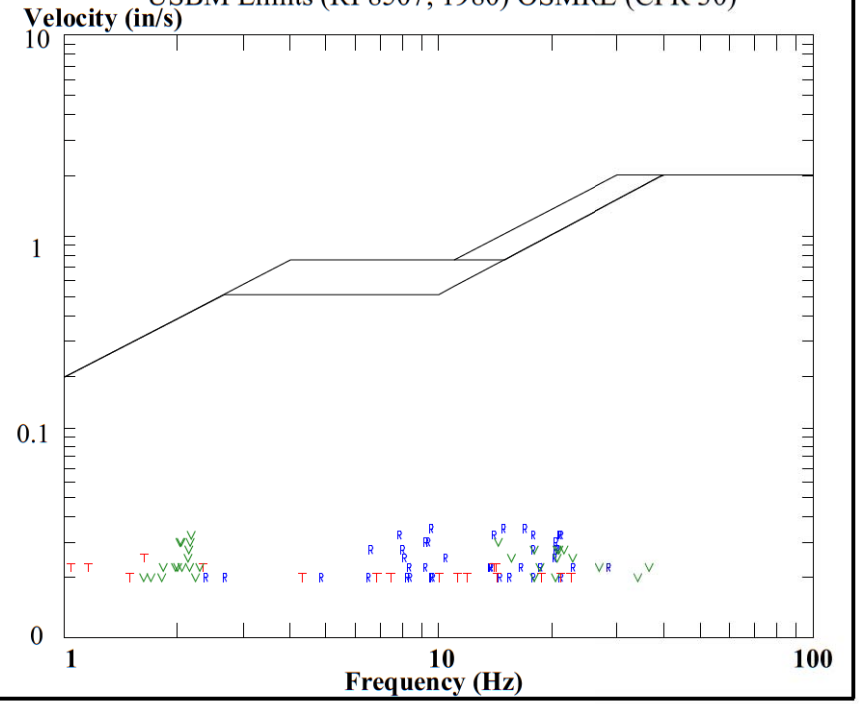
Measurement	Value	Trigger >>> Peak	
psi	.00022	7834.7	
dBL	**98**		
Hz	9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

27-Mar-18 at 11:09:06 AM Event # 66

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.015**	**0.018**
Frequency (Hz)	**20.00**	**1.20**	**2.50**
Displacement (in)	**0.0002**	**0.0020**	**0.0011**
Acceleration (g's)	**0.0073**	**0.0003**	**0.0007**
Trigger >>> Peak	1078.1	4577.6	8492.7

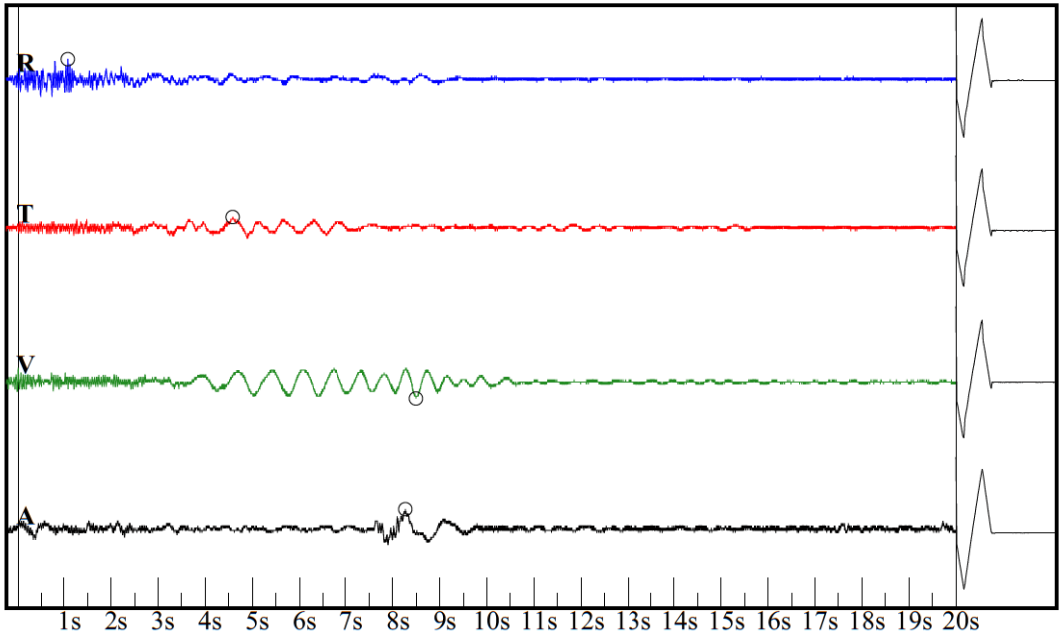
Air

Gain: 1 Trigger: 120 dBL

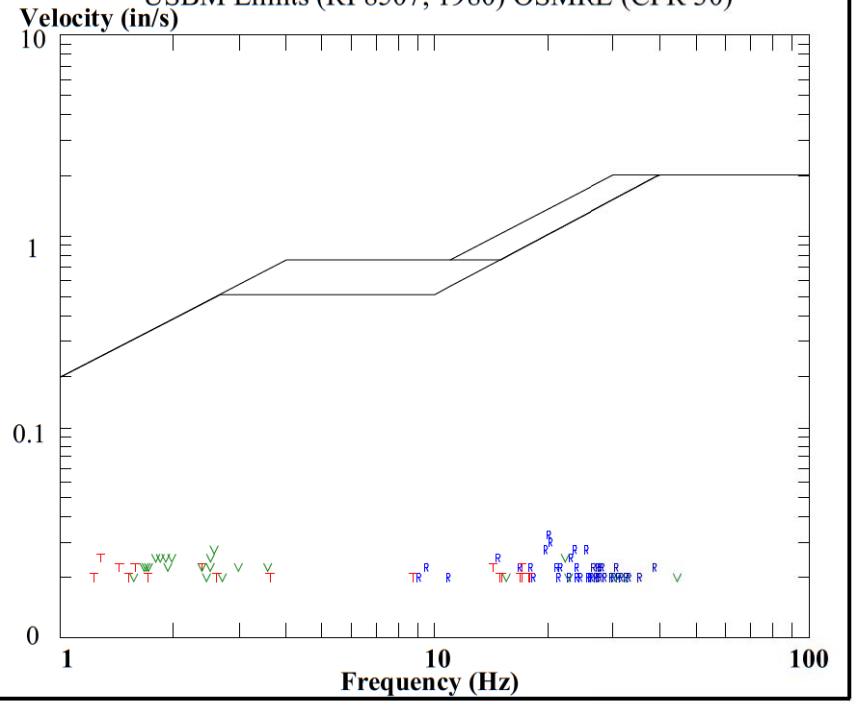
Measurement	Value	Trigger >>> Peak	
psi	.00036	8267.8	
dBL	**102**		
Hz	1.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

02-Apr-18 at 11:28:47 AM Event # 75

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.013**	**0.023**
Frequency (Hz)	**19.50**	**17.60**	**2.20**
Displacement (in)	**0.0002**	**0.0001**	**0.0016**
Acceleration (g's)	**0.0079**	**0.0036**	**0.0008**
Trigger >>> Peak	428.2	462.6	7716.8

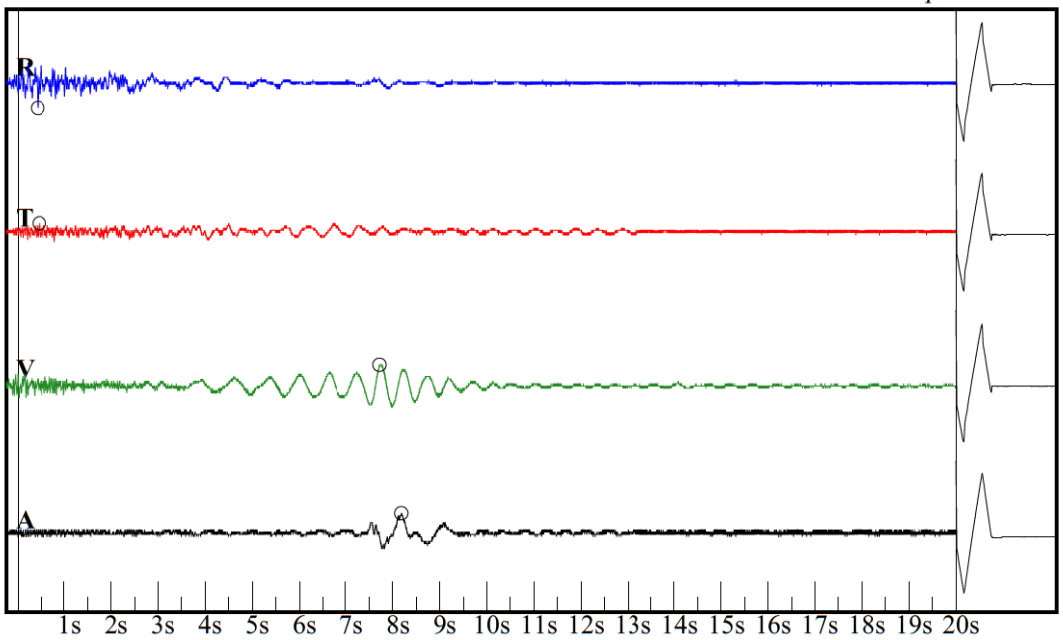
Air

Gain: 1 Trigger: 120 dBL

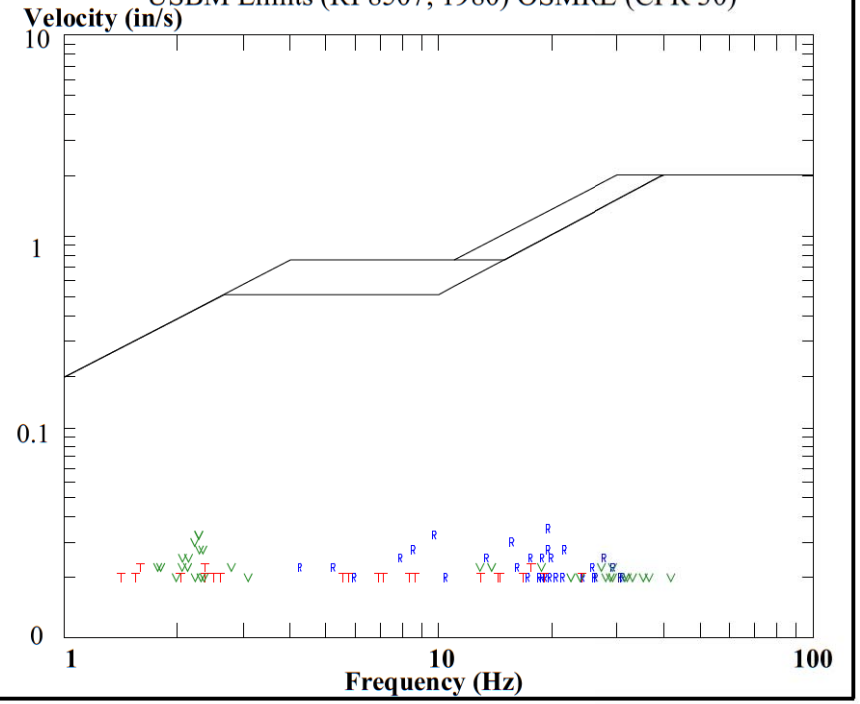
Measurement	Value	Trigger >>> Peak	
psi	.00036	8182.9	
dBL	**102**		
Hz	1.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

03-Apr-18 at 10:31:05 AM Event # 77

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.013**	**0.005**
Frequency (Hz)	**8.40**	**8.20**	**0.00**
Displacement (in)	**0.0002**	**0.0002**	
Acceleration (g's)	**0.0014**	**0.0017**	**0.0000**
Trigger >>> Peak	34.4	0	0

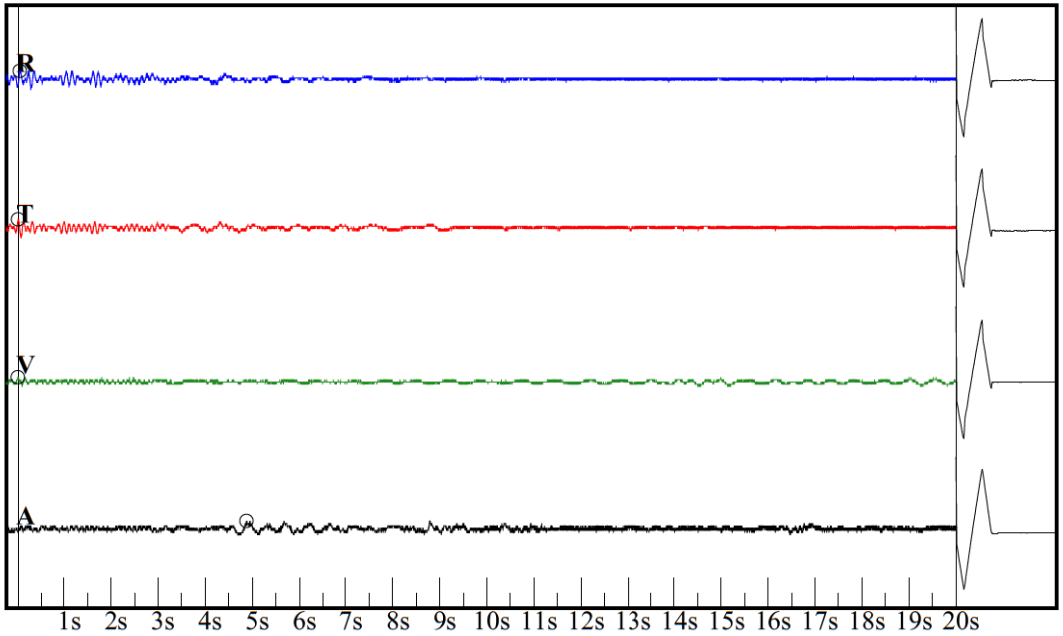
Air

Gain: 1 Trigger: 120 dBL

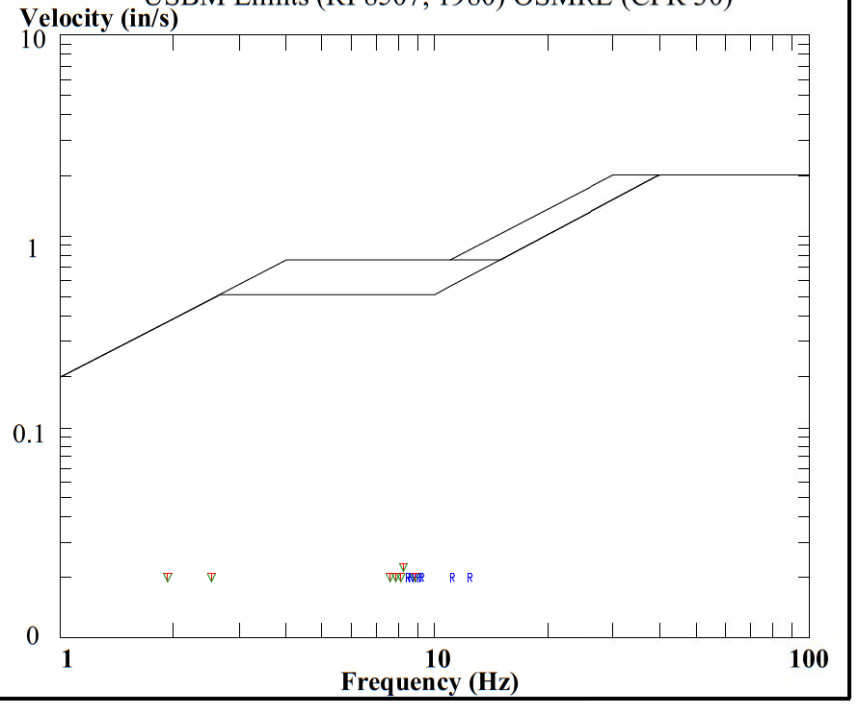
Measurement	Value	Trigger >>> Peak	
psi	.00018	4873	
dBL	**96**		
Hz	2.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

04-Apr-18 at 11:46:20 AM Event # 79

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.013**	**0.020**
Frequency (Hz)	**21.50**	**19.60**	**2.50**
Displacement (in)	**0.0002**	**0.0001**	**0.0013**
Acceleration (g's)	**0.0079**	**0.0040**	**0.0008**
Trigger >>> Peak	782.7	1429.4	7900.4

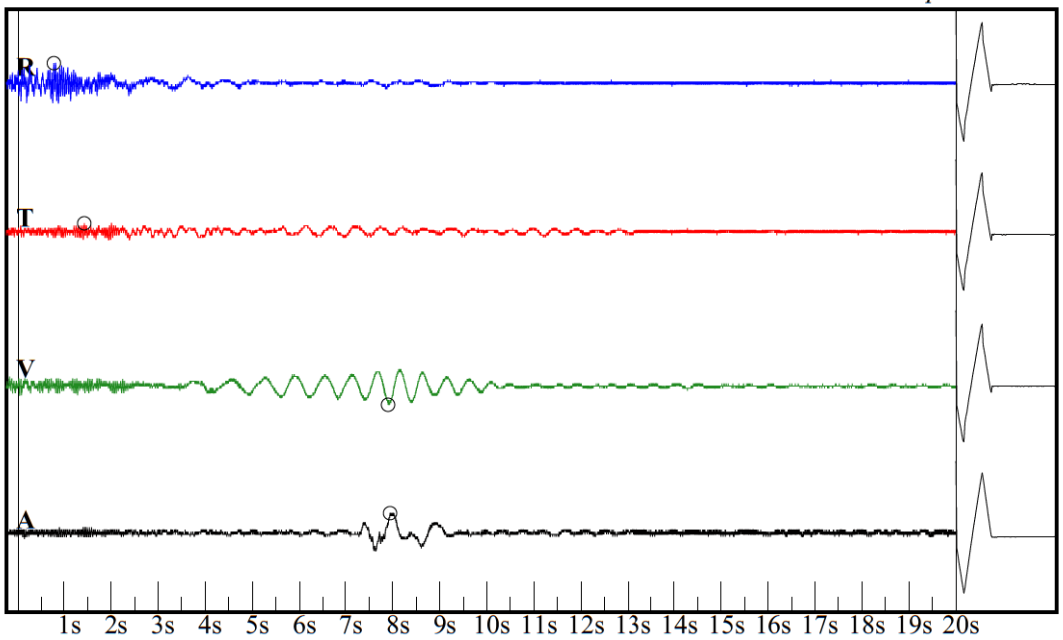
Air

Gain: 1 Trigger: 120 dBL

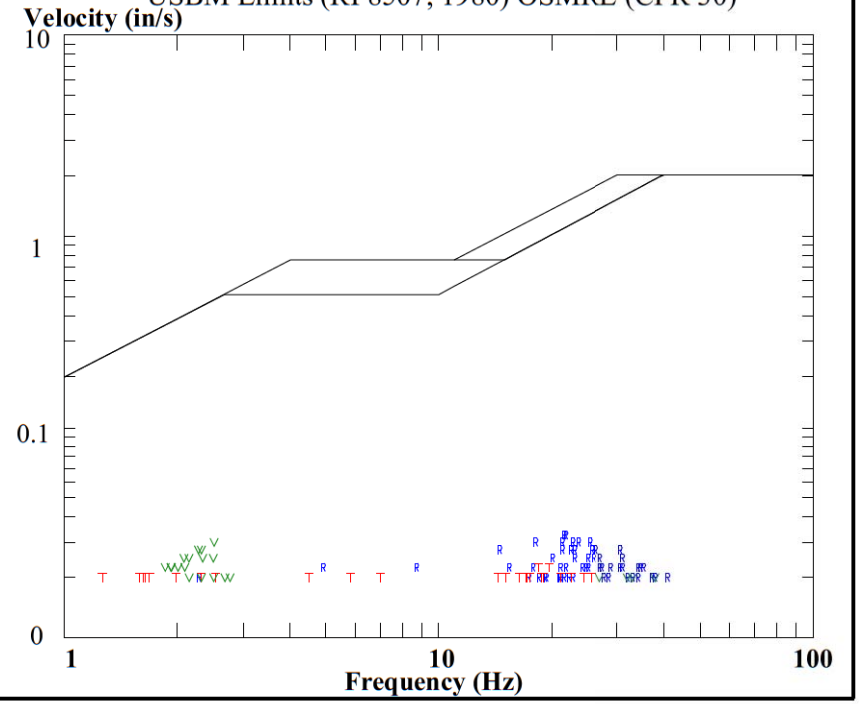
Measurement	Value	Trigger >>> Peak	
psi	.00036	7943.8	
dBL	**102**		
Hz	1.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12920

24-Apr-18 at 10:47:52 AM Event # 105

Location: West Lakes Mine Southwest Seismograph

Operator: RESPEC

Notes: 26.44878205 -81.72718093

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.013**	**0.015**	**0.015**
Frequency (Hz)	**2.10**	**1.70**	**1.90**
Displacement (in)	**0.0009**	**0.0014**	**0.0013**
Acceleration (g's)	**0.0004**	**0.0004**	**0.0005**
Trigger >>> Peak	717.5	21	15251.5

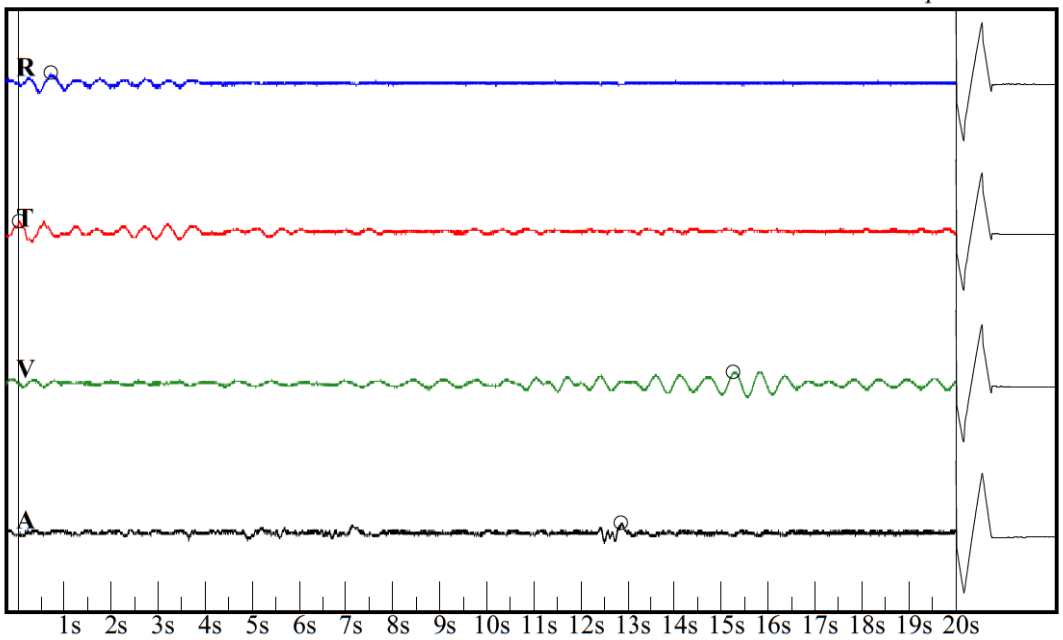
Air

Gain: 1 Trigger: 120 dBL

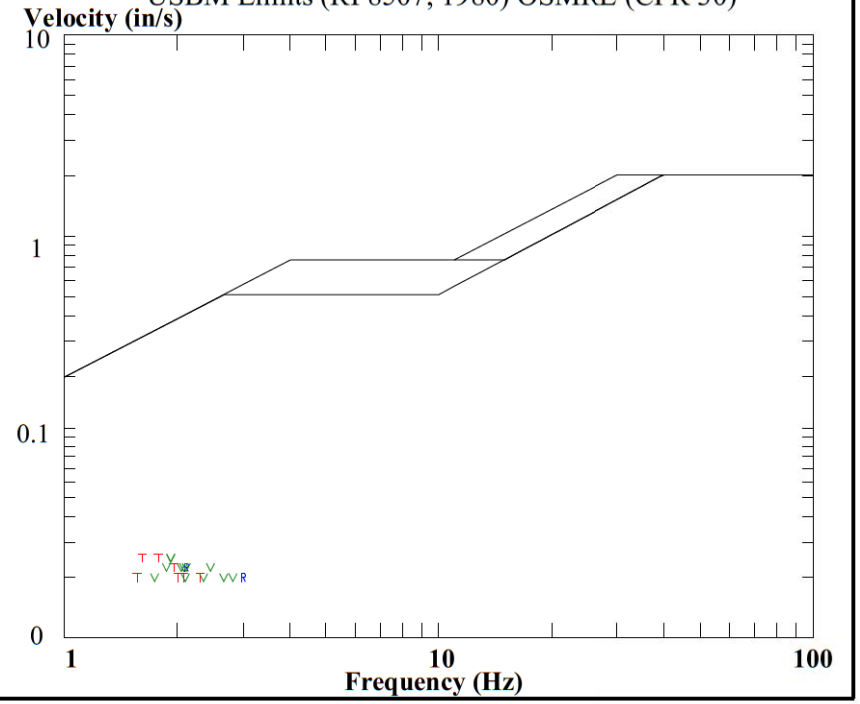
Measurement	Value	Trigger >>> Peak	
psi	.00022	12842.3	
dBL	**98**		
Hz	1.7		

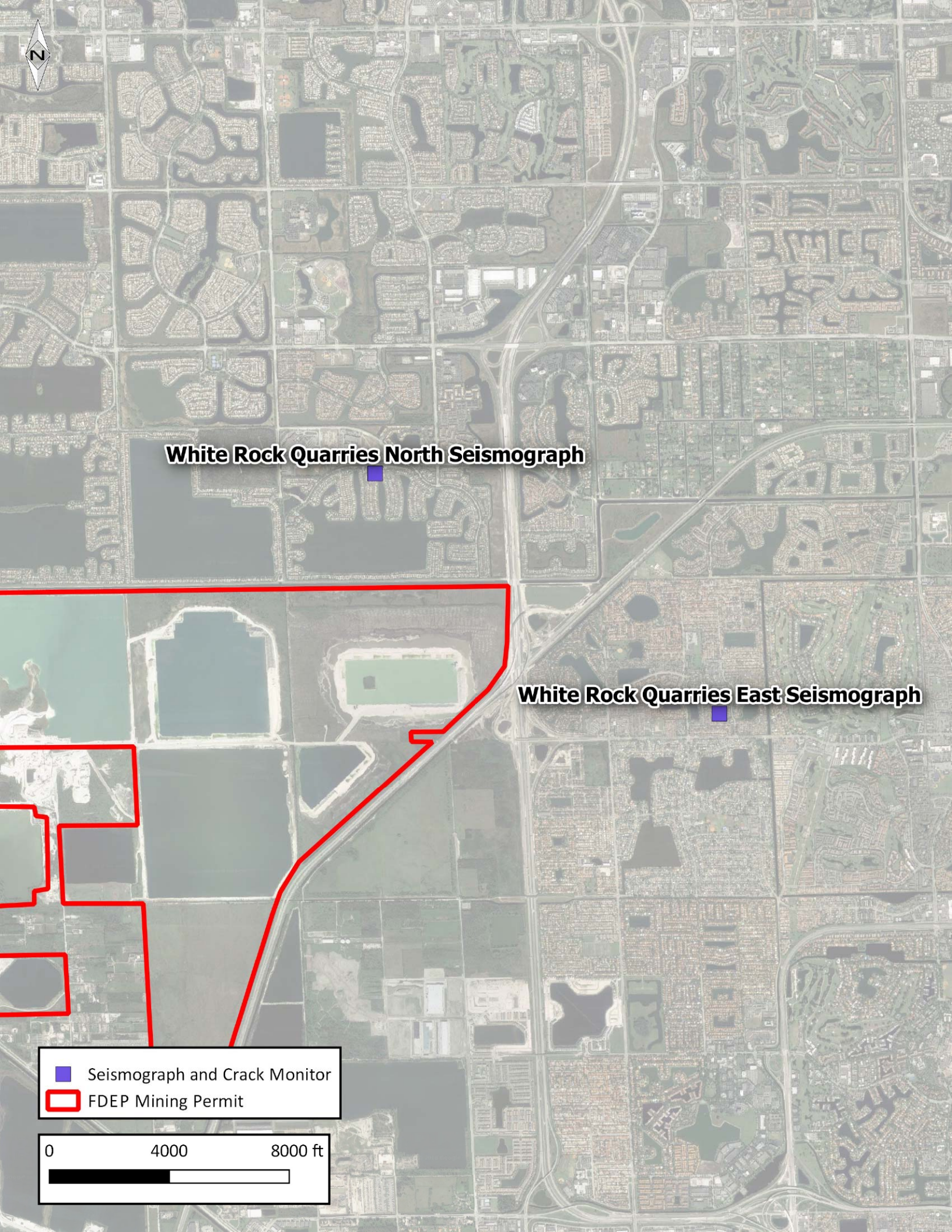
Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)




N
White Rock Quarries North Seismograph
White Rock Quarries East Seismograph
Seismograph and Crack Monitor
FDEP Mining Permit
0
4000
8000 ft

SuperGraphics - Report

Telephone: (205)592-2488 x 23

Company: RESPEC

Unit #: 11131

2/13/2018 at 13:15:00 Event # 8

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 28.944566 -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N | Wgt. Per Delay: N | Scaled Distance: 0.0

Seismic

Gain: 2 Trigger: .02 in/s ▽ Vector Sum: 0.12 in/s @ 27.31 Hz

Channel	Radial	Transverse	Vertical
○ Velocity (in/s)	0.078	0.050	0.108
Frequency (Hz)	9.00	1.50	27.60
Trigger >>> Peak	1033.4	3959.2	935.5

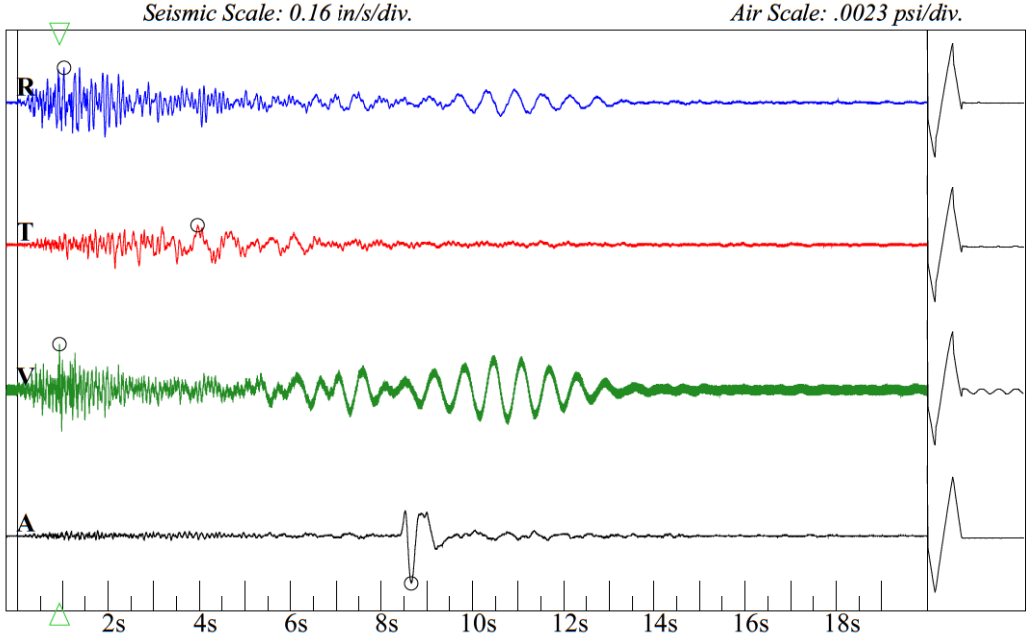
Air

Gain: 1 Air Trigger: 120 dBL

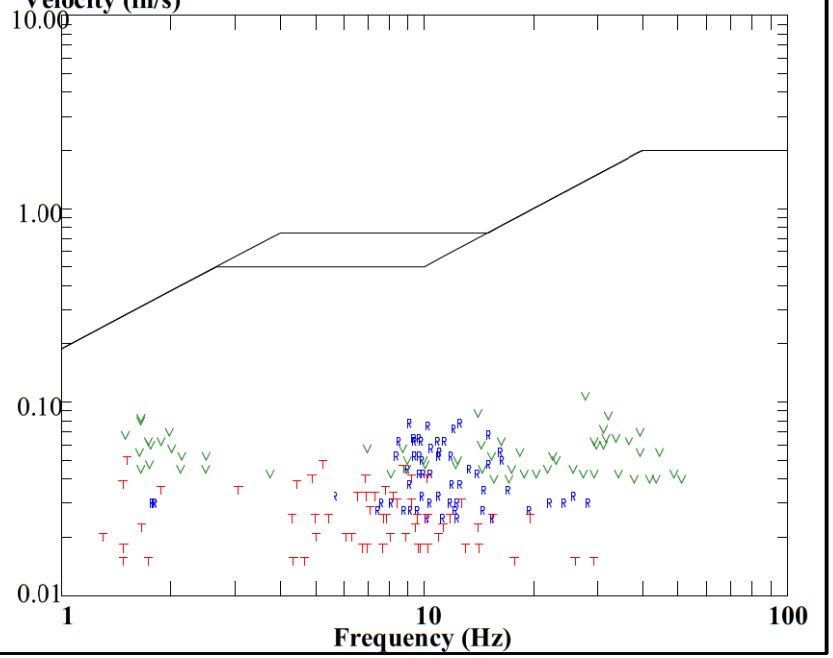
Measurement	Value	Trigger >>> Peak	
		8658.2	
psi	.0014508		
dBL	114.0		
Hz	2.7		

Waveform Analysis / Frequency Plot

Seismic Scale: 0.16 in/s/div. Air Scale: .0023 psi/div.



USBM Limits (RI 8507, 1980)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

14-Feb-18 at 13:36:05 PM Event # 11

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 28.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .01 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.018**	**0.025**
Frequency (Hz)	**5.80**	**7.30**	**28.80**
Displacement (in)	**0.0007**	**0.0004**	**0.0001**
Acceleration (g's)	**0.0024**	**0.0021**	**0.0117**
Trigger >>> Peak	4102.1	6385.3	3918.5

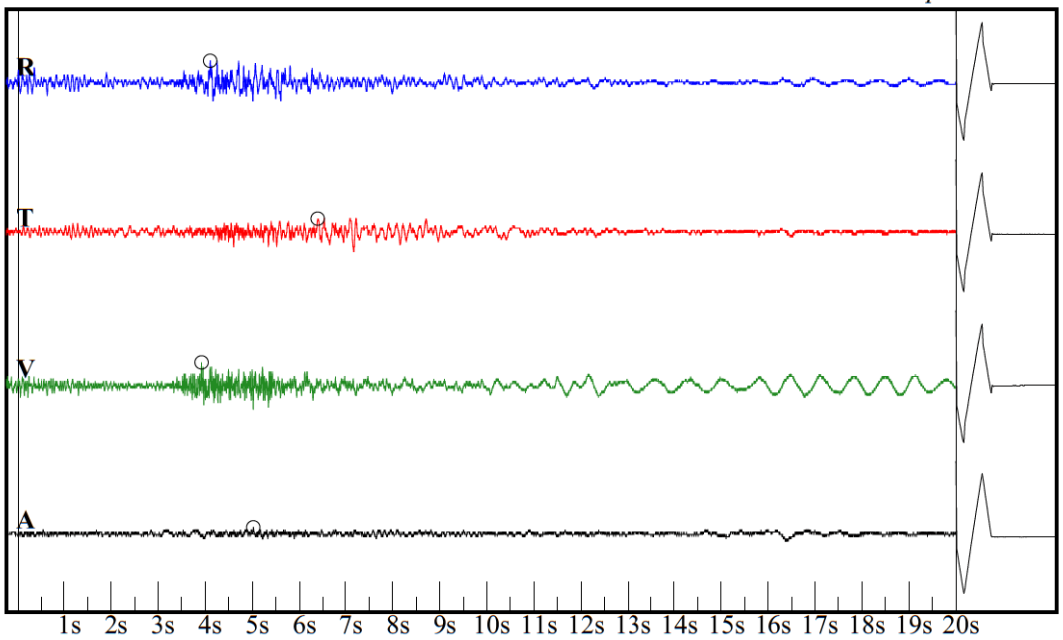
Air

Gain: 1 Trigger: 120 dBL

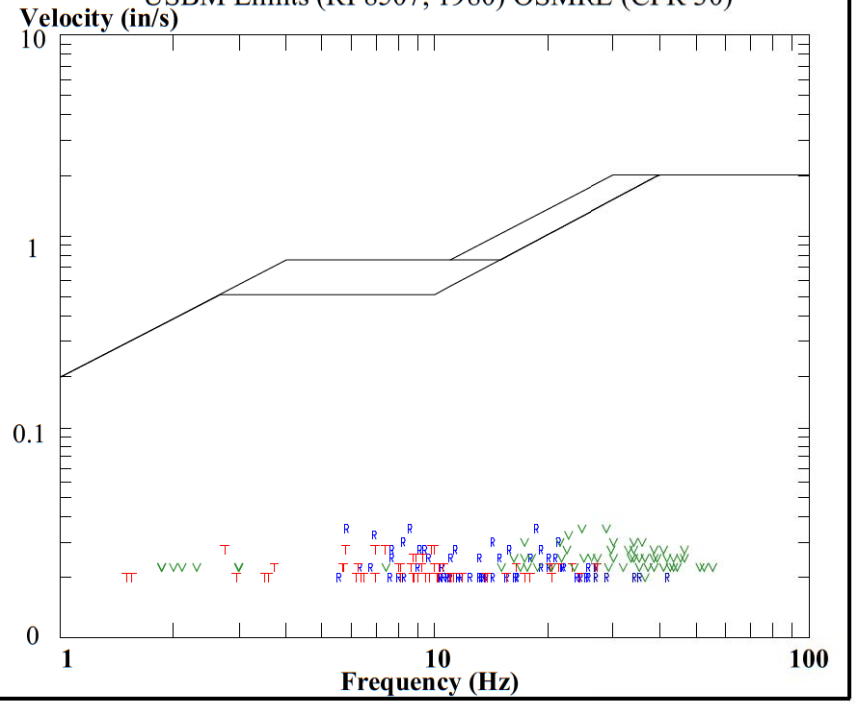
Measurement	Value	Trigger >>> Peak	
psi	.00015	5016.6	
dBL	**94**		
Hz	8.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

16-Feb-18 at 11:29:41 AM Event # 148

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.033**	**0.063**
Frequency (Hz)	**11.30**	**5.00**	**34.10**
Displacement (in)	**0.0006**	**0.0010**	**0.0003**
Acceleration (g's)	**0.0083**	**0.0026**	**0.0347**
Trigger >>> Peak	2048.1	3212.9	473.1

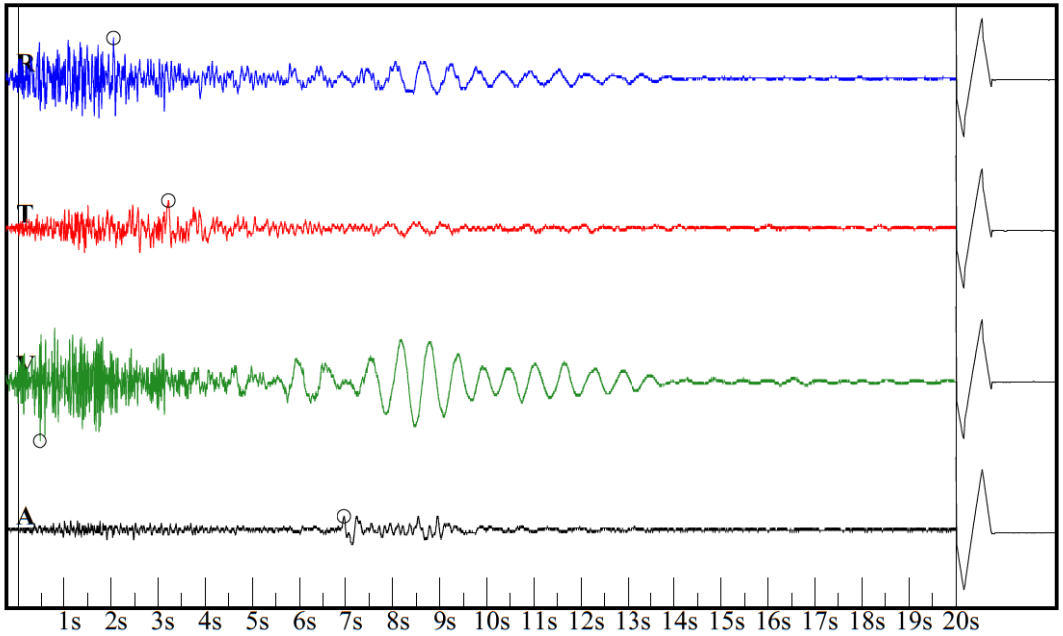
Air

Gain: 1 Trigger: 120 dBL

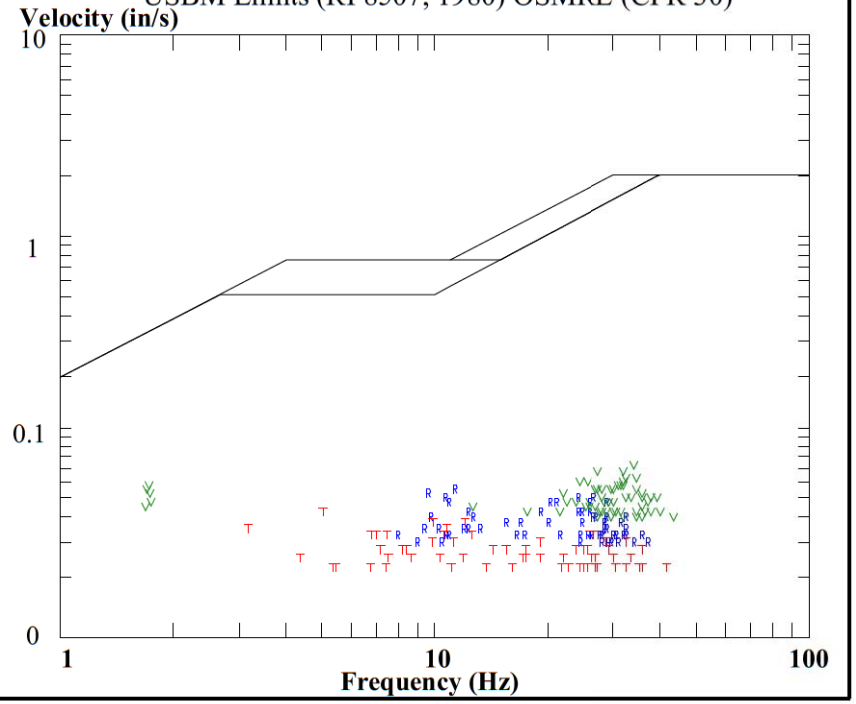
Measurement	Value	Trigger >>> Peak	
psi	.00025	6960.4	
dBL	**99**		
Hz	4.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

19-Feb-18 at 13:59:46 PM Event # 156

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.093**	**0.055**	**0.105**
Frequency (Hz)	**19.60**	**8.80**	**33.50**
Displacement (in)	**0.0008**	**0.0010**	**0.0005**
Acceleration (g's)	**0.0295**	**0.0079**	**0.0572**
Trigger >>> Peak	1252.7	2099.6	460.9

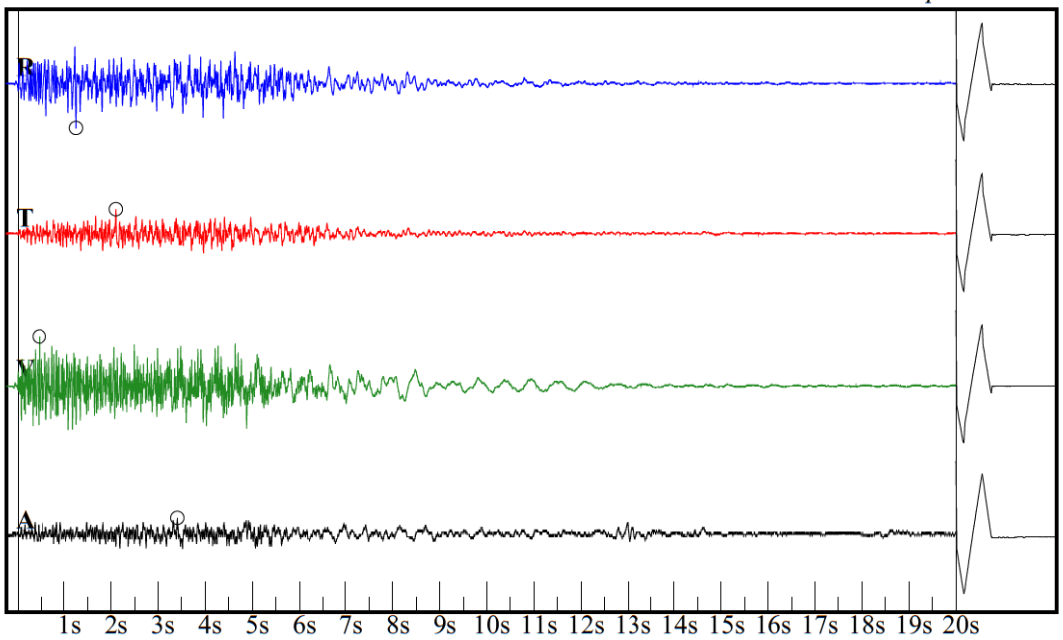
Air

Gain: 1 Trigger: 120 dBL

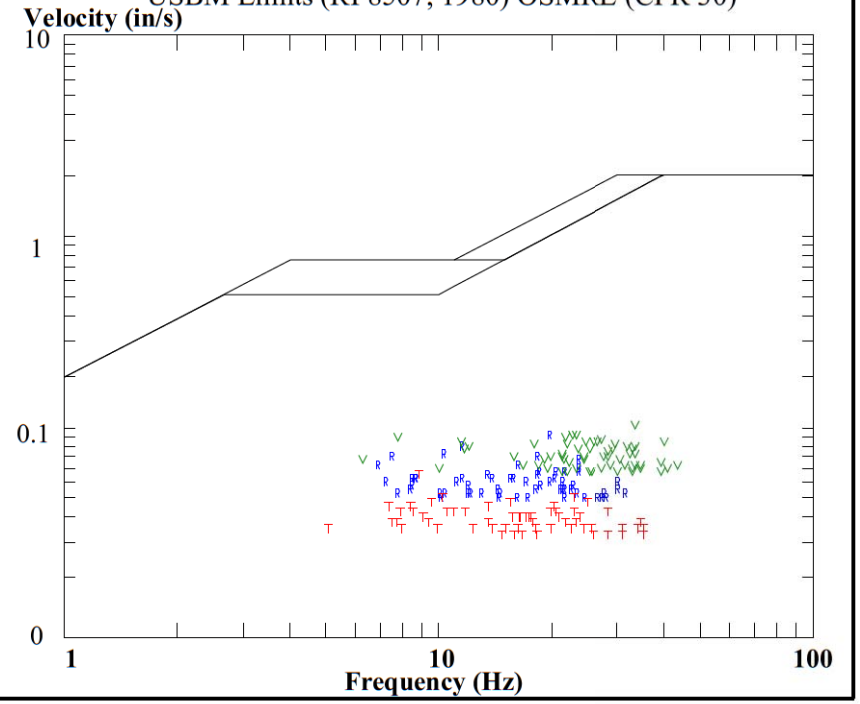
Measurement	Value	Trigger >>> Peak	
psi	.00029	3403.8	
dBL	**100**		
Hz	13.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

20-Feb-18 at 13:15:03 PM Event # 158

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.020**	**0.060**
Frequency (Hz)	**11.10**	**16.70**	**28.80**
Displacement (in)	**0.0006**	**0.0002**	**0.0003**
Acceleration (g's)	**0.0072**	**0.0054**	**0.0281**
Trigger >>> Peak	886	1611.8	471.4

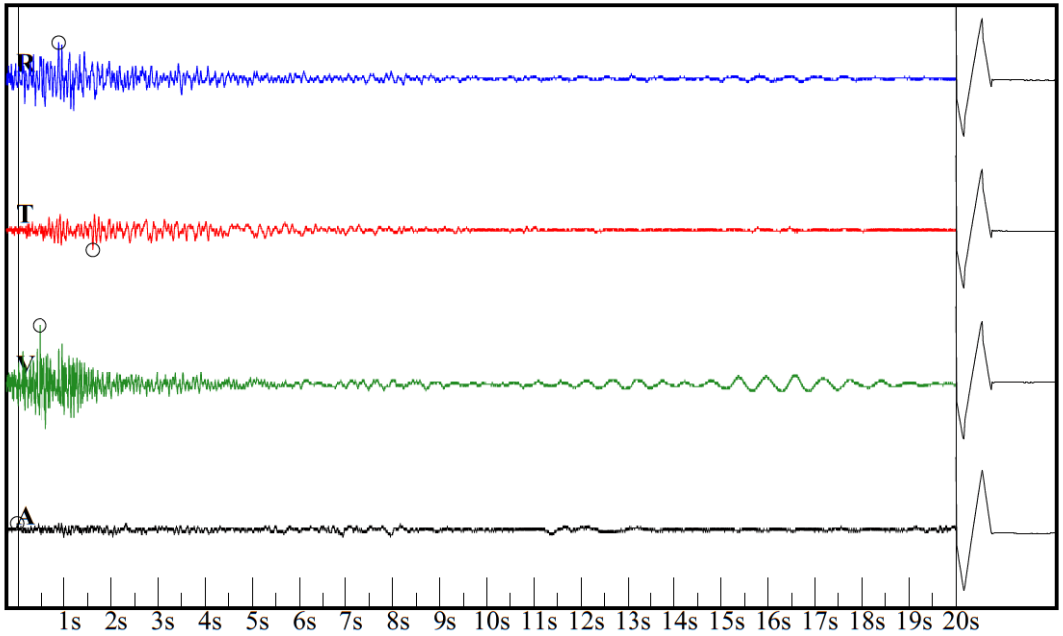
Air

Gain: 1 Trigger: 120 dBL

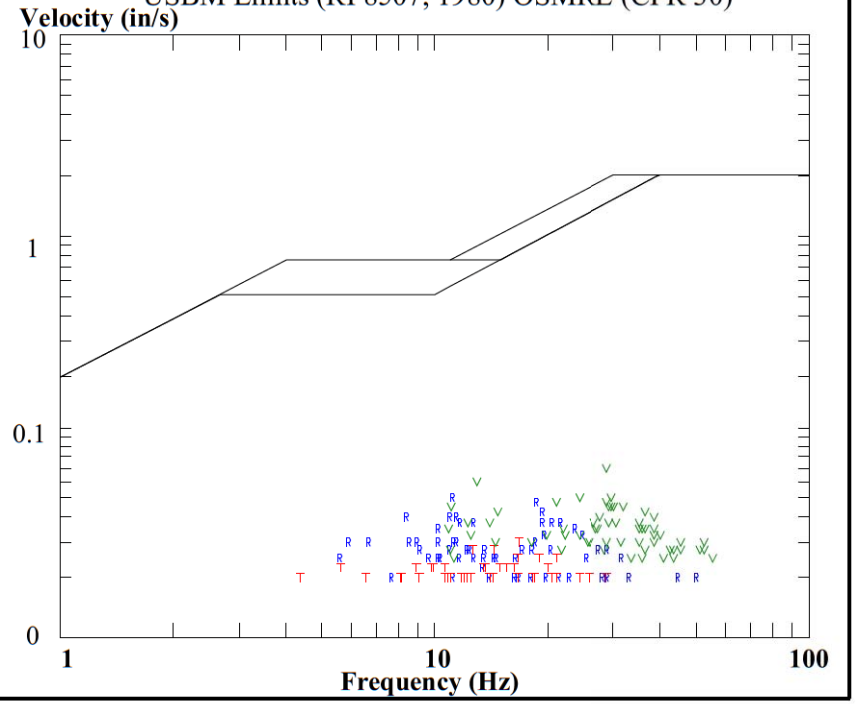
Measurement	Value	Trigger >>> Peak	
psi	.00015	0	
dBL	**94**		
Hz	11		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

22-Feb-18 at 13:31:15 PM Event # 161

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.083**	**0.053**	**0.115**
Frequency (Hz)	**20.00**	**15.10**	**24.60**
Displacement (in)	**0.0007**	**0.0006**	**0.0007**
Acceleration (g's)	**0.0268**	**0.0129**	**0.0460**
Trigger >>> Peak	658.7	2098.4	3927.2

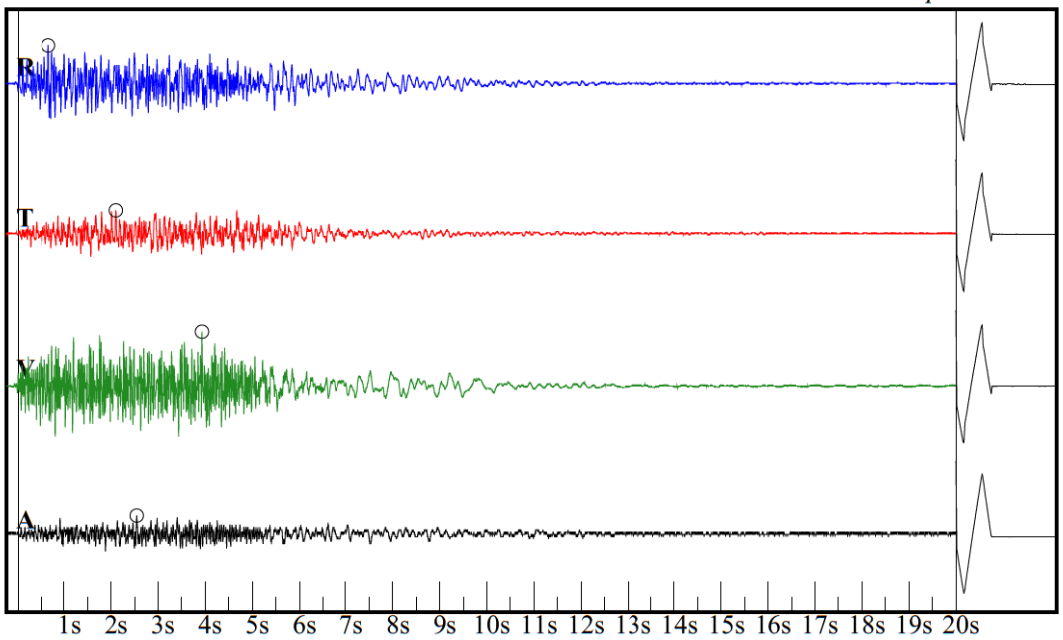
Air

Gain: 1 Trigger: 120 dBL

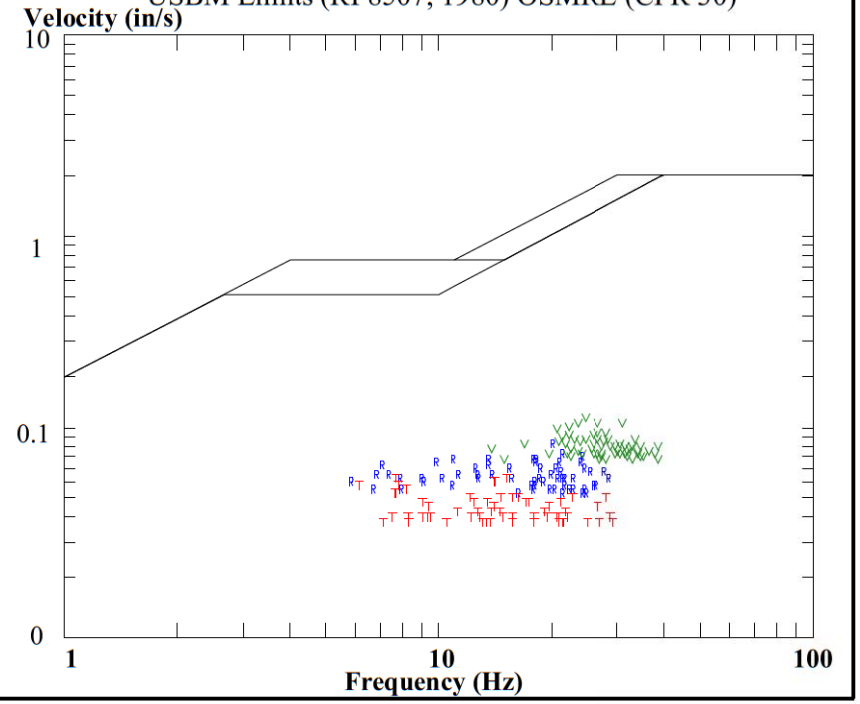
Measurement	Value	Trigger >>> Peak	
psi	.00033	2542.7	
dBL	**101**		
Hz	13.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

26-Feb-18 at 13:59:49 PM Event # 174

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.078**	**0.048**	**0.115**
Frequency (Hz)	**18.20**	**12.80**	**19.50**
Displacement (in)	**0.0007**	**0.0006**	**0.0009**
Acceleration (g's)	**0.0229**	**0.0099**	**0.0365**
Trigger >>> Peak	1349.9	3074.2	1453.1

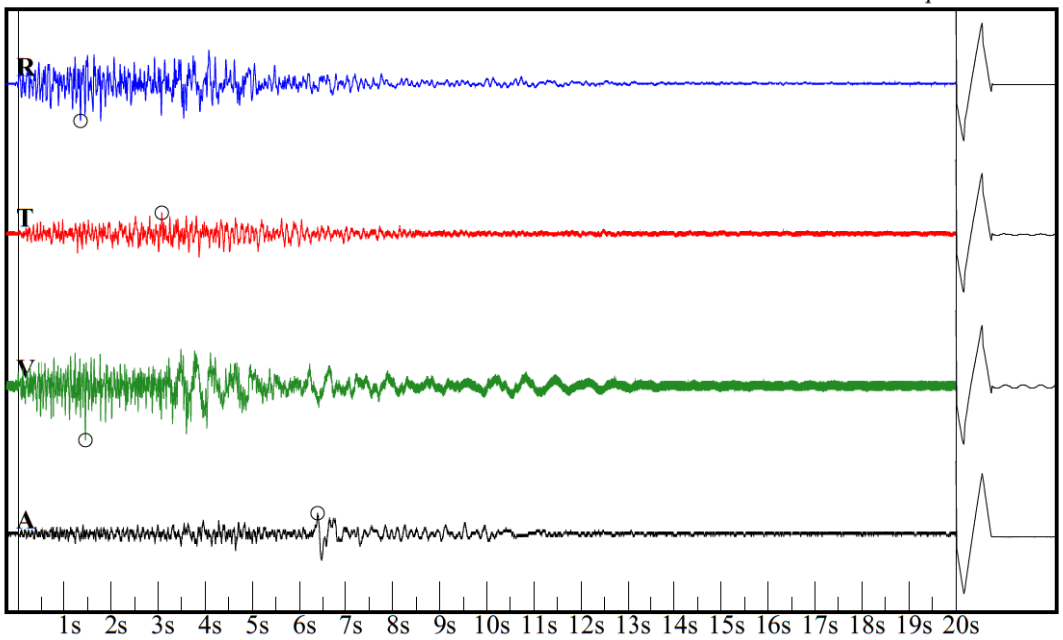
Air

Gain: 1 Trigger: 120 dBL

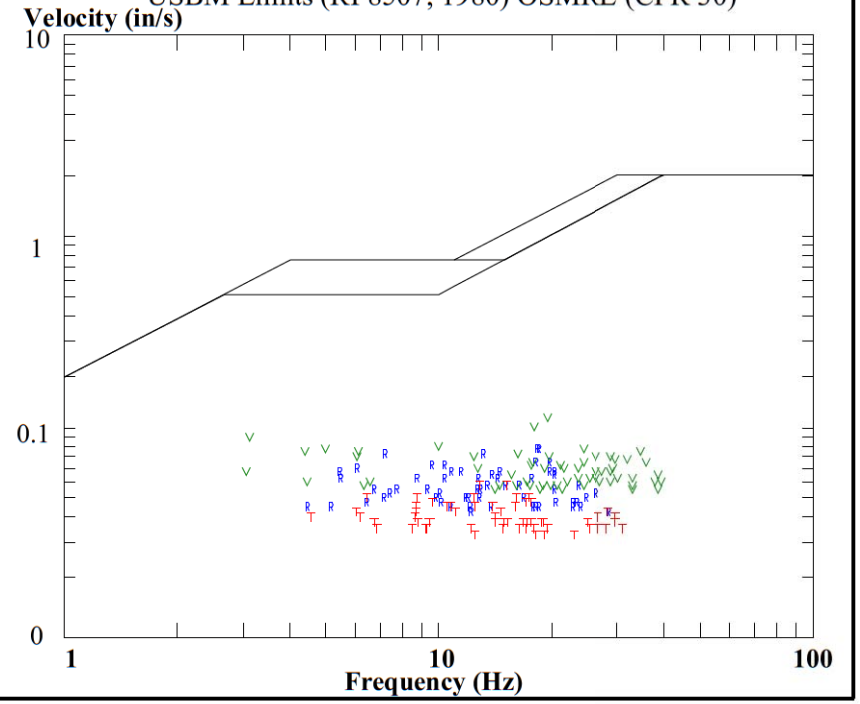
Measurement	Value	Trigger >>> Peak	
psi	.00036	6381.6	
dBL	**102**		
Hz	3.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

05-Mar-18 at 14:00:07 PM Event # 202

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.075**	**0.043**	**0.085**
Frequency (Hz)	**9.90**	**7.00**	**24.30**
Displacement (in)	**0.0012**	**0.0010**	**0.0006**
Acceleration (g's)	**0.0121**	**0.0048**	**0.0336**
Trigger >>> Peak	3452.9	4614.7	3823

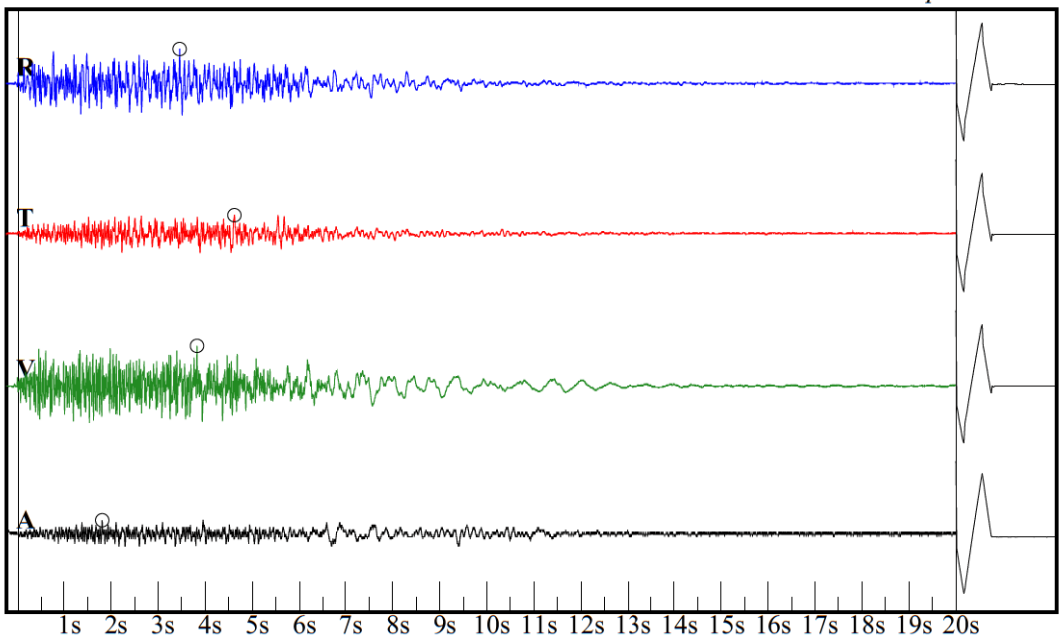
Air

Gain: 1 Trigger: 120 dBL

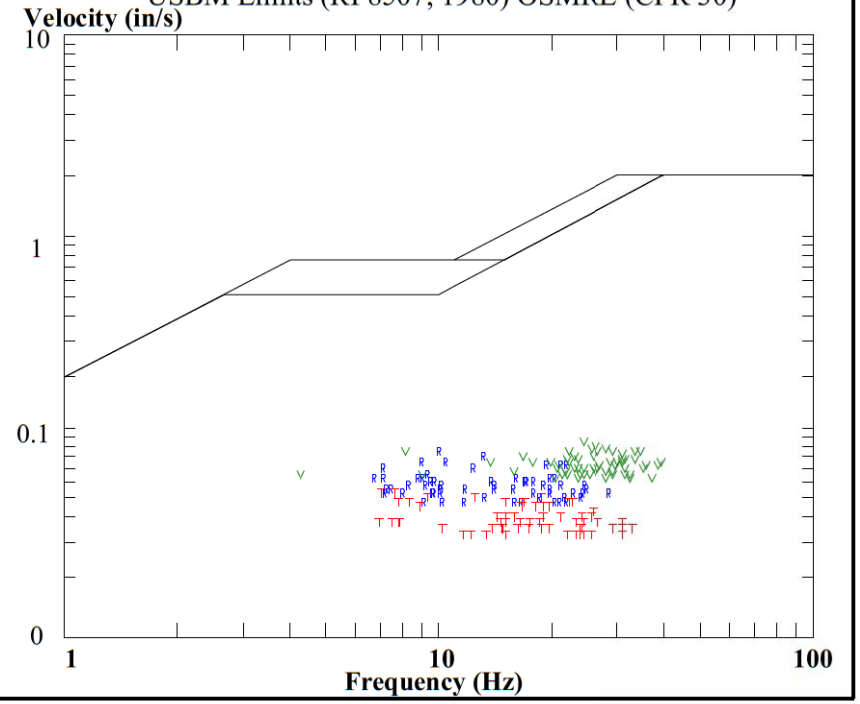
Measurement	Value	Trigger >>> Peak	
psi	.00025	1808.4	
dBL	**99**		
Hz	8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

07-Mar-18 at 11:36:39 AM Event # 206

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.020**	**0.040**
Frequency (Hz)	**15.60**	**9.40**	**33.50**
Displacement (in)	**0.0002**	**0.0003**	**0.0002**
Acceleration (g's)	**0.0057**	**0.0031**	**0.0218**
Trigger >>> Peak	667	2482.7	653.3

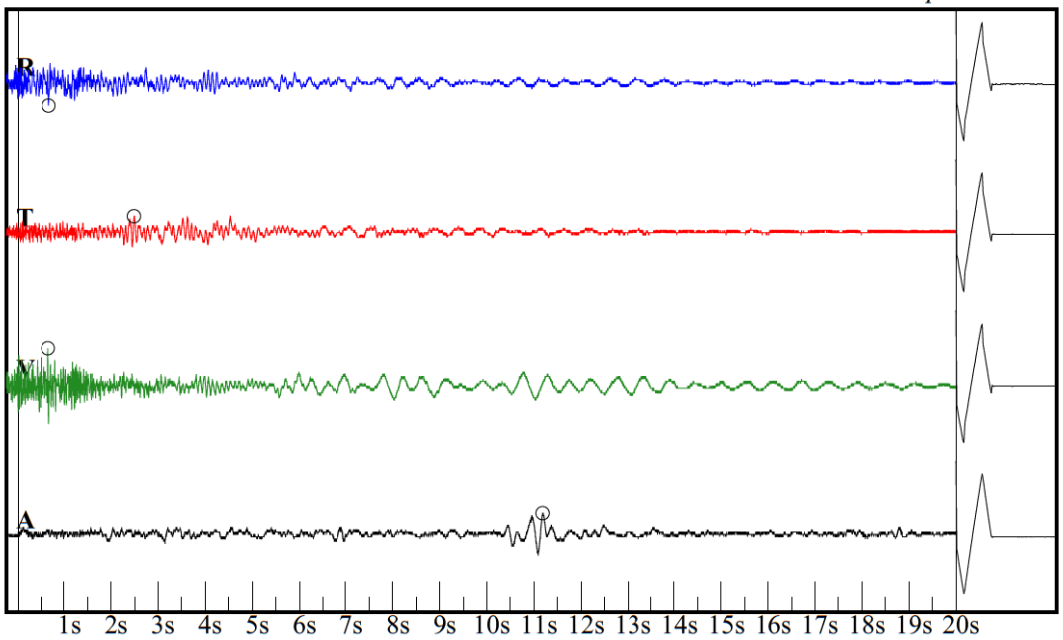
Air

Gain: 1 Trigger: 120 dBL

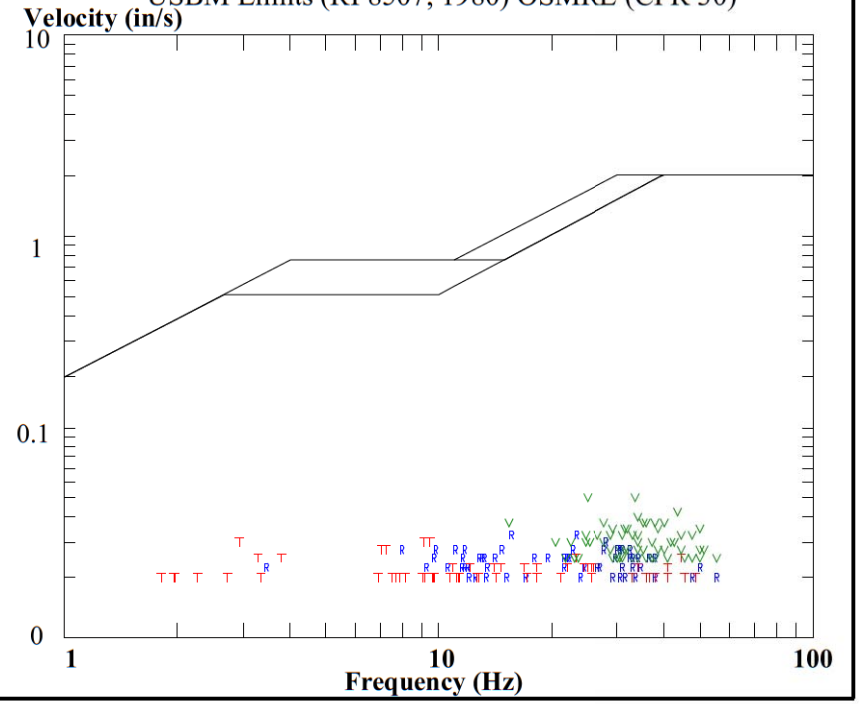
Measurement	Value	Trigger >>> Peak	
psi	.00036	11179.9	
dBL	**102**		
Hz	3.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

09-Mar-18 at 13:15:50 PM Event # 210

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.068**	**0.050**	**0.083**
Frequency (Hz)	**4.40**	**6.90**	**3.20**
Displacement (in)	**0.0024**	**0.0012**	**0.0041**
Acceleration (g's)	**0.0048**	**0.0056**	**0.0043**
Trigger >>> Peak	3215.8	3246.6	4291.7

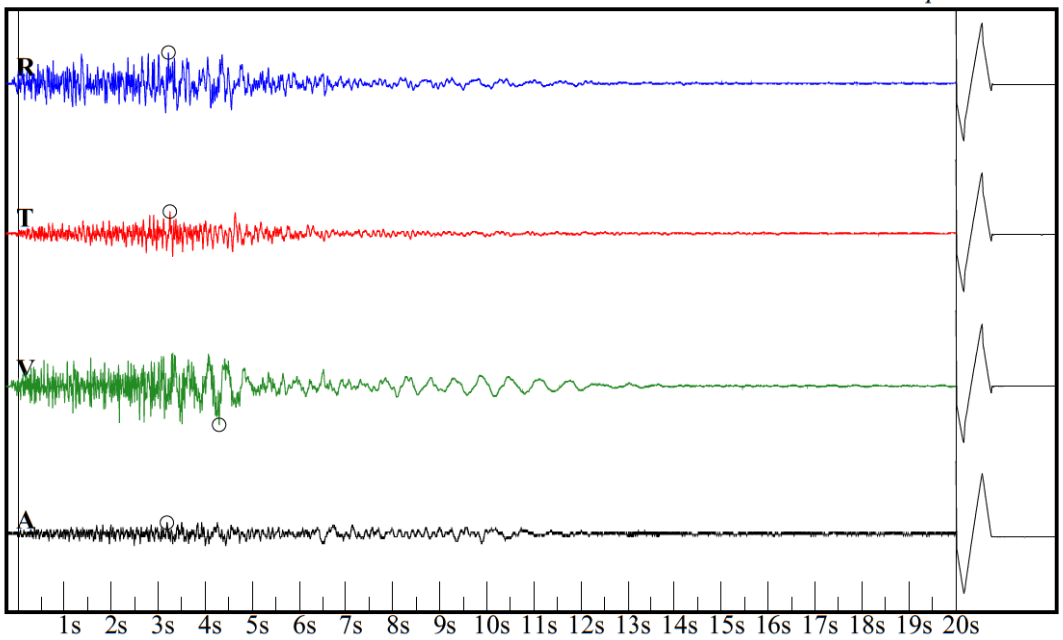
Air

Gain: 1 Trigger: 120 dBL

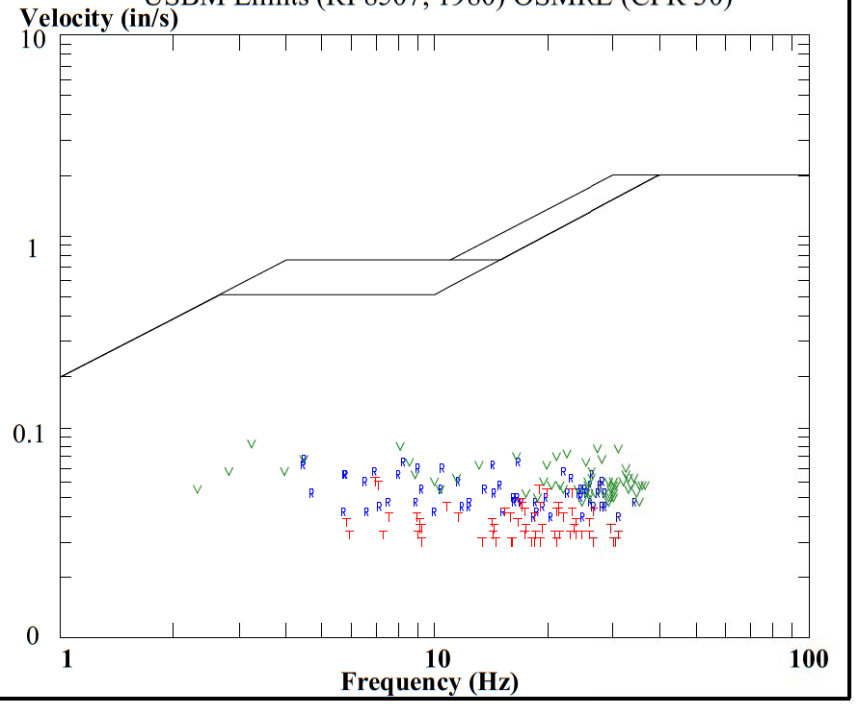
Measurement	Value	Trigger >>> Peak	
psi	.00022	3183.4	
dBL	**98**		
Hz	10.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

19-Mar-18 at 14:19:30 PM Event # 227

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.083**	**0.053**	**0.095**
Frequency (Hz)	**10.60**	**8.20**	**25.90**
Displacement (in)	**0.0012**	**0.0010**	**0.0006**
Acceleration (g's)	**0.0142**	**0.0070**	**0.0400**
Trigger >>> Peak	1667.7	2266.8	1580.6

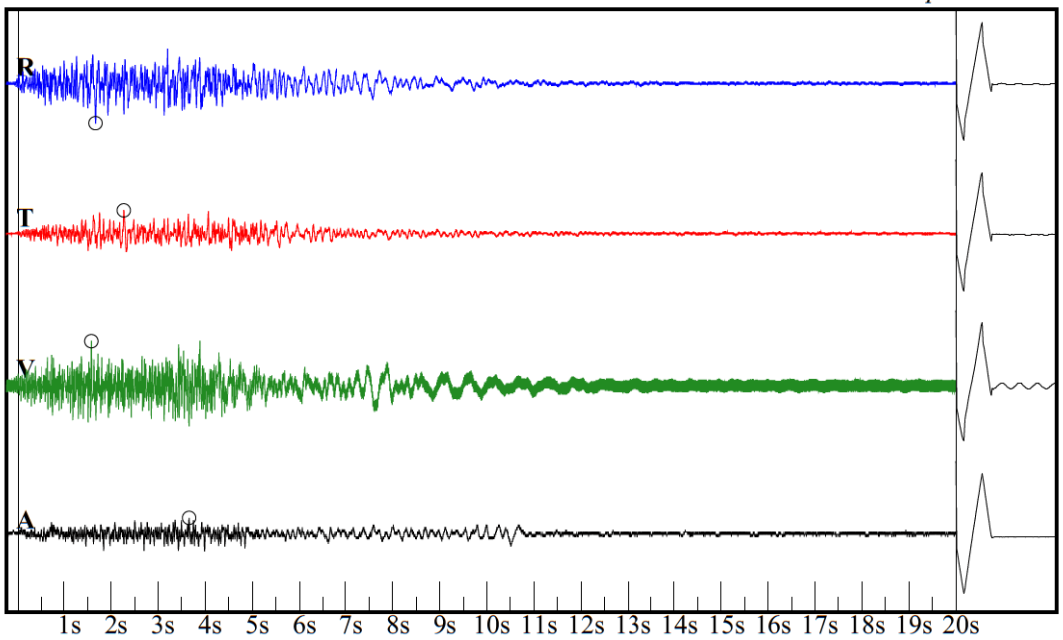
Air

Gain: 1 Trigger: 120 dBL

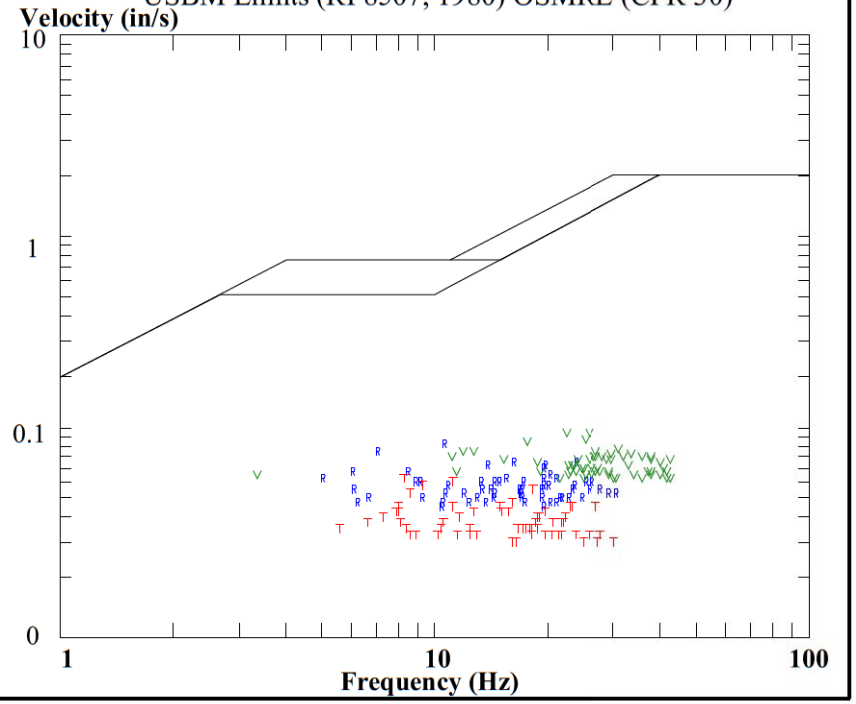
Measurement	Value	Trigger >>> Peak	
psi	.00029	3655	
dBL	**100**		
Hz	14.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

20-Mar-18 at 11:45:43 AM Event # 229

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.035**	**0.080**
Frequency (Hz)	**19.30**	**17.60**	**23.20**
Displacement (in)	**0.0004**	**0.0003**	**0.0005**
Acceleration (g's)	**0.0141**	**0.0100**	**0.0302**
Trigger >>> Peak	888.9	1977.5	886.7

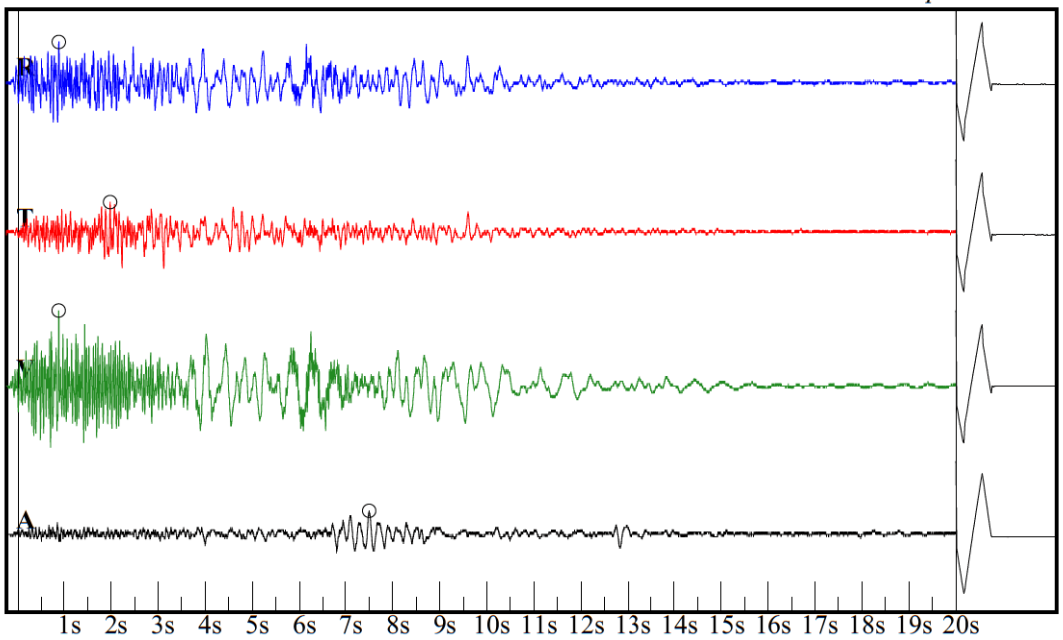
Air

Gain: 1 Trigger: 120 dBL

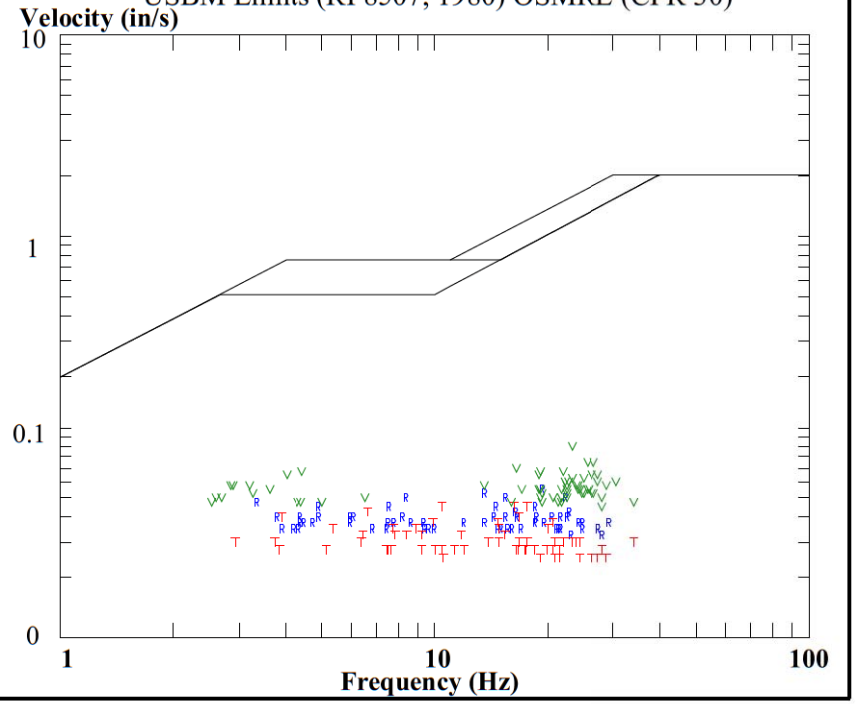
Measurement	Value	Trigger >>> Peak	
psi	.0004	7498	
dBL	**103**		
Hz	5.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

23-Mar-18 at 13:15:33 PM Event # 234

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.098**	**0.073**	**0.110**
Frequency (Hz)	**9.90**	**8.90**	**26.20**
Displacement (in)	**0.0016**	**0.0013**	**0.0007**
Acceleration (g's)	**0.0157**	**0.0105**	**0.0469**
Trigger >>> Peak	1091.3	1924.1	897.9

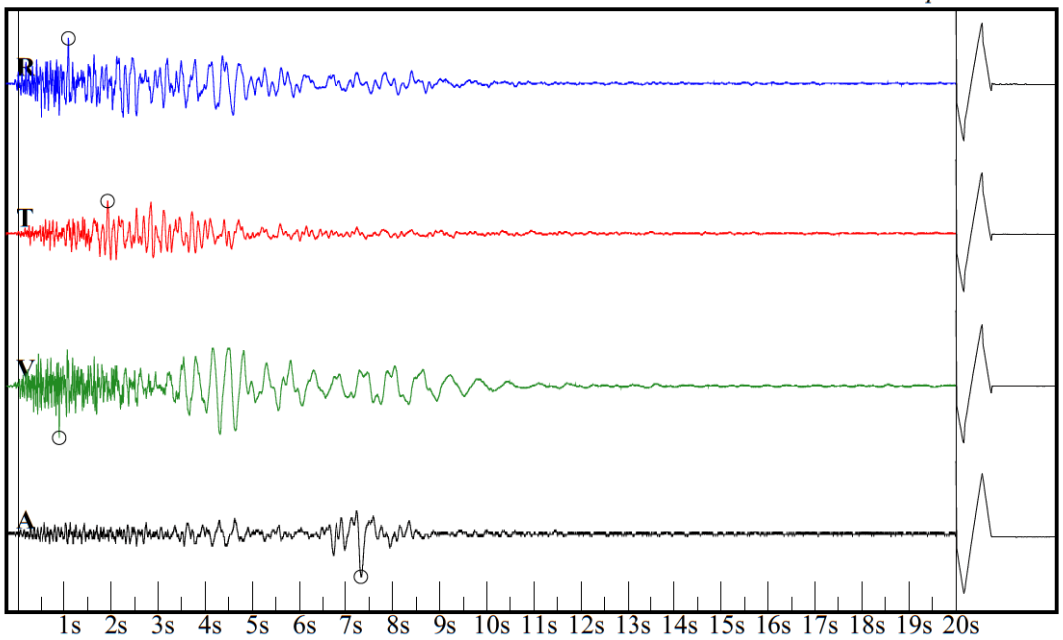
Air

Gain: 1 Trigger: 120 dBL

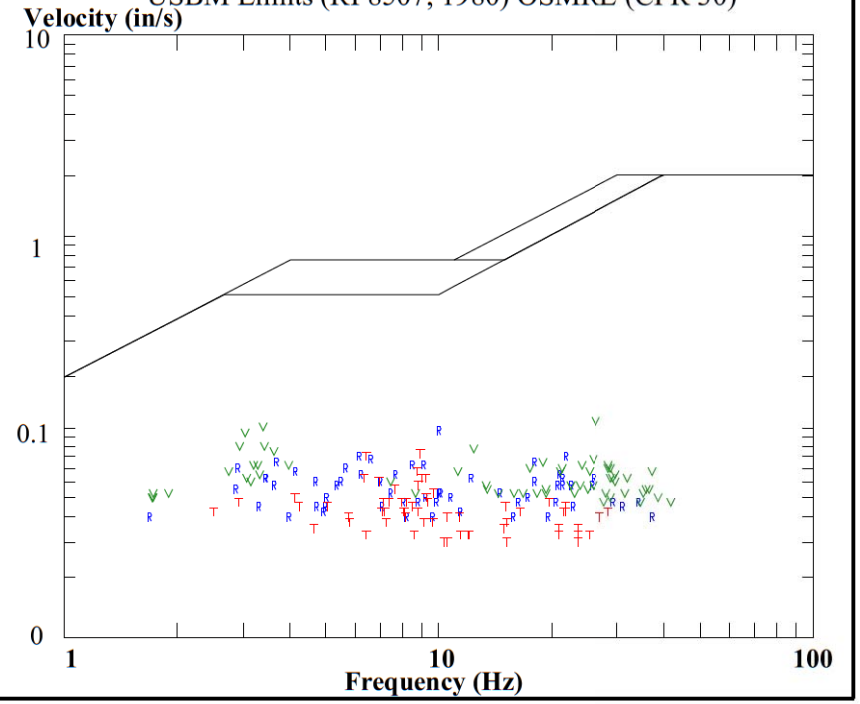
Measurement	Value	Trigger >>> Peak	
psi	.00062	7321.8	
dBL	**107**		
Hz	4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

26-Mar-18 at 14:30:41 PM Event # 242

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.053**	**0.038**	**0.068**
Frequency (Hz)	**5.80**	**8.90**	**4.30**
Displacement (in)	**0.0014**	**0.0007**	**0.0025**
Acceleration (g's)	**0.0050**	**0.0054**	**0.0047**
Trigger >>> Peak	4075.4	3459.5	5204.8

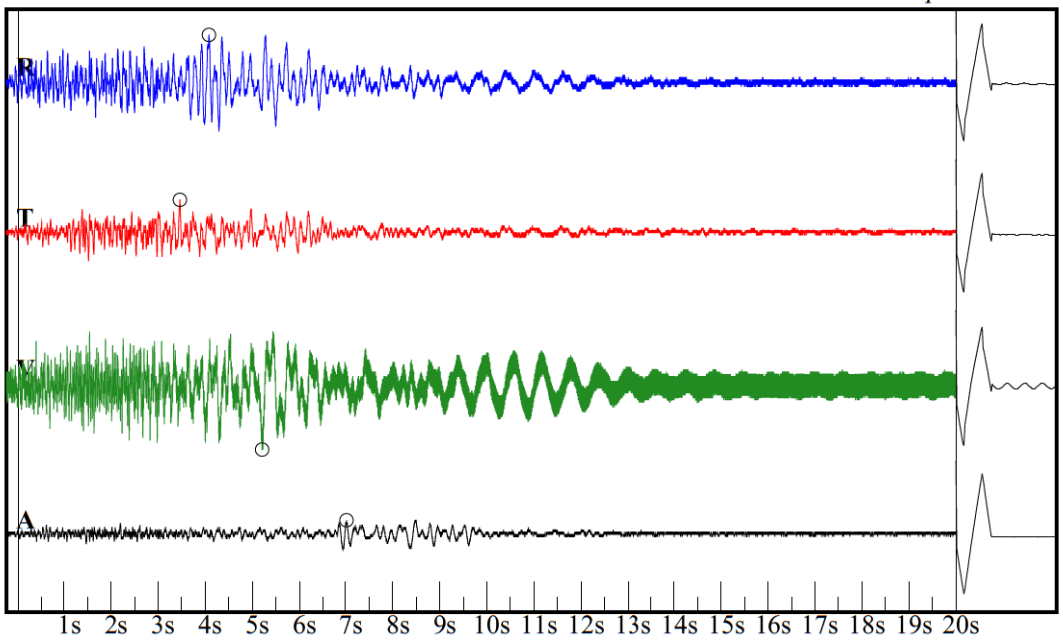
Air

Gain: 1 Trigger: 120 dBL

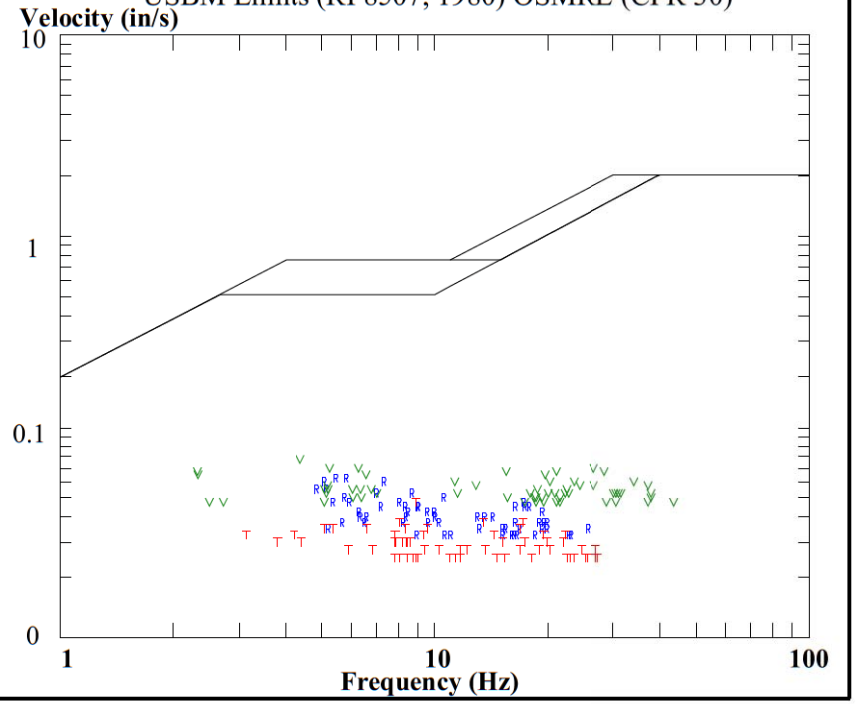
Measurement	Value	Trigger >>> Peak	
psi	.00025	7018.1	
dBL	**99**		
Hz	6.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

30-Mar-18 at 11:30:57 AM Event # 251

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.053**	**0.033**	**0.070**
Frequency (Hz)	**9.70**	**12.70**	**4.10**
Displacement (in)	**0.0009**	**0.0004**	**0.0027**
Acceleration (g's)	**0.0083**	**0.0067**	**0.0047**
Trigger >>> Peak	2675	1578.4	3757.6

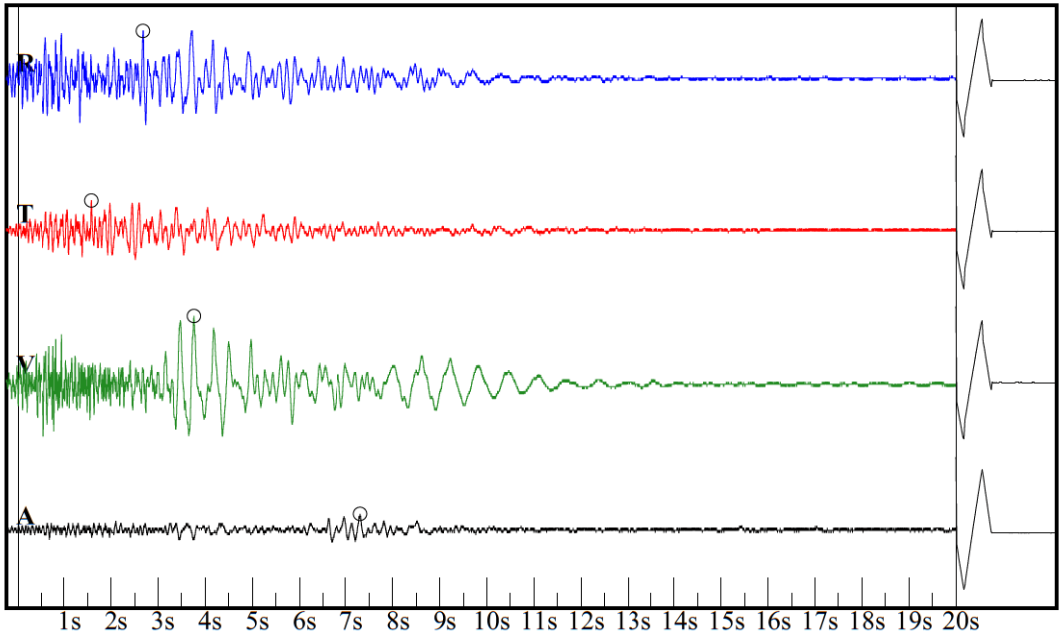
Air

Gain: 1 Trigger: 120 dBL

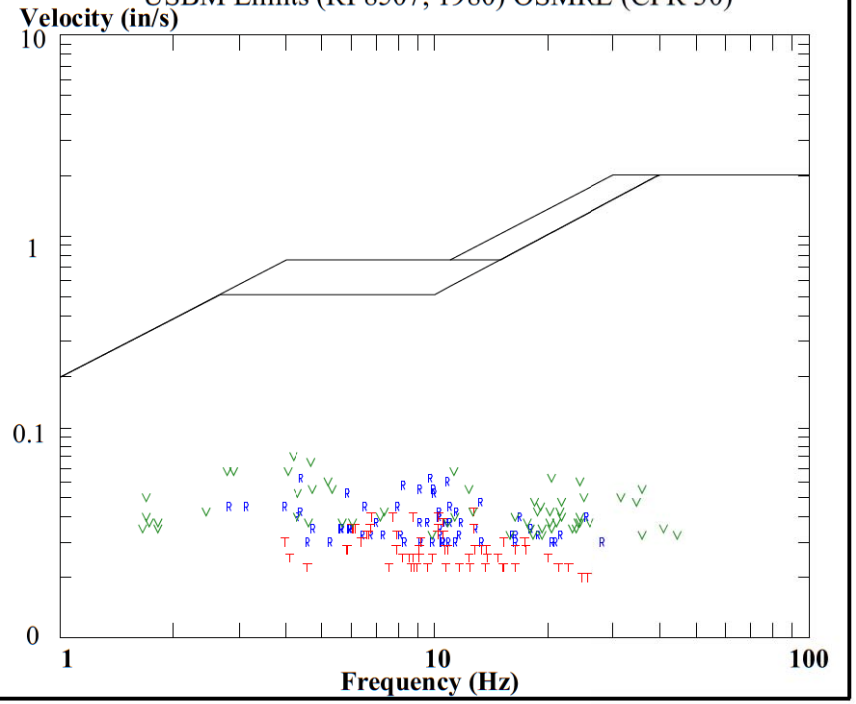
Measurement	Value	Trigger >>> Peak	
psi	.00029	7304.9	
dBL	**100**		
Hz	4.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

03-Apr-18 at 15:02:17 PM Event # 383

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.055**	**0.040**	**0.060**
Frequency (Hz)	**14.30**	**9.20**	**22.00**
Displacement (in)	**0.0006**	**0.0007**	**0.0004**
Acceleration (g's)	**0.0128**	**0.0060**	**0.0215**
Trigger >>> Peak	2545.2	2660.2	2656.5

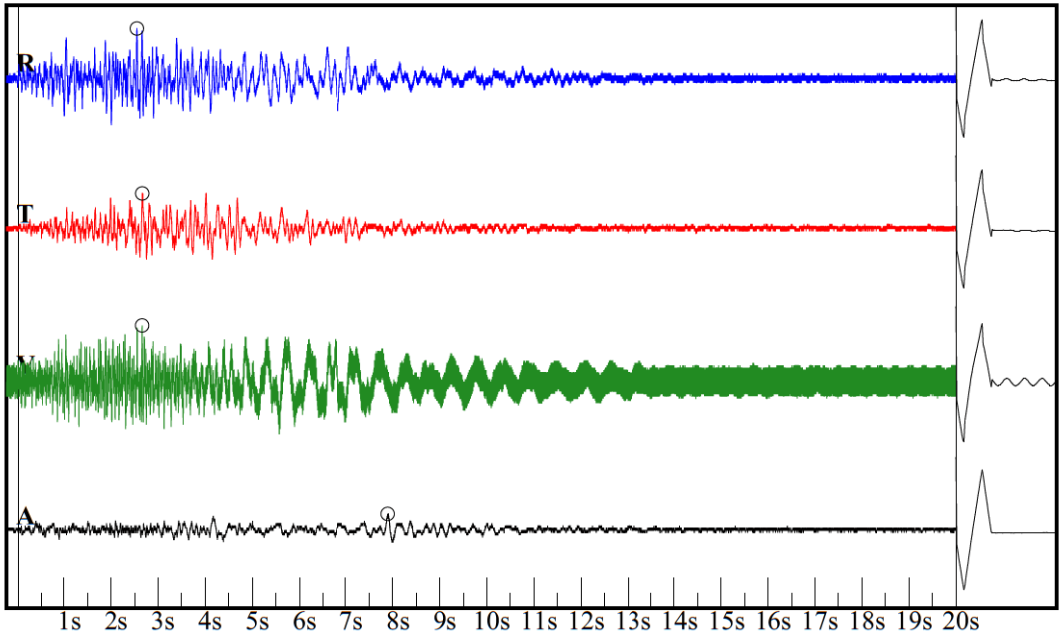
Air

Gain: 1 Trigger: 120 dBL

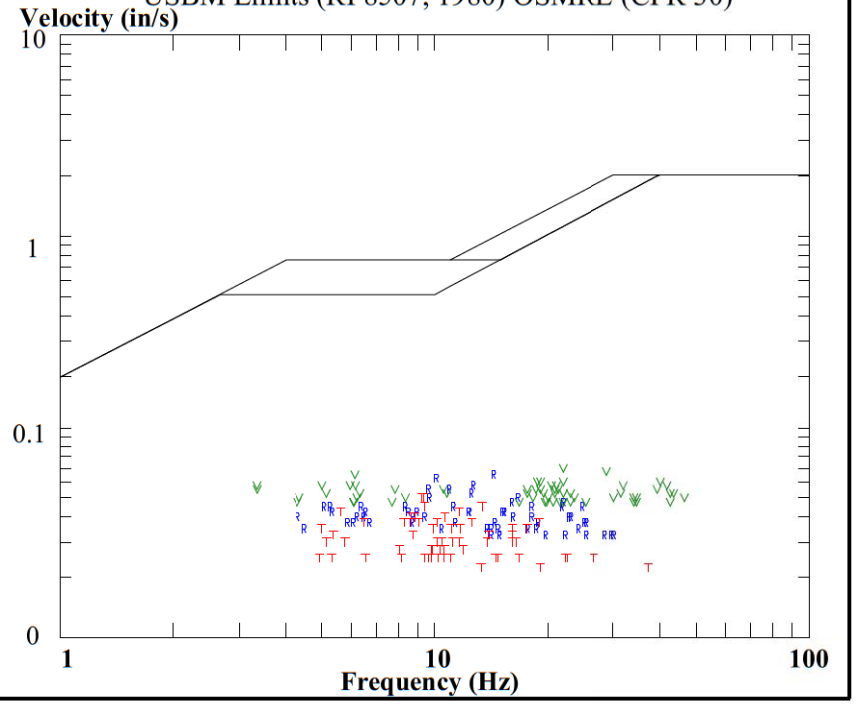
Measurement	Value	Trigger >>> Peak	
psi	.00029	7892.1	
dBL	**100**		
Hz	4.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

05-Apr-18 at 14:00:48 PM Event # 386

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.030**	**0.043**
Frequency (Hz)	**16.50**	**5.40**	**20.40**
Displacement (in)	**0.0004**	**0.0009**	**0.0003**
Acceleration (g's)	**0.0107**	**0.0026**	**0.0141**
Trigger >>> Peak	885.5	3912.1	810.3

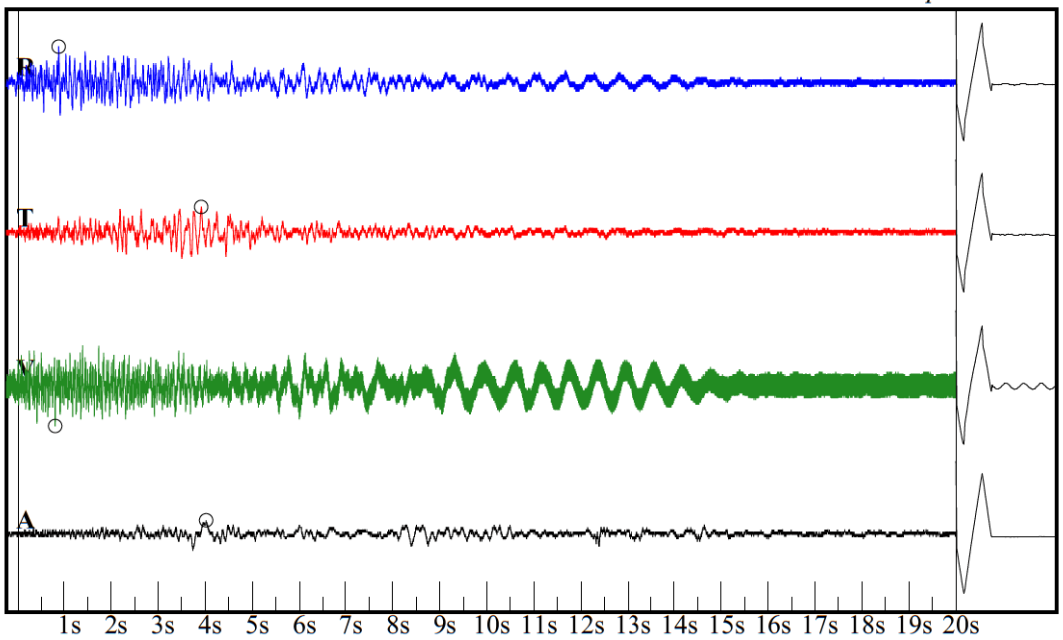
Air

Gain: 1 Trigger: 120 dBL

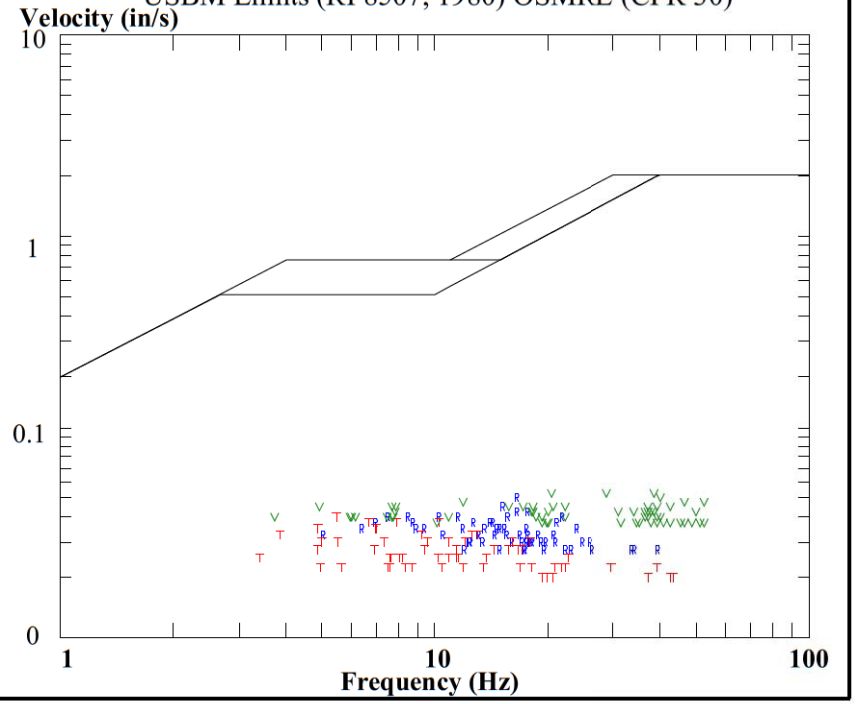
Measurement	Value	Trigger >>> Peak	
psi	.00025	4016.1	
dBL	**99**		
Hz	2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Version 4.1.8
Executable Date: 03Novl2016

Nomis Seismographs, Inc.

Sauls Seismic, LLC - Report

Telephone: (205)592-2466

Company: RESPEC

Unit #: 12801

4/9/2018 at 13:47:58 Event # 400

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N | Wgt. Per Delay: N | Scaled Distance: 0.0

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
○ Velocity (in/s)	0.013	0.008	0.030
Frequency (Hz)	7.50	0.00	40.90
Displacement (in)	0.0003	0	0.0001
Acceleration (g's)	0.002	0.000	0.020
Trigger >>> Peak	4362.5	221.4	10882.3

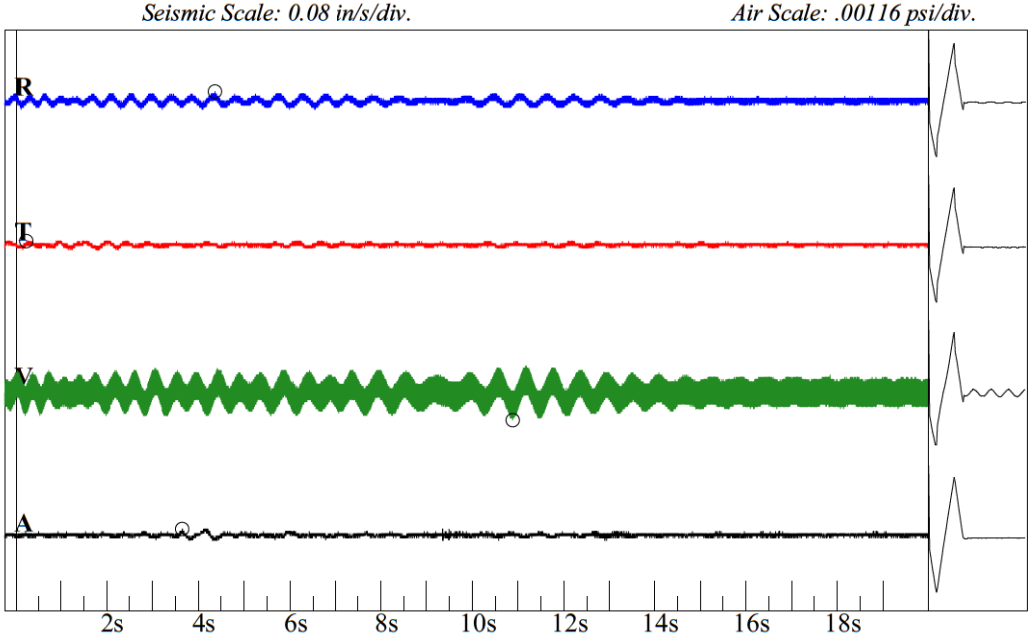
Air

Gain: 1 Air Trigger: 120 dBL

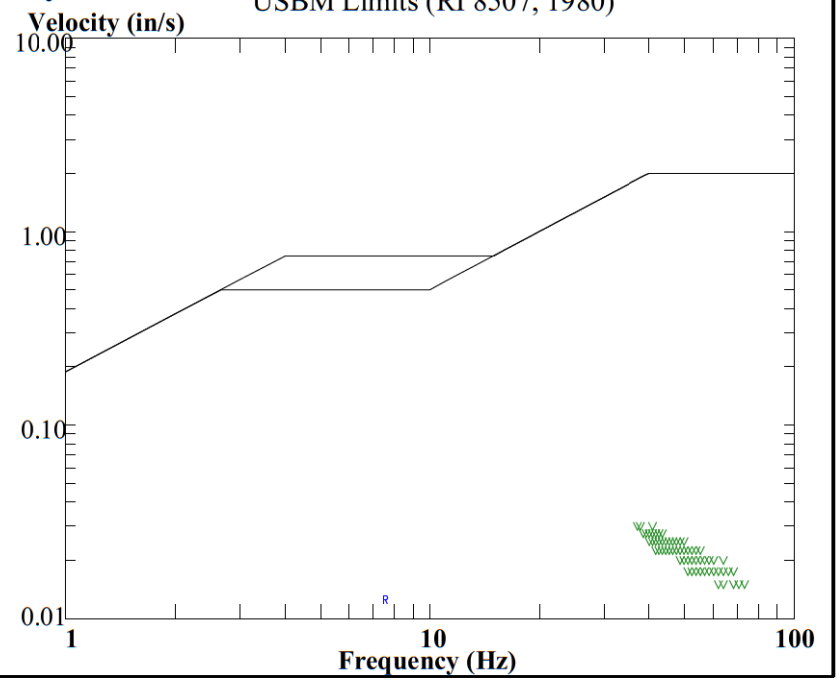
Measurement	Value	Trigger >>> Peak	
		3646.0	
psi	.0001451		
dBL	94.0		
Hz	3.8		

Waveform Analysis / Frequency Plot

Seismic Scale: 0.08 in/s/div. Air Scale: .00116 psi/div.



USBM Limits (RI 8507, 1980)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

10-Apr-18 at 14:00:52 PM Event # 404

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.053**	**0.038**	**0.048**
Frequency (Hz)	**15.60**	**6.60**	**18.40**
Displacement (in)	**0.0005**	**0.0009**	**0.0004**
Acceleration (g's)	**0.0133**	**0.0040**	**0.0142**
Trigger >>> Peak	2433.6	3317.6	3019.8

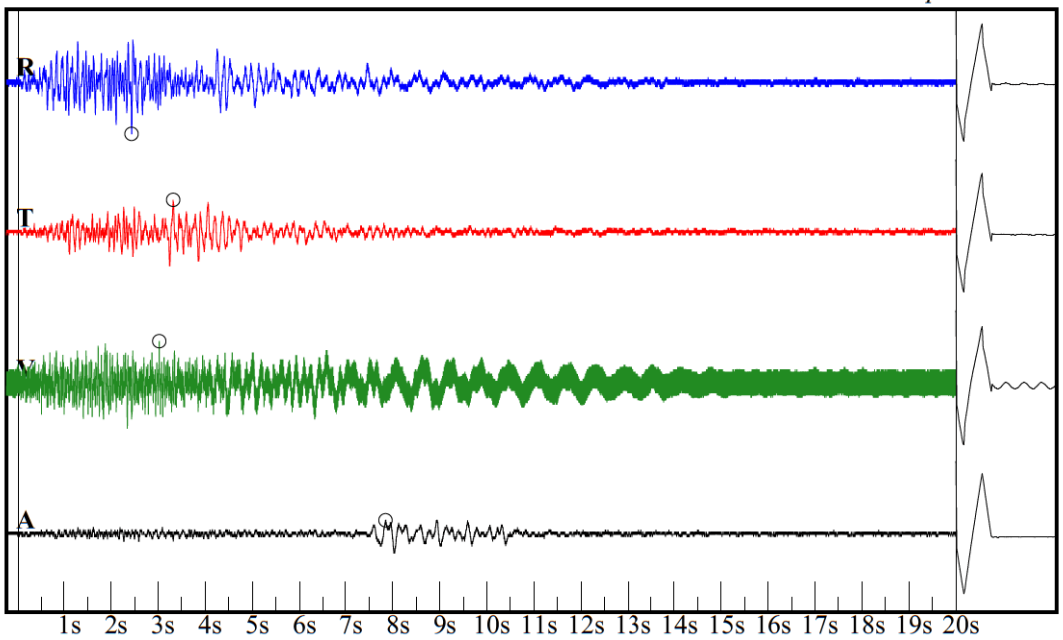
Air

Gain: 1 Trigger: 120 dBL

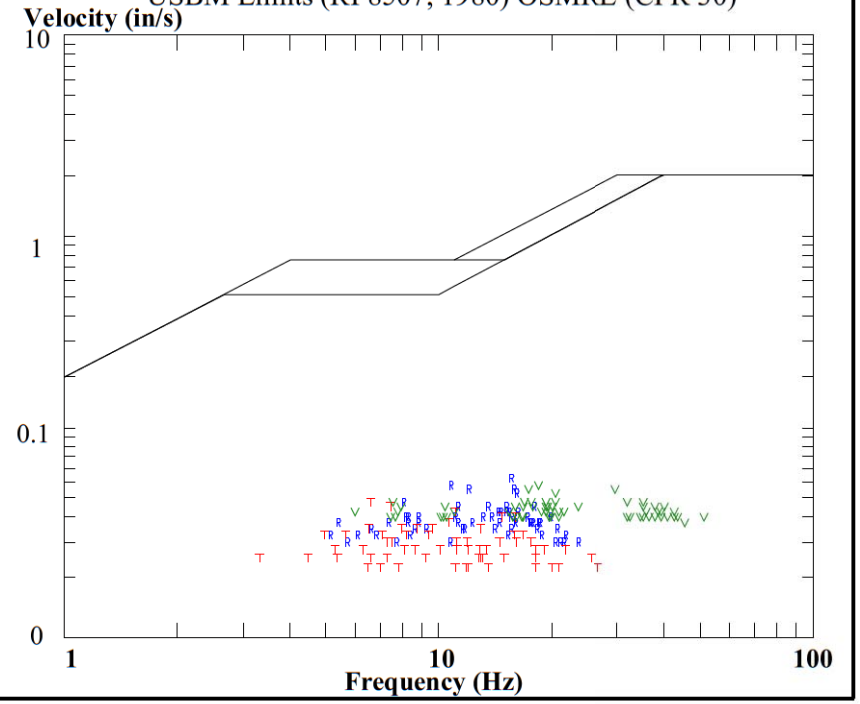
Measurement	Value	Trigger >>> Peak	
psi	.00025	7845	
dBL	**99**		
Hz	2.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

12-Apr-18 at 13:30:52 PM Event # 470

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.048**	**0.040**	**0.063**
Frequency (Hz)	**16.70**	**7.40**	**24.90**
Displacement (in)	**0.0005**	**0.0009**	**0.0004**
Acceleration (g's)	**0.0129**	**0.0048**	**0.0253**
Trigger >>> Peak	947	2473.1	449.2

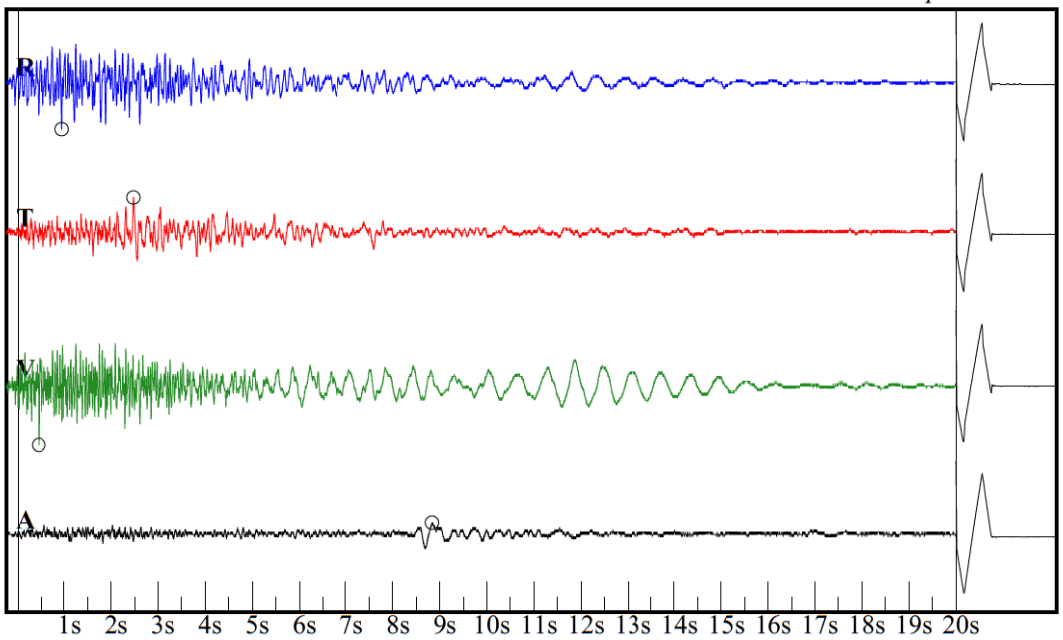
Air

Gain: 1 Trigger: 120 dBL

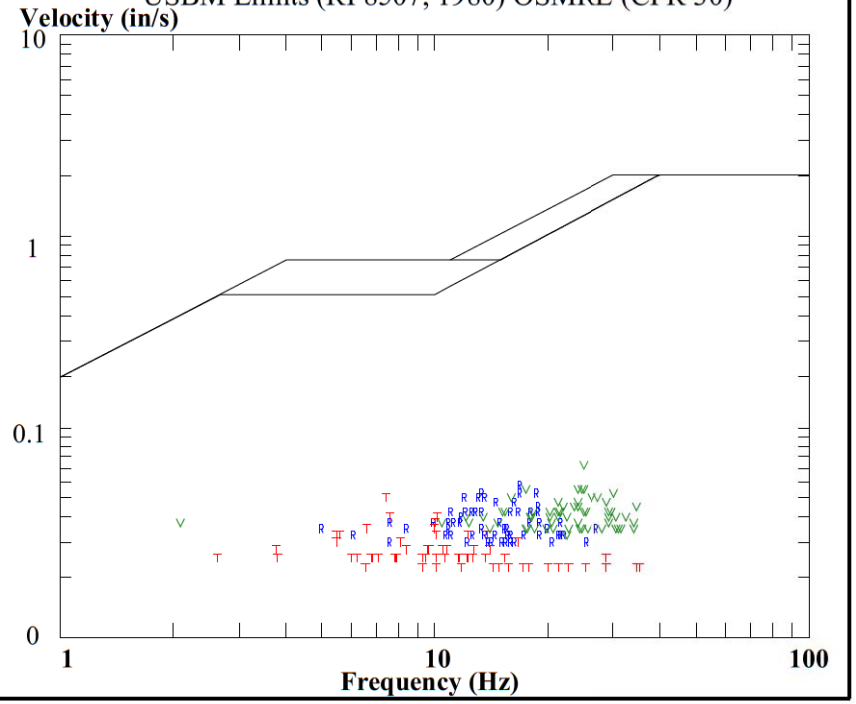
Measurement	Value	Trigger >>> Peak	
psi	.00022	8831.5	
dBL	**98**		
Hz	1.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

13-Apr-18 at 11:31:36 AM Event # 473

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.025**	**0.043**
Frequency (Hz)	**8.60**	**1.40**	**1.80**
Displacement (in)	**0.0006**	**0.0028**	**0.0038**
Acceleration (g's)	**0.0049**	**0.0006**	**0.0012**
Trigger >>> Peak	137.9	3908.7	9496.3

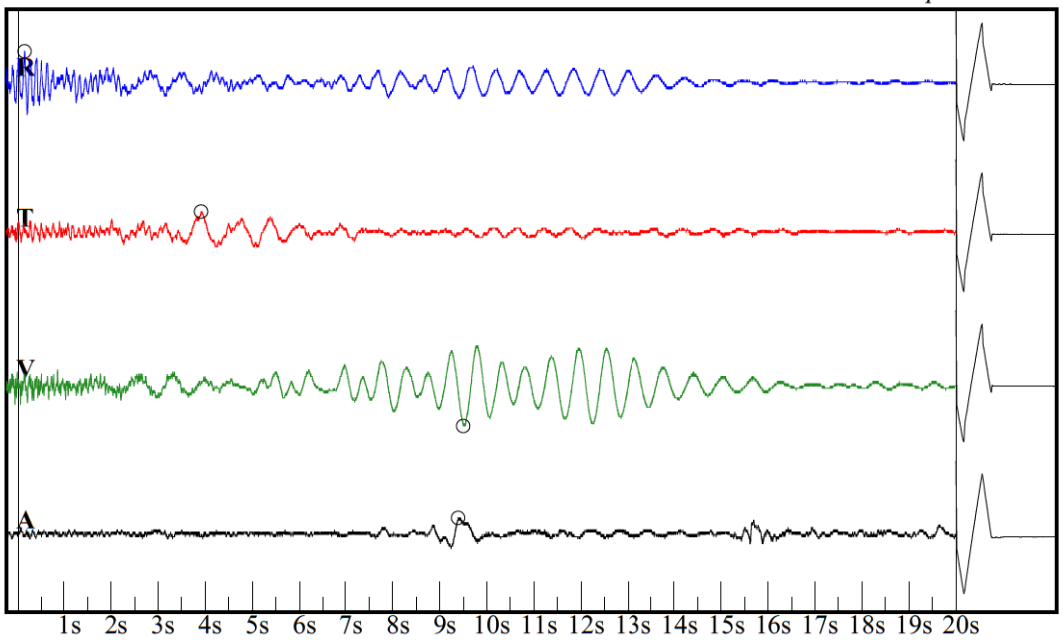
Air

Gain: 1 Trigger: 120 dBL

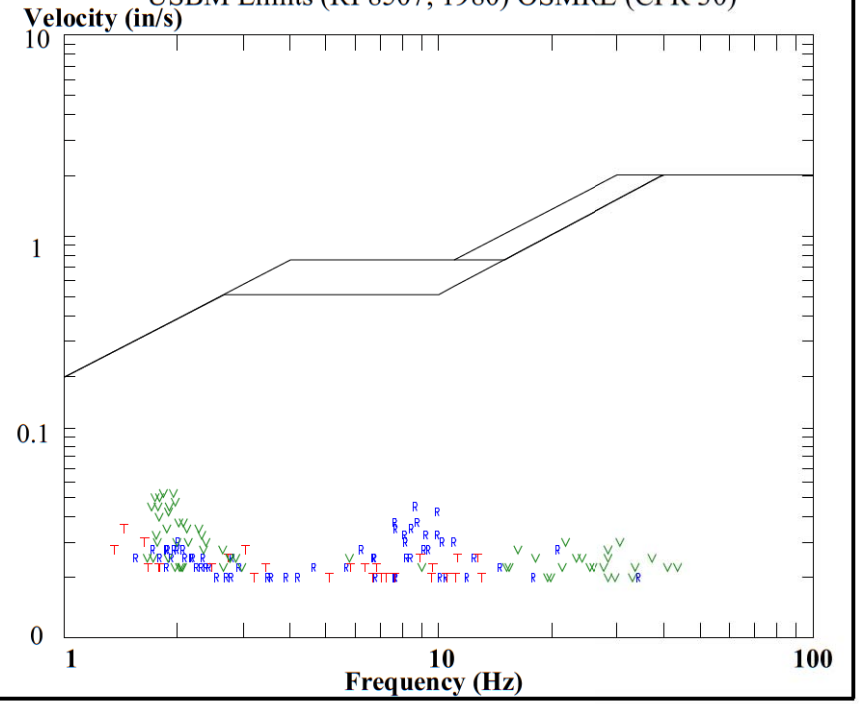
Measurement	Value	Trigger >>> Peak	
psi	.00029	9387.2	
dBL	**100**		
Hz	1.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

17-Apr-18 at 13:30:59 PM Event # 491

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.048**	**0.028**	**0.063**
Frequency (Hz)	**15.50**	**5.80**	**23.50**
Displacement (in)	**0.0005**	**0.0008**	**0.0004**
Acceleration (g's)	**0.0120**	**0.0026**	**0.0239**
Trigger >>> Peak	1168.7	3147.9	1827.4

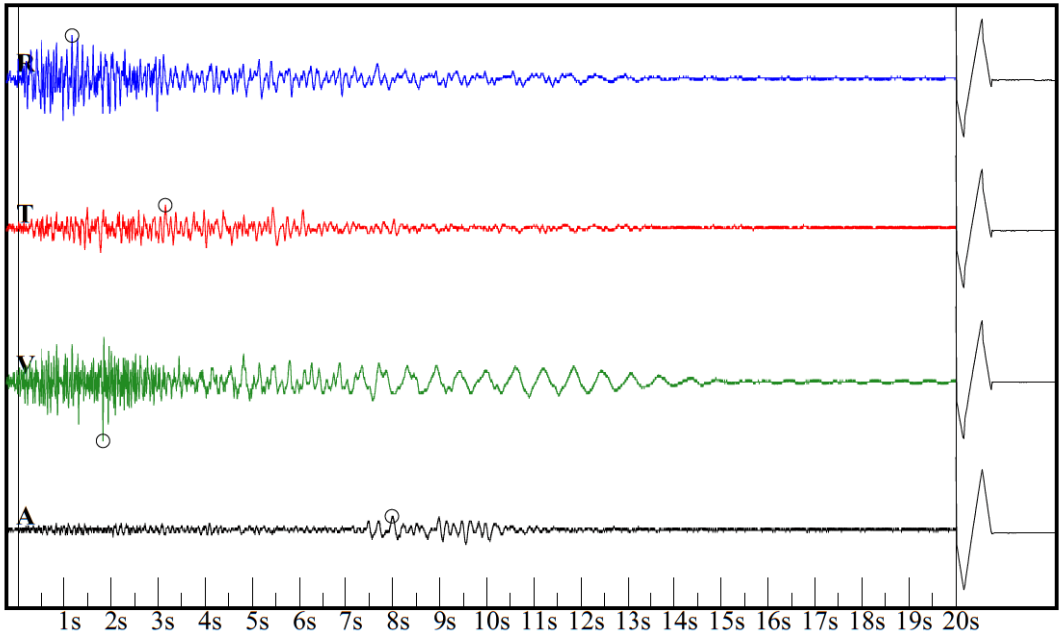
Air

Gain: 1 Trigger: 120 dBL

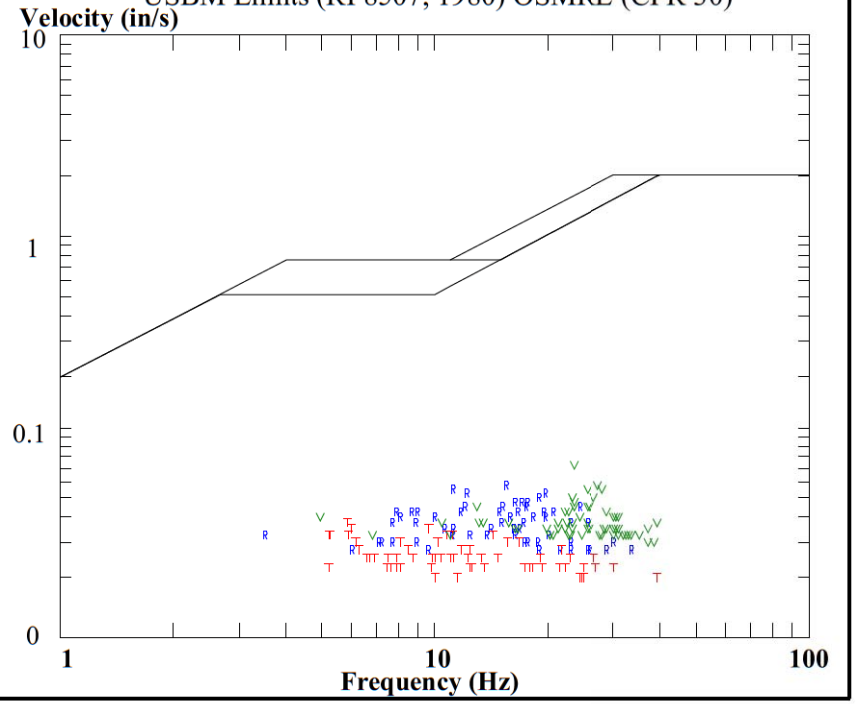
Measurement	Value	Trigger >>> Peak	
psi	.00025	7981.4	
dBL	**99**		
Hz	3.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

19-Apr-18 at 13:30:59 PM Event # 494

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.033**	**0.023**	**0.033**
Frequency (Hz)	**12.40**	**6.40**	**24.60**
Displacement (in)	**0.0004**	**0.0006**	**0.0002**
Acceleration (g's)	**0.0066**	**0.0023**	**0.0130**
Trigger >>> Peak	912.4	4579.1	1668.9

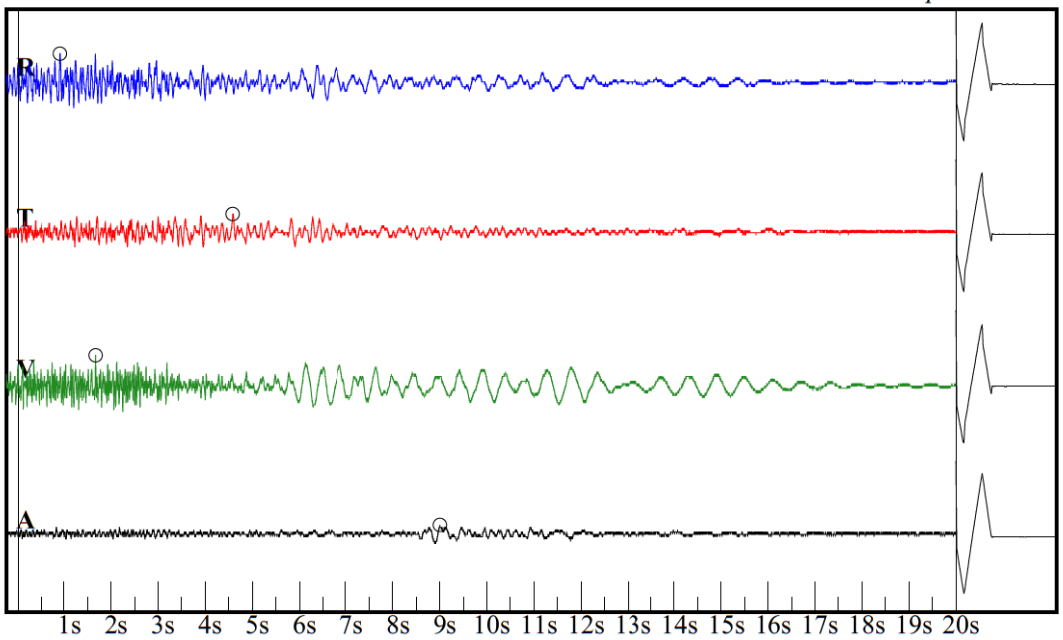
Air

Gain: 1 Trigger: 120 dBL

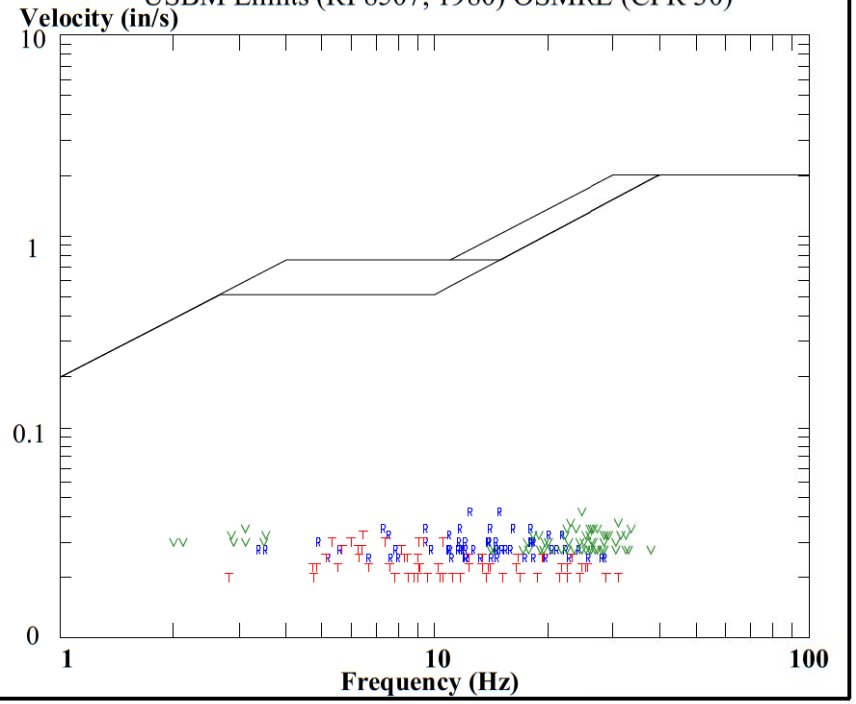
Measurement	Value	Trigger >>> Peak	
psi	.00018	9000.7	
dBL	**96**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

23-Apr-18 at 14:33:03 PM Event # 507

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.043**	**0.030**	**0.045**
Frequency (Hz)	**15.10**	**8.00**	**14.30**
Displacement (in)	**0.0004**	**0.0006**	**0.0005**
Acceleration (g's)	**0.0104**	**0.0039**	**0.0105**
Trigger >>> Peak	881.3	1891.4	1944.8

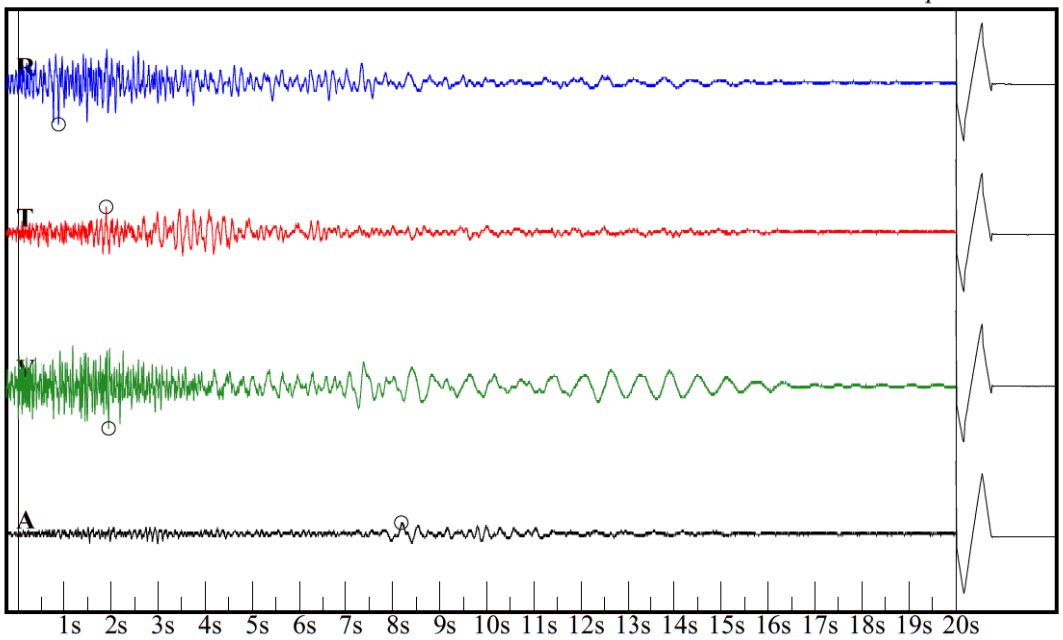
Air

Gain: 1 Trigger: 120 dBL

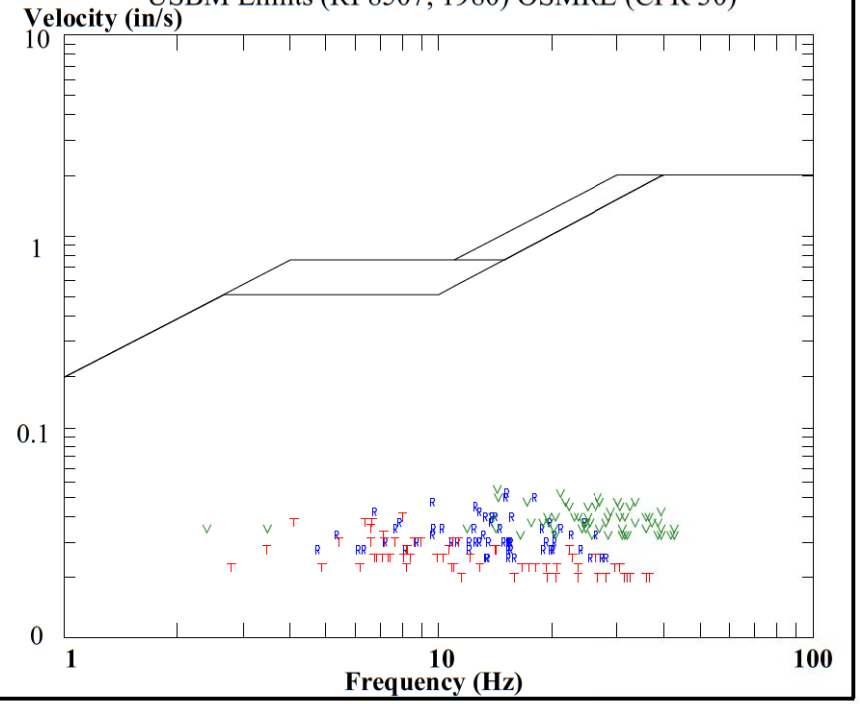
Measurement	Value	Trigger >>> Peak	
psi	.00022	8181.9	
dBL	**98**		
Hz	2.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

25-Apr-18 at 14:31:09 PM Event # 511

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.025**	**0.043**
Frequency (Hz)	**11.50**	**6.30**	**23.20**
Displacement (in)	**0.0005**	**0.0006**	**0.0003**
Acceleration (g's)	**0.0065**	**0.0026**	**0.0160**
Trigger >>> Peak	1481.4	3082	1579.6

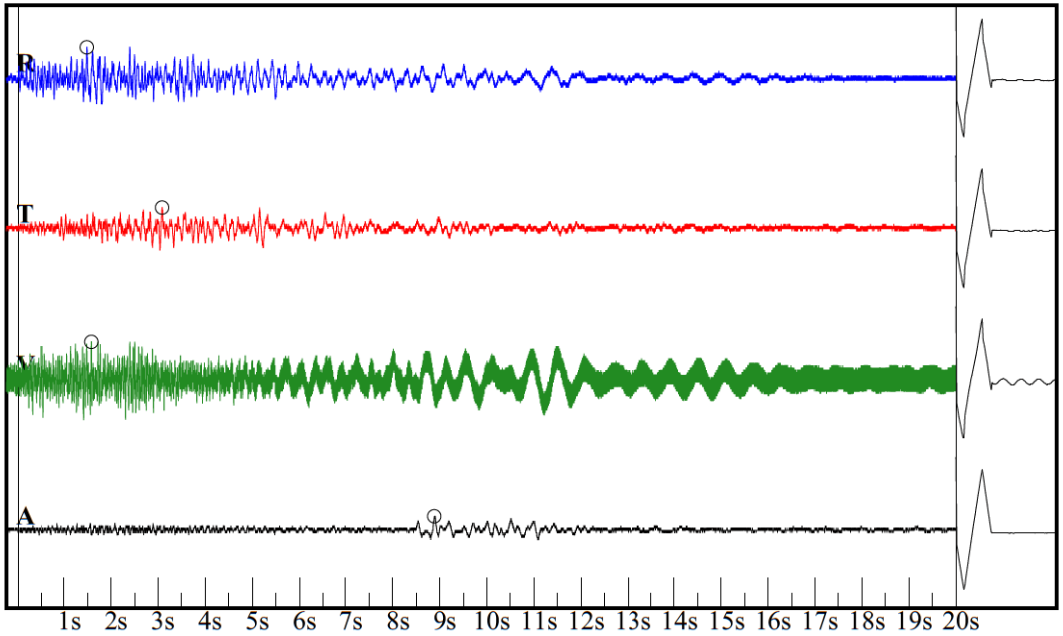
Air

Gain: 1 Trigger: 120 dBL

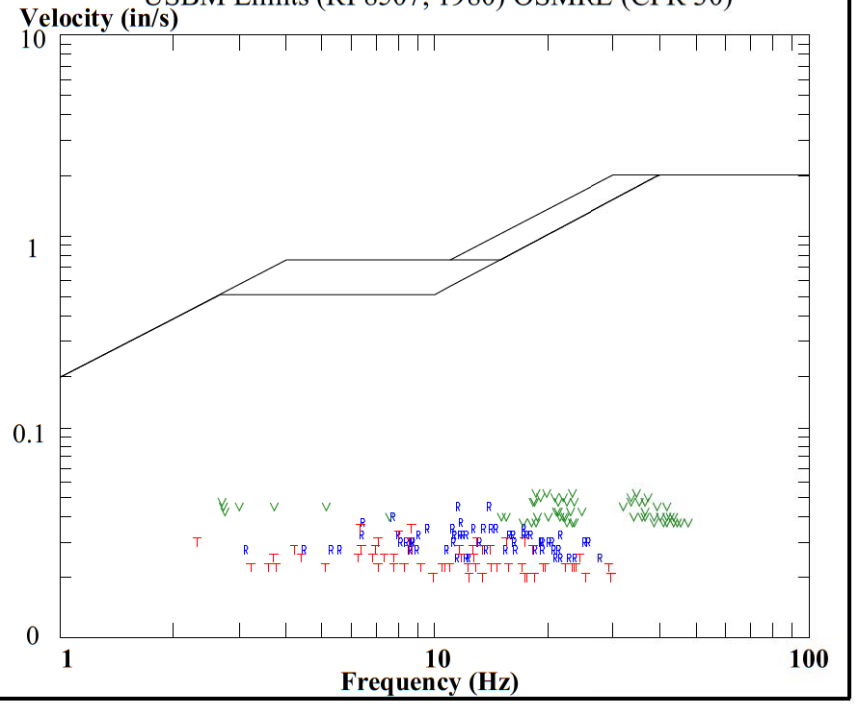
Measurement	Value	Trigger >>> Peak	
psi	.00025	8880.4	
dBL	**99**		
Hz	6.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

30-Apr-18 at 15:01:27 PM Event # 561

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.015**	**0.010**	**0.025**
Frequency (Hz)	**10.50**	**7.90**	**37.90**
Displacement (in)	**0.0002**	**0.0002**	**0.0001**
Acceleration (g's)	**0.0026**	**0.0013**	**0.0154**
Trigger >>> Peak	2.4	99.6	12277.1

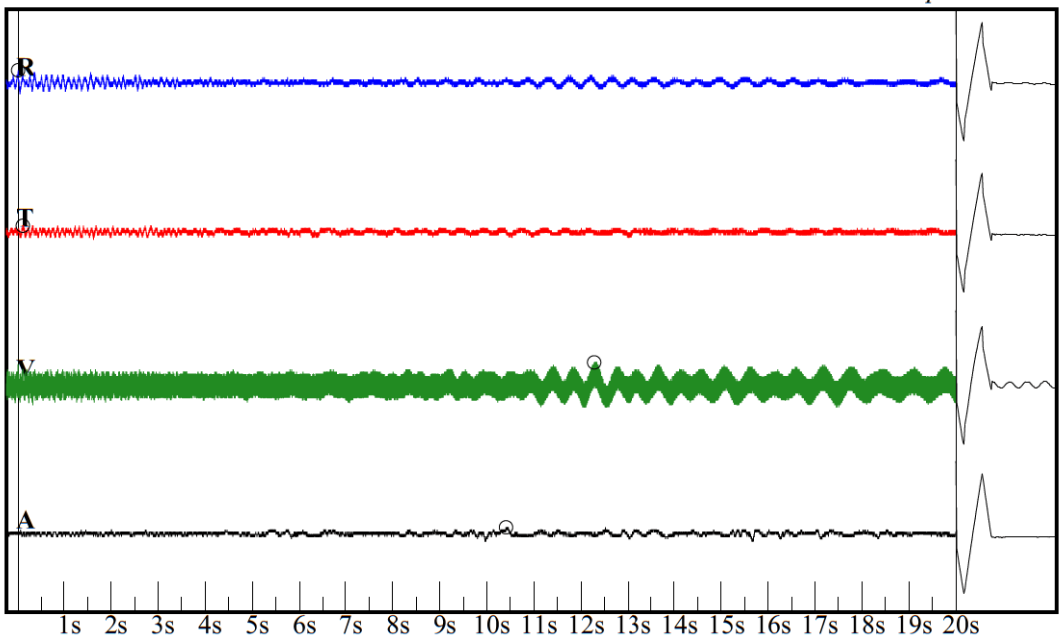
Air

Gain: 1 Trigger: 120 dBL

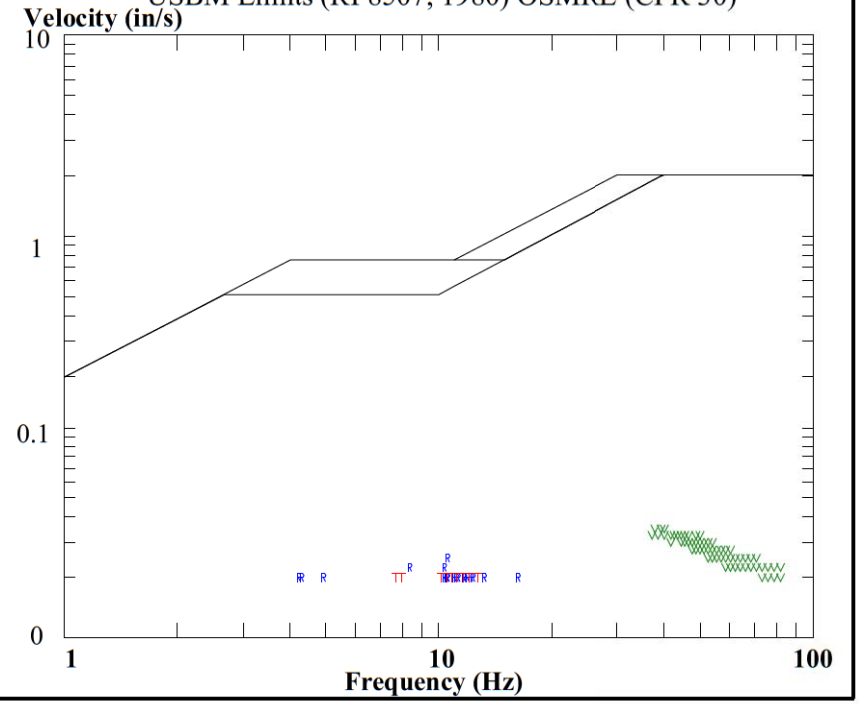
Measurement	Value	Trigger >>> Peak	
psi	.00015	10405	
dBL	**94**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

01-May-18 at 13:31:22 PM Event # 563

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.055**	**0.028**	**0.028**
Frequency (Hz)	**8.50**	**5.80**	**17.20**
Displacement (in)	**0.0010**	**0.0008**	**0.0003**
Acceleration (g's)	**0.0076**	**0.0026**	**0.0077**
Trigger >>> Peak	1346.9	2794.4	1095.7

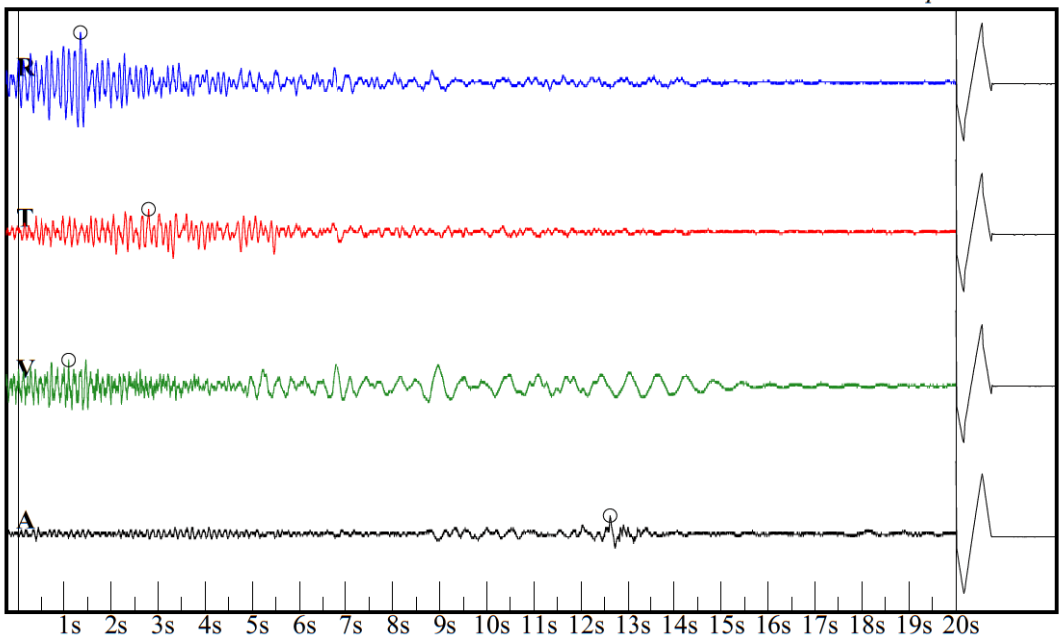
Air

Gain: 1 Trigger: 120 dBL

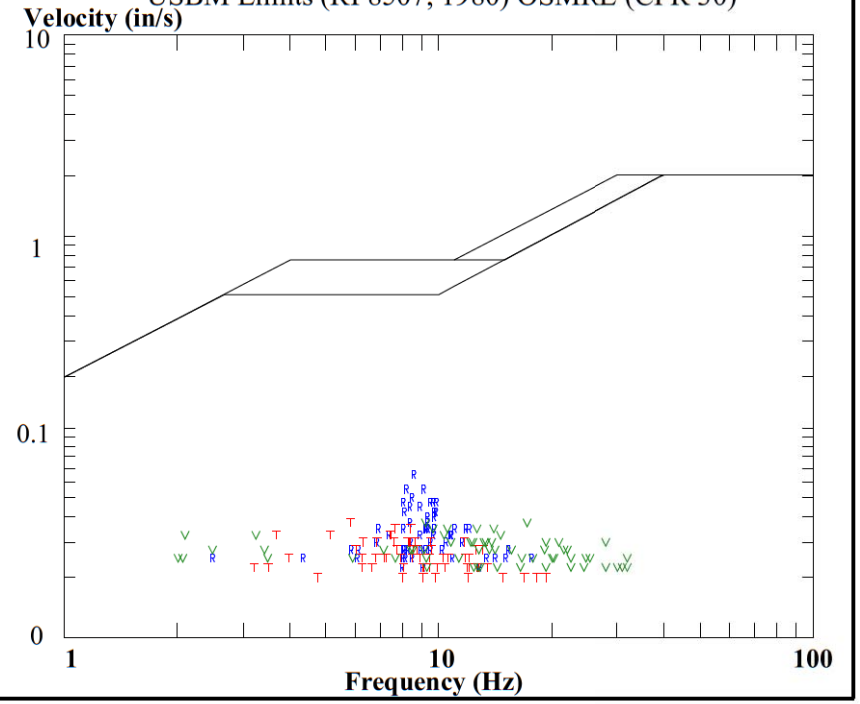
Measurement	Value	Trigger >>> Peak	
psi	.00033	12615	
dBL	**101**		
Hz	2.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

02-May-18 at 14:31:48 PM Event # 566

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.030**
Frequency (Hz)	**3.60**	**3.00**	**6.00**
Displacement (in)	**0.0004**	**0.0005**	**0.0008**
Acceleration (g's)	**0.0006**	**0.0005**	**0.0029**
Trigger >>> Peak	0	2004.6	10872.1

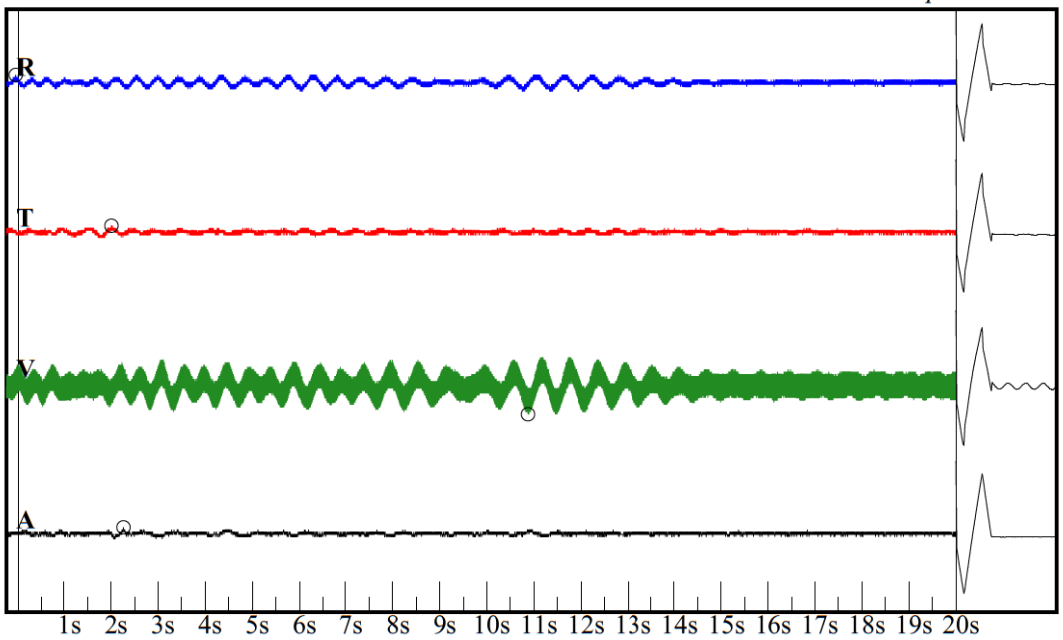
Air

Gain: 1 Trigger: 120 dBL

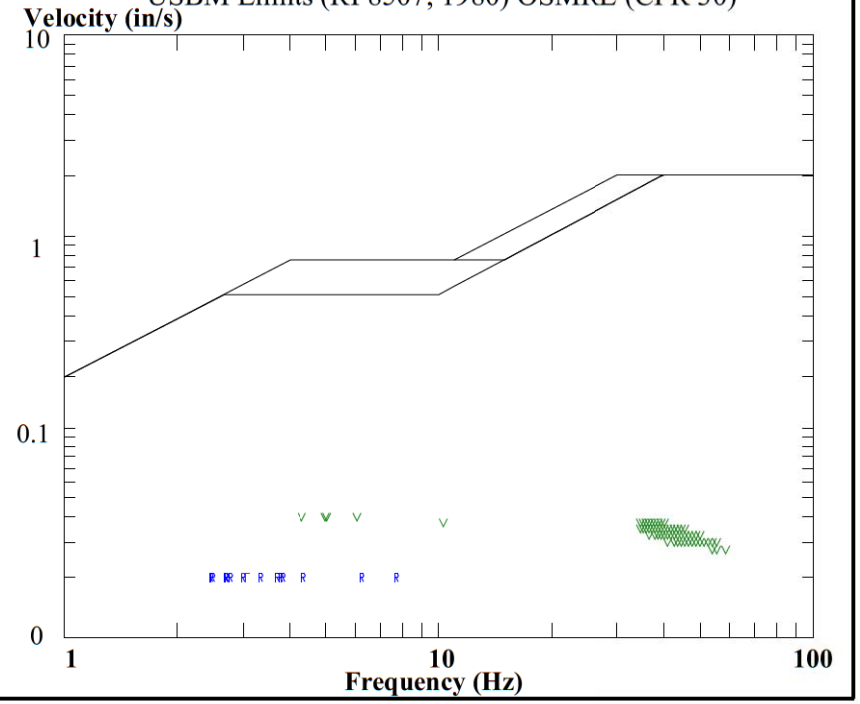
Measurement	Value	Trigger >>> Peak	
psi	.00015	2261	
dBL	**94**		
Hz	4.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

07-May-18 at 14:51:57 PM Event # 577

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.028**
Frequency (Hz)	**4.10**	**3.00**	**40.90**
Displacement (in)	**0.0004**	**0.0005**	**0.0001**
Acceleration (g's)	**0.0007**	**0.0005**	**0.0183**
Trigger >>> Peak	1311.5	747.1	2266.8

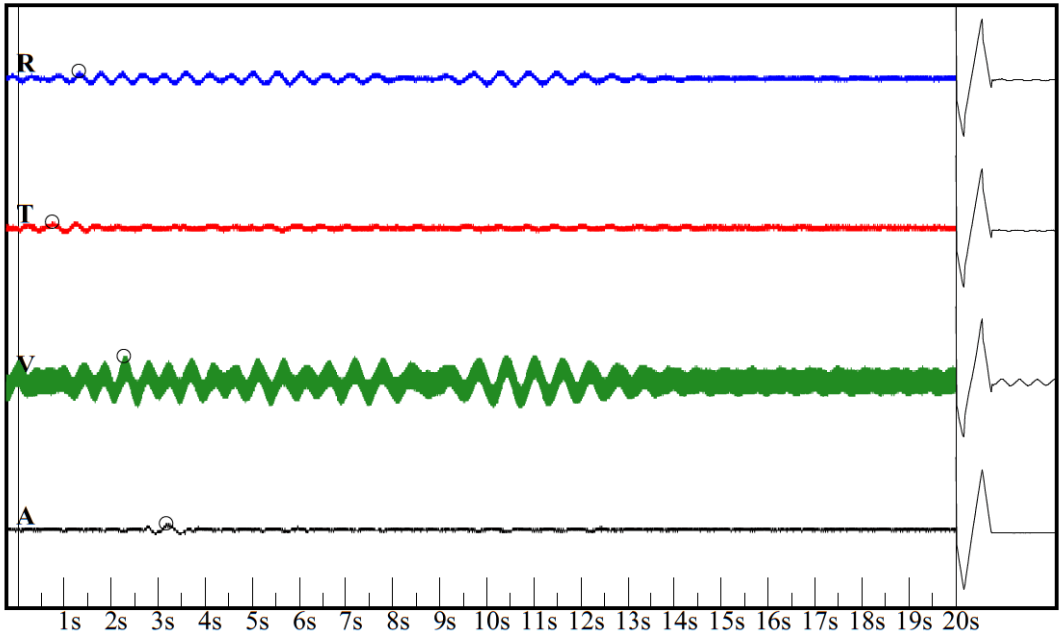
Air

Gain: 1 Trigger: 120 dBL

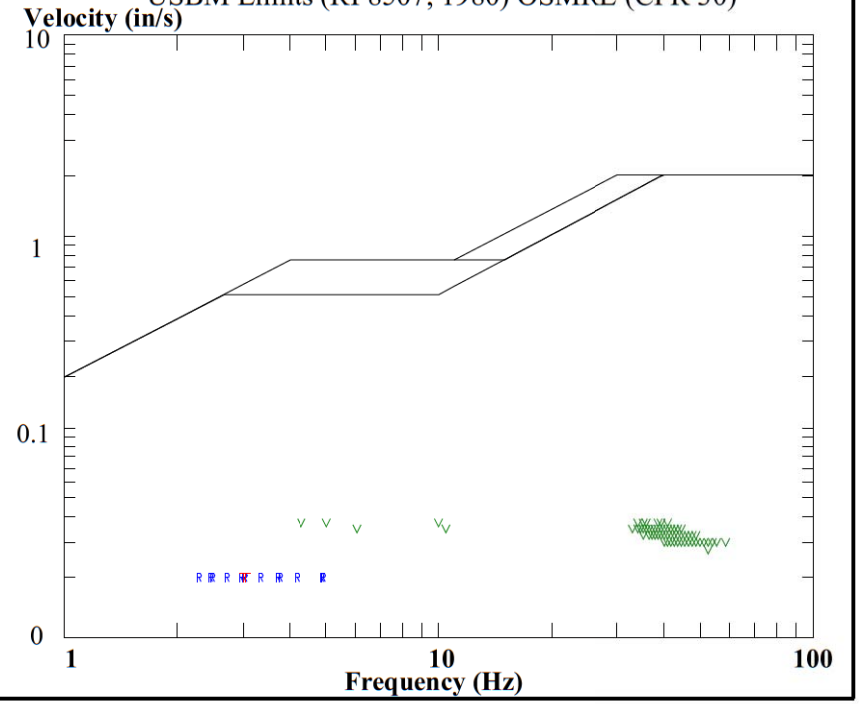
Measurement	Value	Trigger >>> Peak	
psi	.00015	3167	
dBL	**94**		
Hz	1.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12801

08-May-18 at 13:32:36 PM Event # 581

Location: White Rock Quarries East Seismograph

Operator: RESPEC

Notes: 25.944566, -80.331138

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 12Jan18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.050**	**0.033**	**0.043**
Frequency (Hz)	**12.10**	**8.60**	**32.50**
Displacement (in)	**0.0007**	**0.0006**	**0.0002**
Acceleration (g's)	**0.0098**	**0.0045**	**0.0225**
Trigger >>> Peak	2134.3	2513.7	611.6

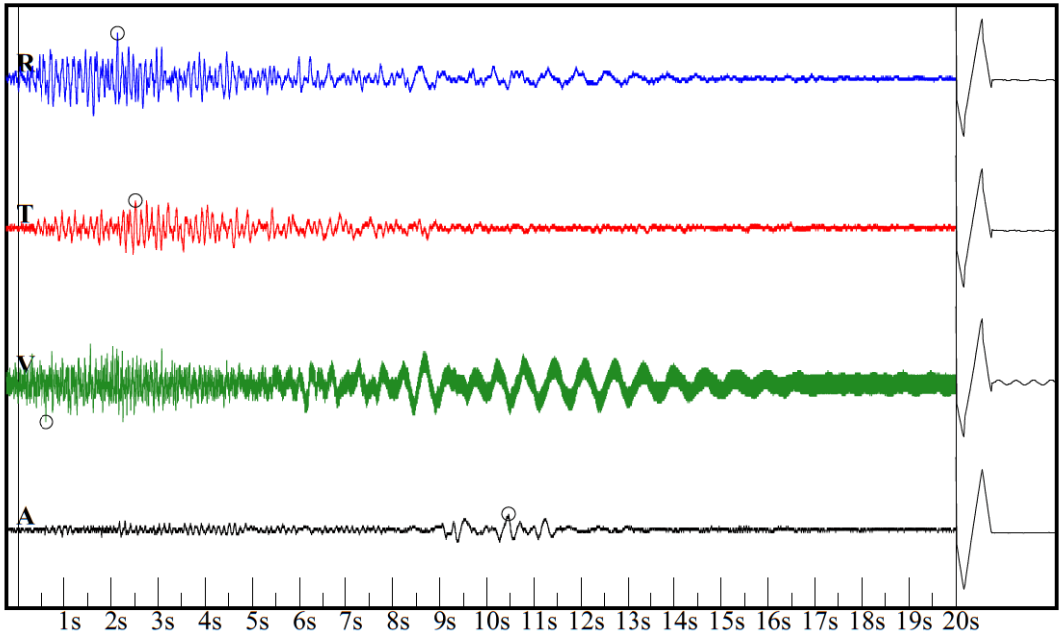
Air

Gain: 1 Trigger: 120 dBL

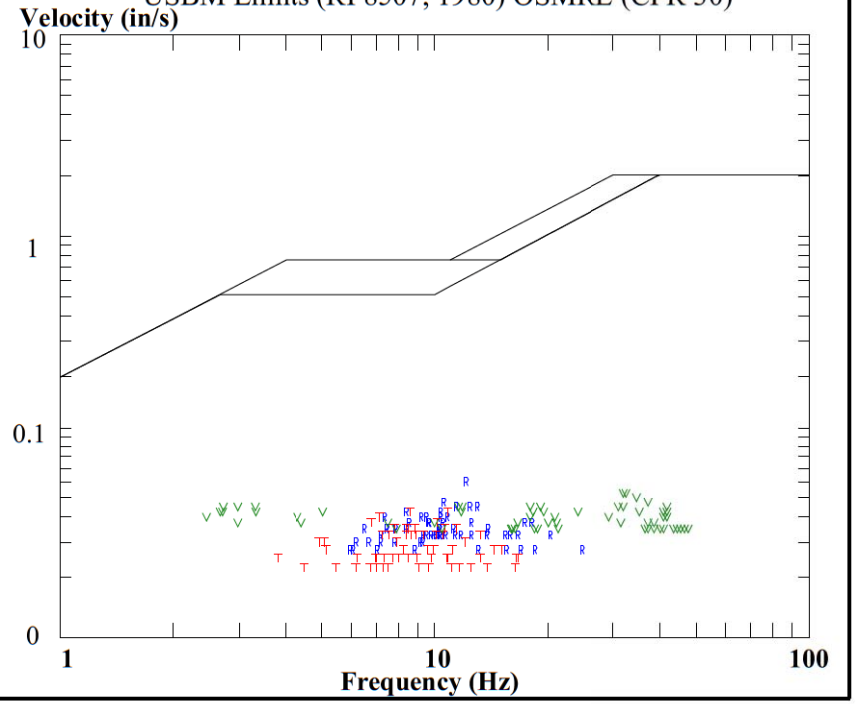
Measurement	Value	Trigger >>> Peak	
psi	.00029	10460.2	
dBL	**100**		
Hz	3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

13-Feb-18 at 13:13:50 PM Event # 5

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .05 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.075**	**0.035**	**0.070**
Frequency (Hz)	**9.30**	**8.50**	**1.70**
Displacement (in)	**0.0013**	**0.0007**	**0.0066**
Acceleration (g's)	**0.0113**	**0.0048**	**0.0019**
Trigger >>> Peak	427.5	924.1	9801.3

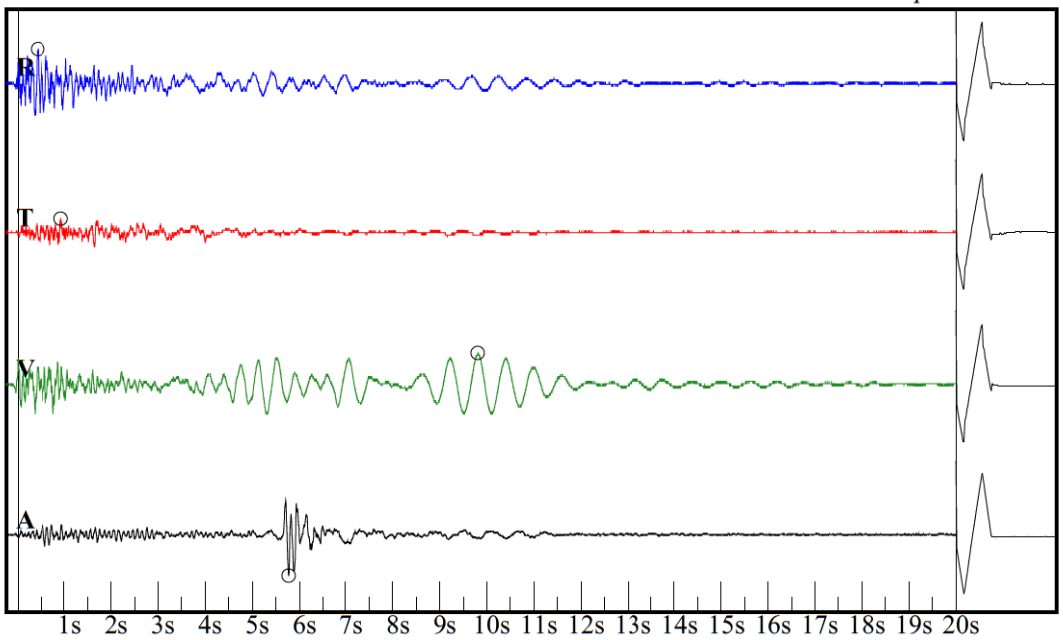
Air

Gain: 1 Trigger: 120 dBL

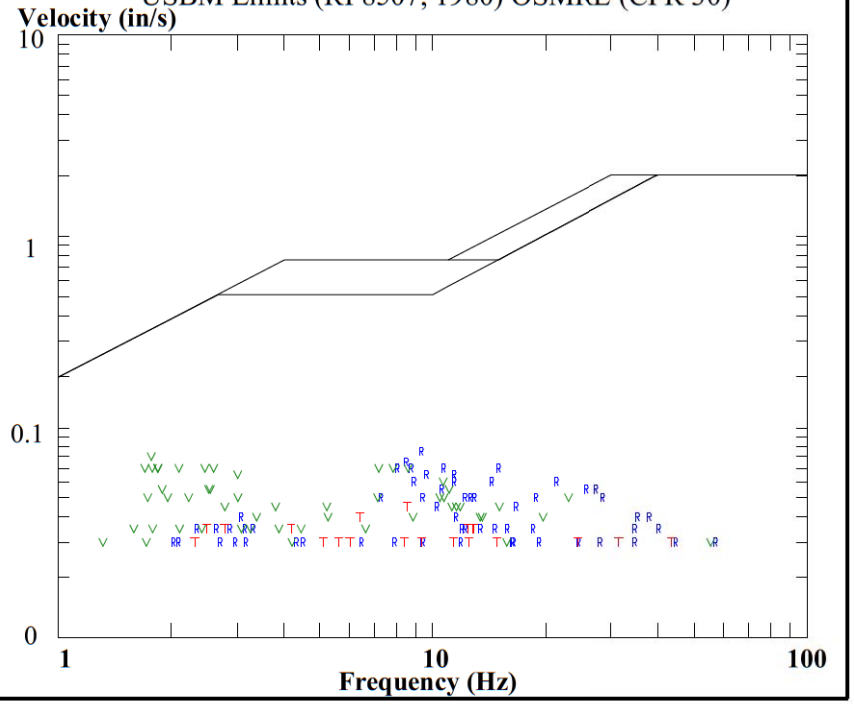
Measurement	Value	Trigger >>> Peak	
psi	.0012	5767.8	
dBL	**112**		
Hz	8.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

16-Feb-18 at 11:29:04 AM Event # 9

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .05 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.015**	**0.075**
Frequency (Hz)	**3.10**	**0.00**	**2.50**
Displacement (in)	**0.0015**		**0.0048**
Acceleration (g's)	**0.0015**	**0.0000**	**0.0030**
Trigger >>> Peak	0	0	884.5

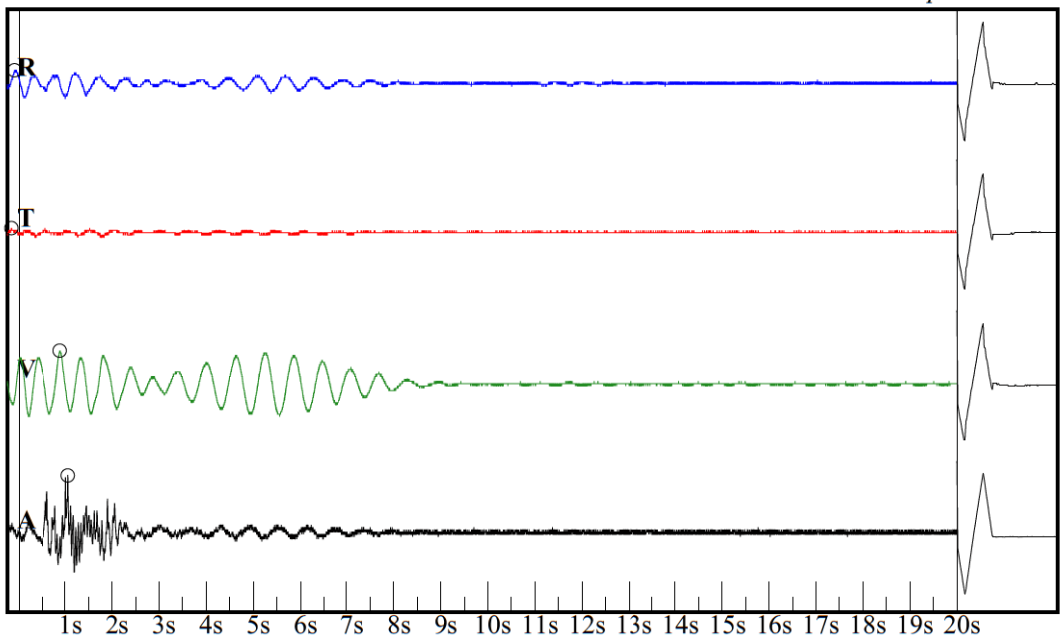
Air

Gain: 1 Trigger: 120 dBL

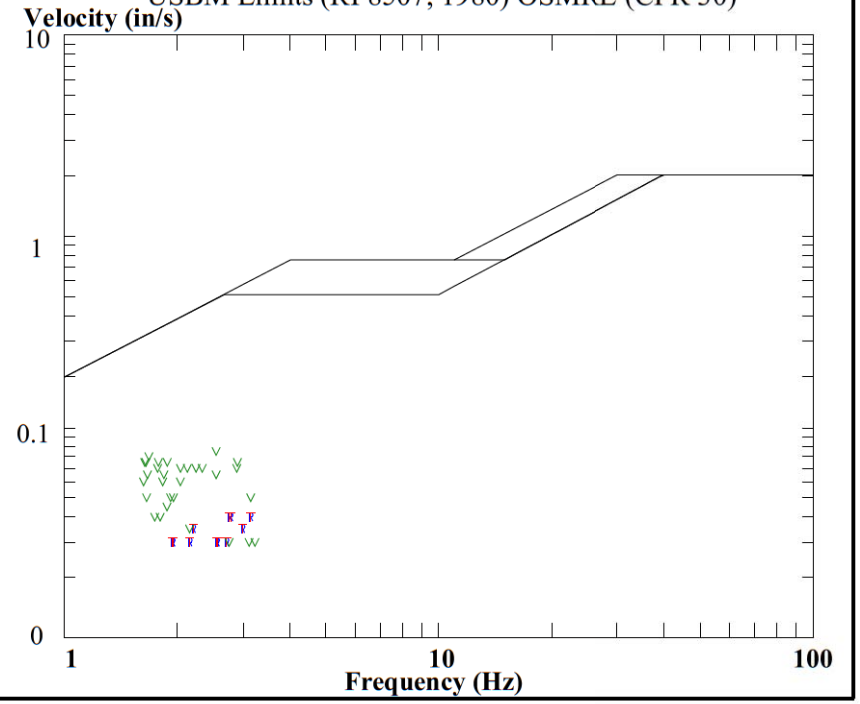
Measurement	Value	Trigger >>> Peak	
psi	.00094	1056.6	
dBL	**110**		
Hz	3.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

19-Feb-18 at 13:59:04 PM Event # 14

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.050**	**0.030**	**0.045**
Frequency (Hz)	**13.80**	**6.10**	**9.70**
Displacement (in)	**0.0006**	**0.0008**	**0.0007**
Acceleration (g's)	**0.0112**	**0.0030**	**0.0071**
Trigger >>> Peak	486.6	4947.3	3267.6

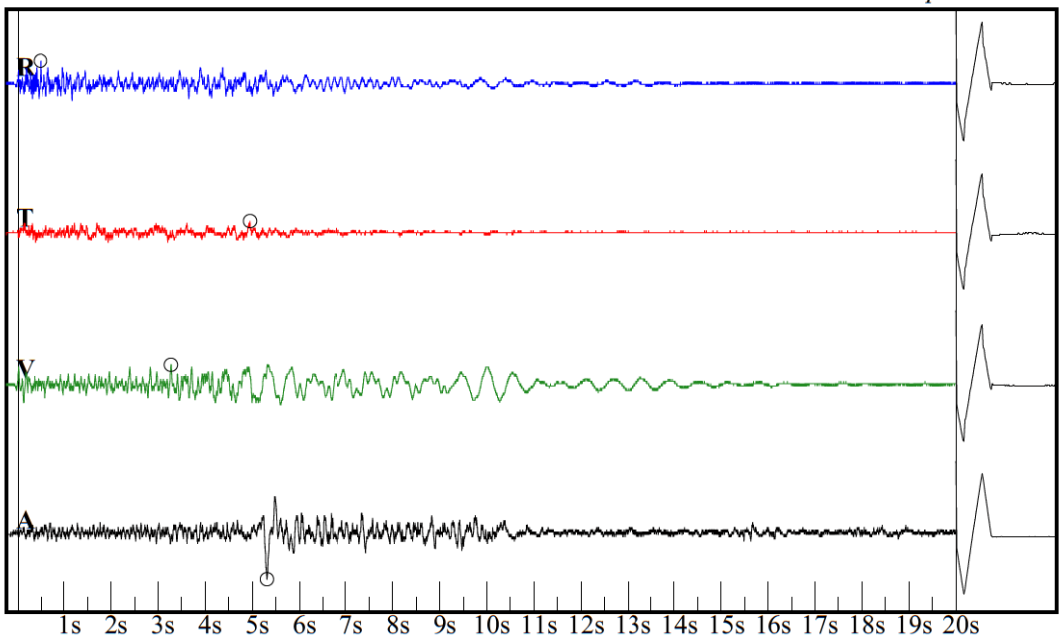
Air

Gain: 1 Trigger: 120 dBL

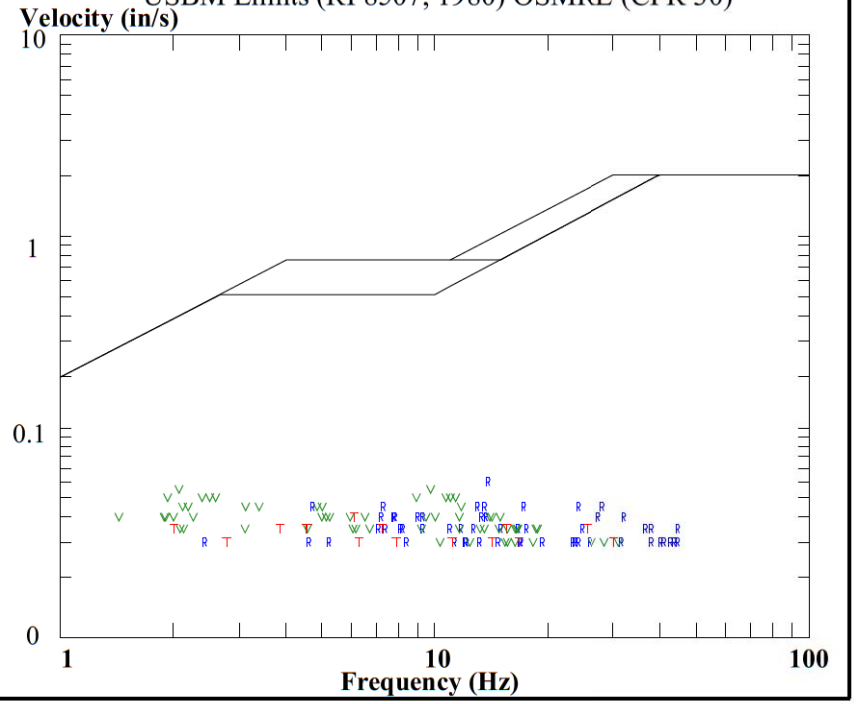
Measurement	Value	Trigger >>> Peak	
psi	.00065	5306.4	
dBL	**107**		
Hz	4.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

20-Feb-18 at 13:14:20 PM Event # 16

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.030**	**0.030**
Frequency (Hz)	**32.50**	**29.60**	**16.70**
Displacement (in)	**0.0001**	**0.0002**	**0.0003**
Acceleration (g's)	**0.0159**	**0.0144**	**0.0081**
Trigger >>> Peak	99.9	170.2	788.8

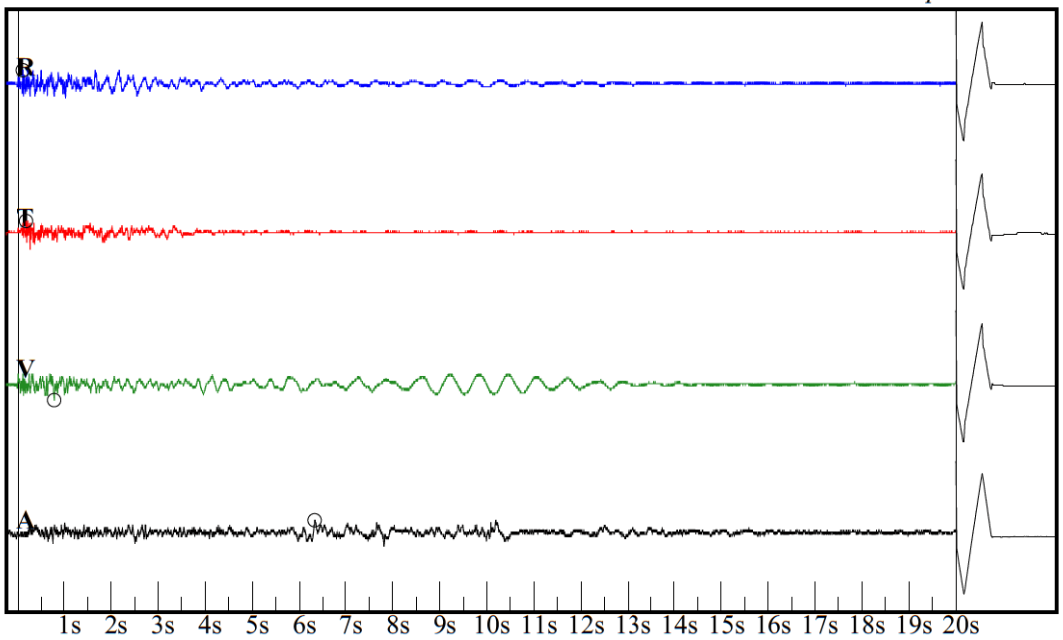
Air

Gain: 1 Trigger: 120 dBL

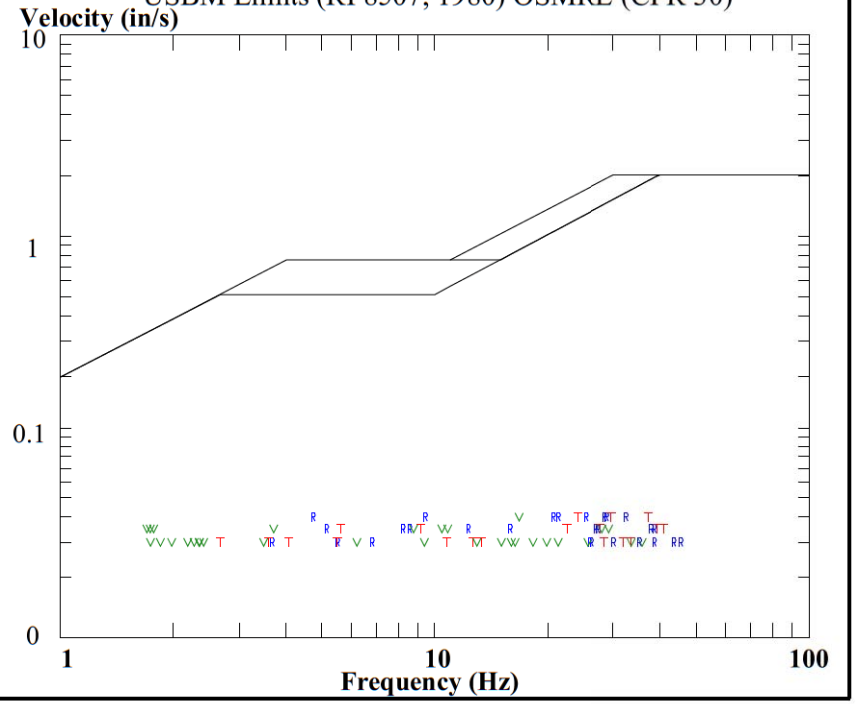
Measurement	Value	Trigger >>> Peak	
psi	.00025	6320.3	
dBL	**99**		
Hz	1.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

22-Feb-18 at 13:30:33 PM Event # 19

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.045**	**0.060**
Frequency (Hz)	**11.90**	**6.20**	**7.20**
Displacement (in)	**0.0006**	**0.0012**	**0.0013**
Acceleration (g's)	**0.0087**	**0.0045**	**0.0070**
Trigger >>> Peak	1242.2	1515.4	2657.2

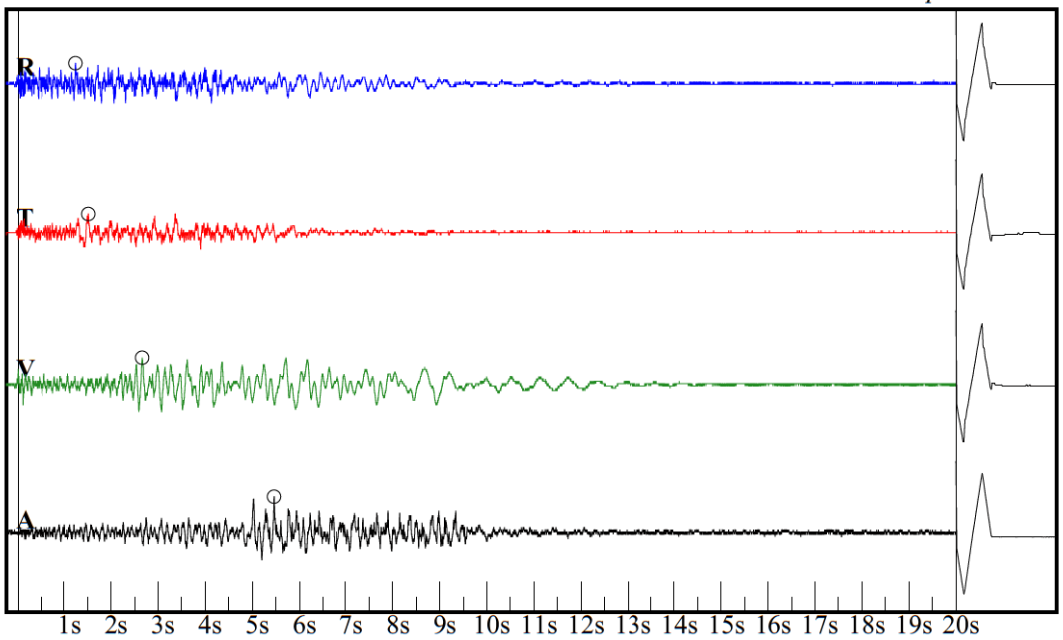
Air

Gain: 1 Trigger: 120 dBL

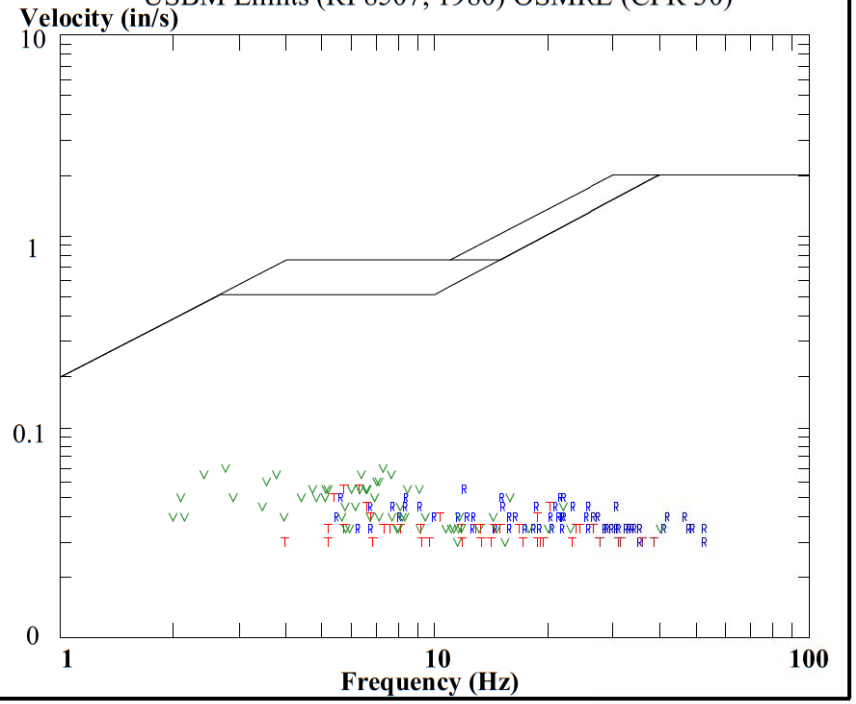
Measurement	Value	Trigger >>> Peak	
psi	.00062	5457.5	
dBL	**107**		
Hz	5.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

26-Feb-18 at 13:59:08 PM Event # 24

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.025**	**0.045**
Frequency (Hz)	**29.60**	**4.00**	**1.90**
Displacement (in)	**0.0002**	**0.0010**	**0.0038**
Acceleration (g's)	**0.0144**	**0.0016**	**0.0014**
Trigger >>> Peak	596.2	2442.4	5551

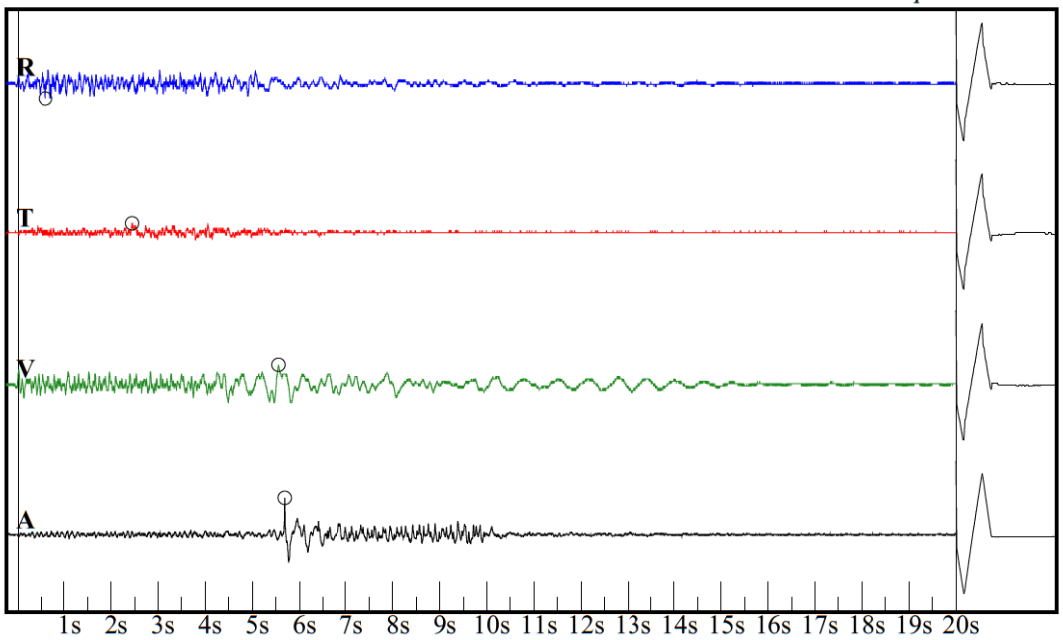
Air

Gain: 1 Trigger: 120 dBL

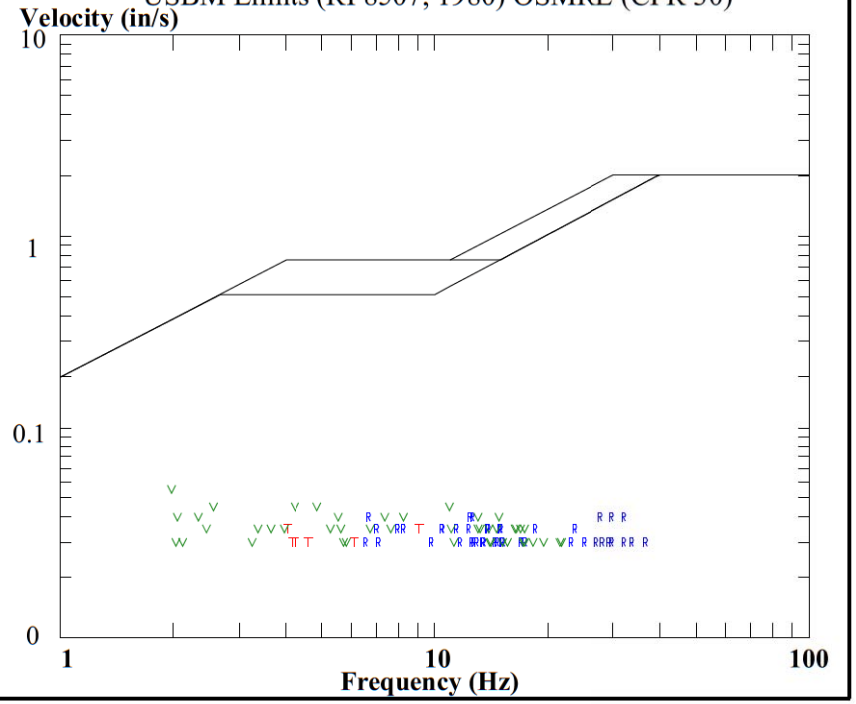
Measurement	Value	Trigger >>> Peak	
psi	.0012	5686	
dBL	**112**		
Hz	6.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

27-Feb-18 at 13:32:52 PM Event # 26

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.025**	**0.025**	**0.030**
Frequency (Hz)	**24.30**	**2.30**	**15.50**
Displacement (in)	**0.0002**	**0.0017**	**0.0003**
Acceleration (g's)	**0.0099**	**0.0009**	**0.0076**
Trigger >>> Peak	189.2	2430.2	349.6

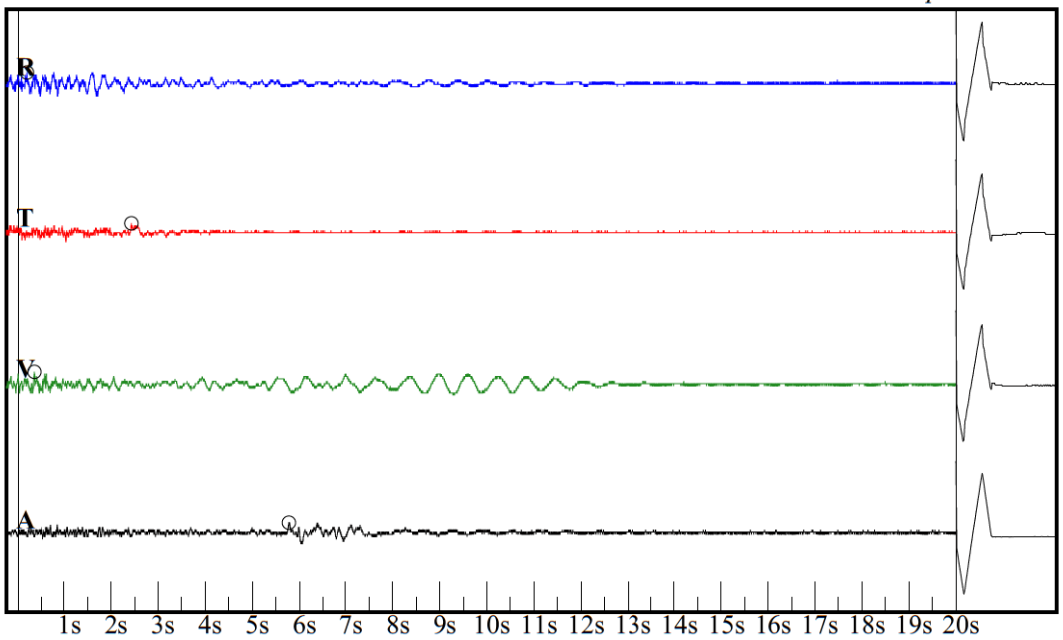
Air

Gain: 1 Trigger: 120 dBL

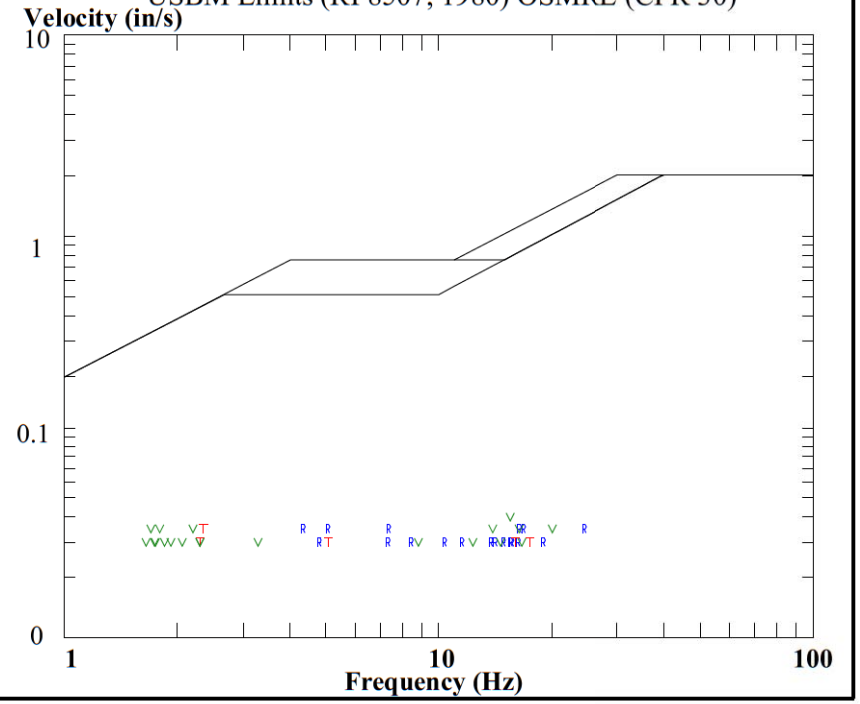
Measurement	Value	Trigger >>> Peak	
psi	.00022	5773.4	
dBL	**98**		
Hz	2.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

05-Mar-18 at 13:59:27 PM Event # 34

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.025**	**0.055**
Frequency (Hz)	**8.00**	**8.30**	**1.90**
Displacement (in)	**0.0007**	**0.0005**	**0.0046**
Acceleration (g's)	**0.0046**	**0.0034**	**0.0017**
Trigger >>> Peak	3764.9	1472.7	6961.4

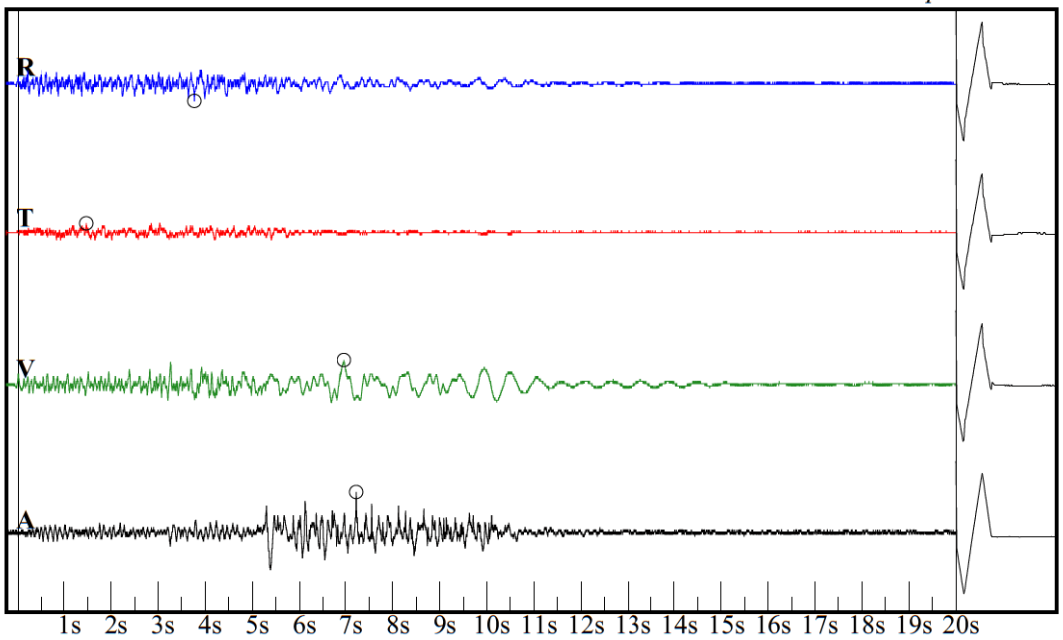
Air

Gain: 1 Trigger: 120 dBL

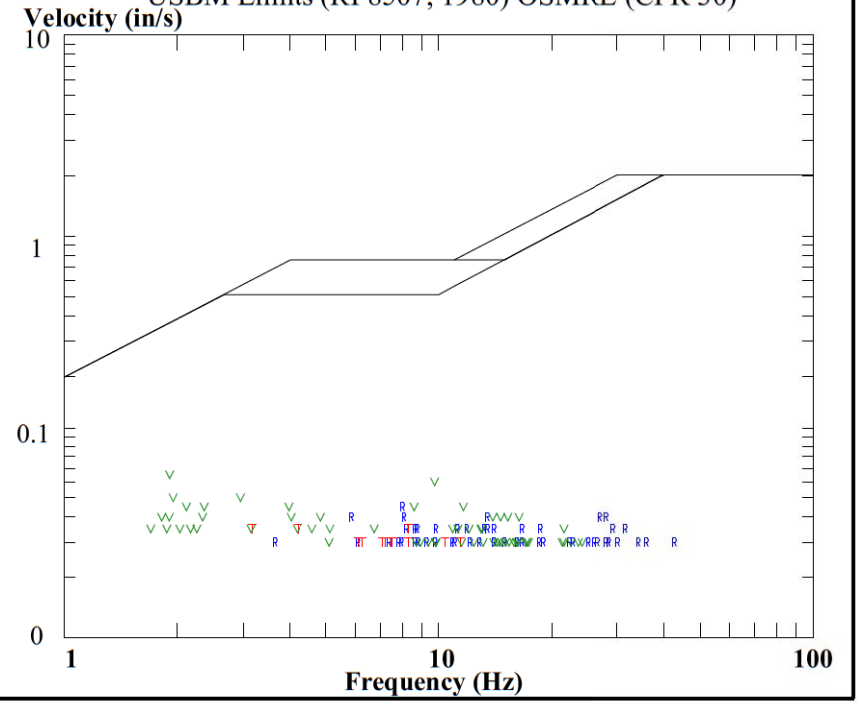
Measurement	Value	Trigger >>> Peak	
psi	.00069	7224.6	
dBL	**108**		
Hz	6.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

07-Mar-18 at 11:35:58 AM Event # 38

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.025**	**0.025**
Frequency (Hz)	**33.00**	**26.50**	**18.20**
Displacement (in)	**0.0001**	**0.0002**	**0.0002**
Acceleration (g's)	**0.0107**	**0.0108**	**0.0074**
Trigger >>> Peak	48.6	195.6	0

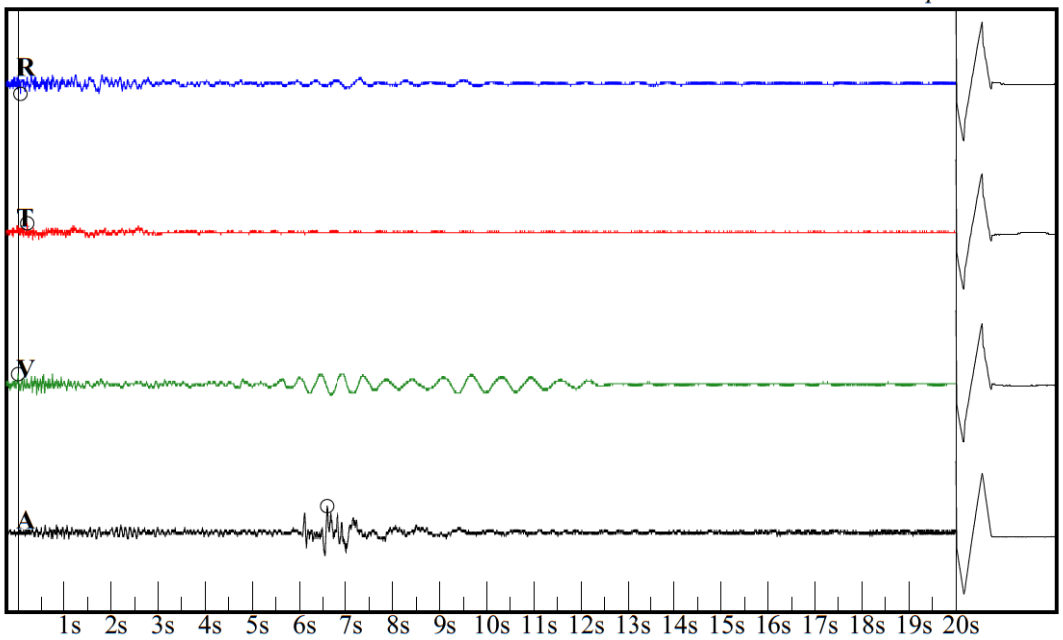
Air

Gain: 1 Trigger: 120 dBL

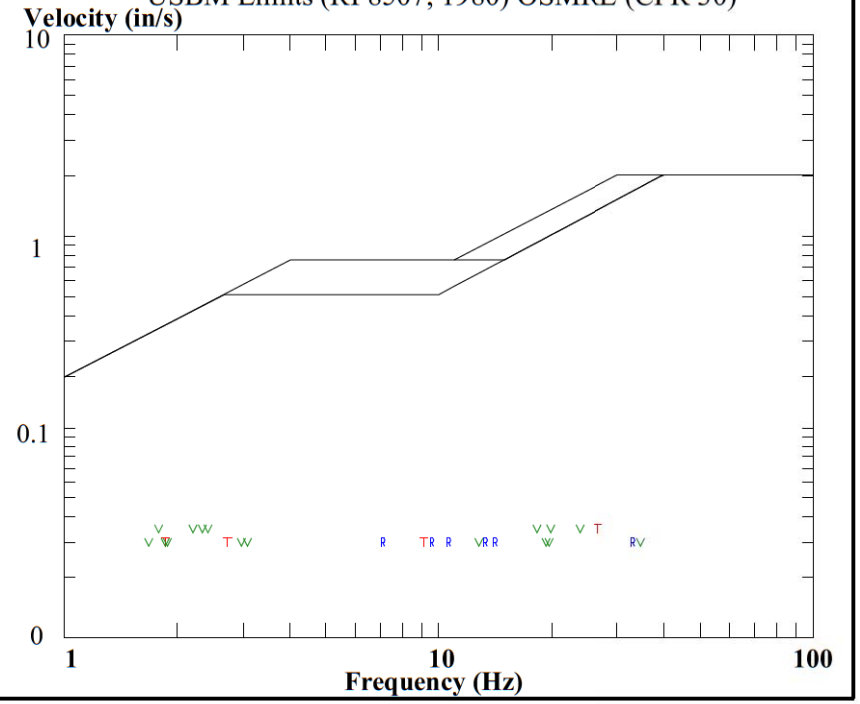
Measurement	Value	Trigger >>> Peak	
psi	.00047	6586.2	
dBL	**104**		
Hz	3.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

09-Mar-18 at 13:15:10 PM Event # 44

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.025**	**0.040**
Frequency (Hz)	**7.60**	**2.40**	**12.90**
Displacement (in)	**0.0007**	**0.0017**	**0.0005**
Acceleration (g's)	**0.0043**	**0.0010**	**0.0084**
Trigger >>> Peak	4047.4	2574.7	1804

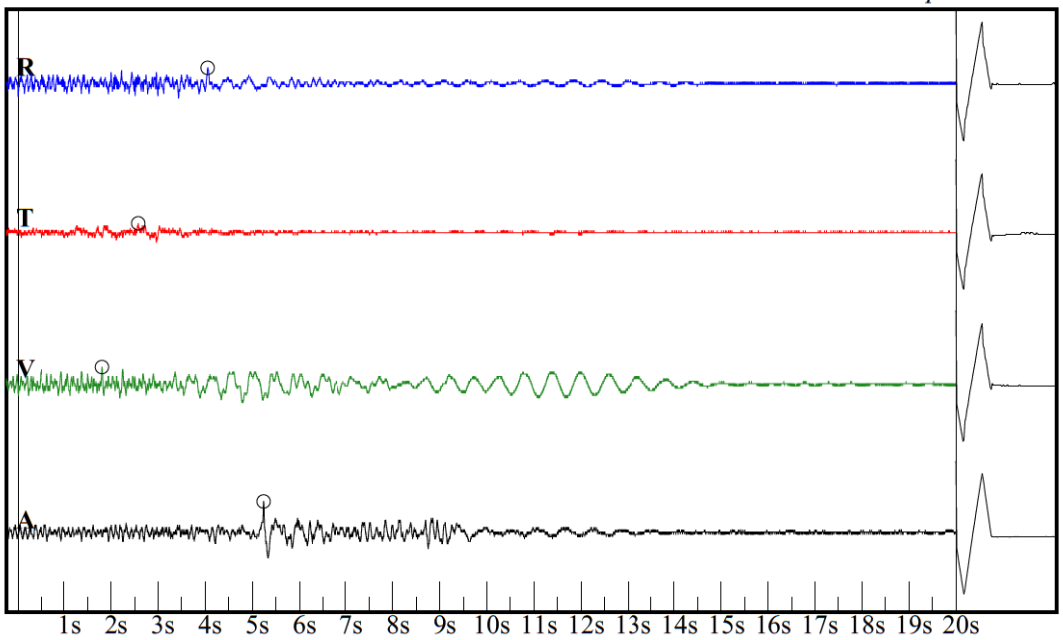
Air

Gain: 1 Trigger: 120 dBL

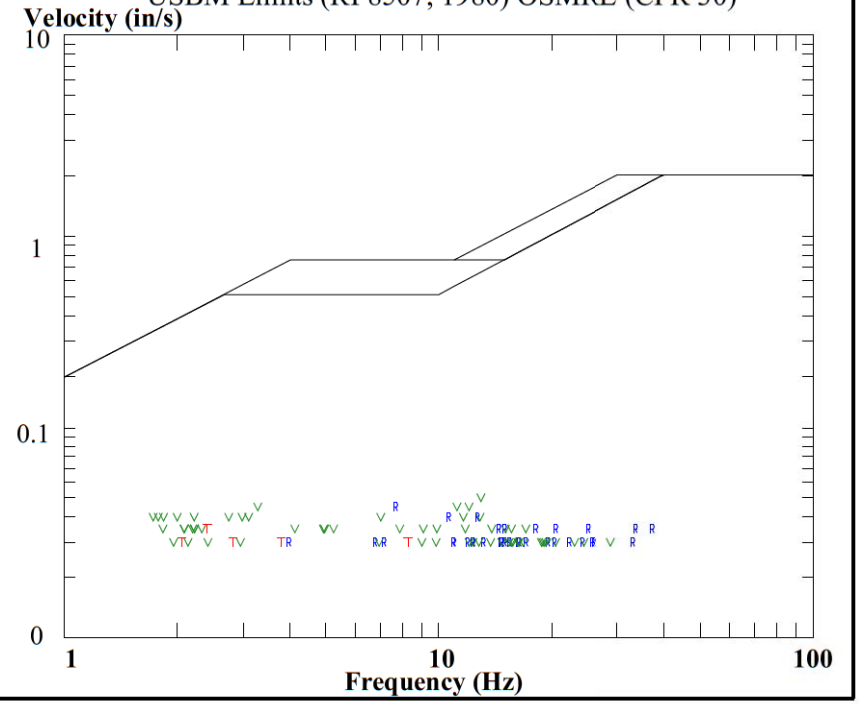
Measurement	Value	Trigger >>> Peak	
psi	.00054	5235.6	
dBL	**105**		
Hz	3.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

19-Mar-18 at 14:18:40 PM Event # 61

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.035**	**0.065**
Frequency (Hz)	**17.30**	**6.40**	**7.70**
Displacement (in)	**0.0004**	**0.0009**	**0.0013**
Acceleration (g's)	**0.0113**	**0.0036**	**0.0081**
Trigger >>> Peak	1916.5	3626.5	3342.5

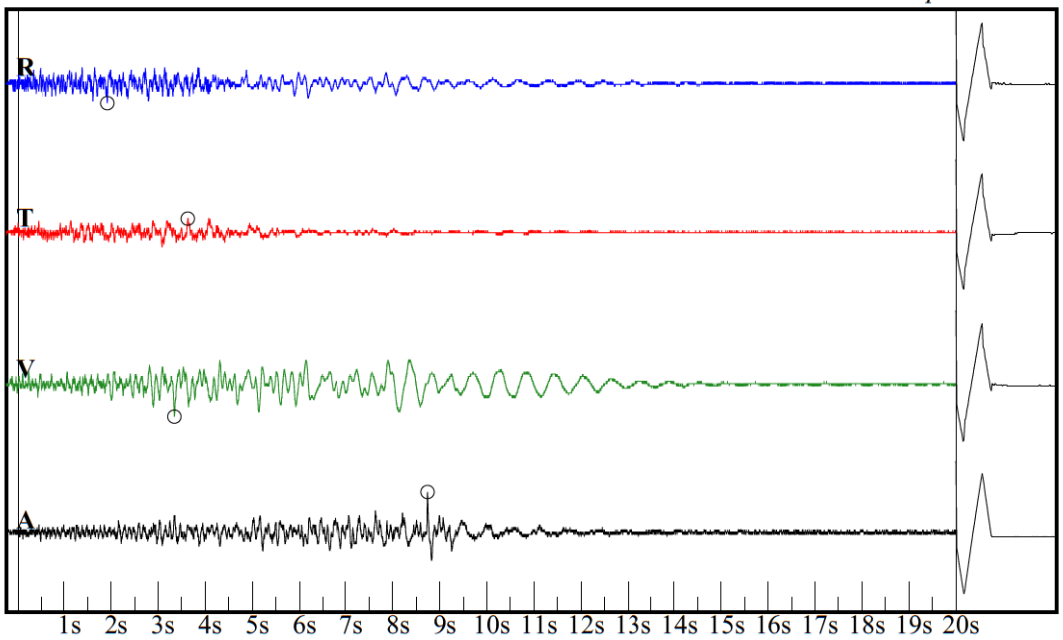
Air

Gain: 1 Trigger: 120 dBL

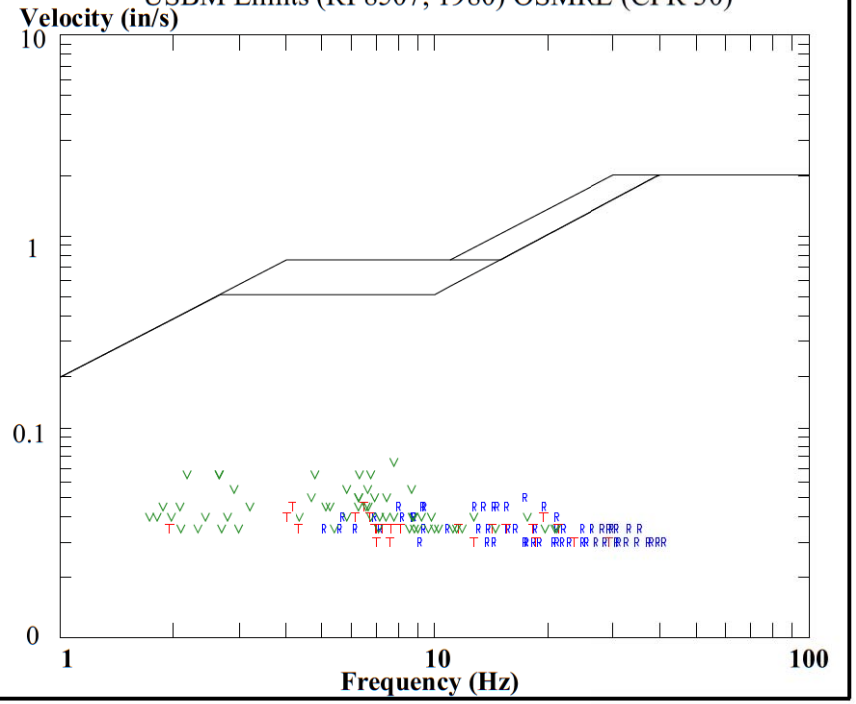
Measurement	Value	Trigger >>> Peak	
psi	.00069	8737.5	
dBL	**108**		
Hz	9.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

20-Mar-18 at 11:44:53 AM Event # 63

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.065**	**0.035**	**0.060**
Frequency (Hz)	**30.10**	**32.00**	**2.00**
Displacement (in)	**0.0003**	**0.0002**	**0.0048**
Acceleration (g's)	**0.0318**	**0.0182**	**0.0020**
Trigger >>> Peak	629.6	424.6	4058.4

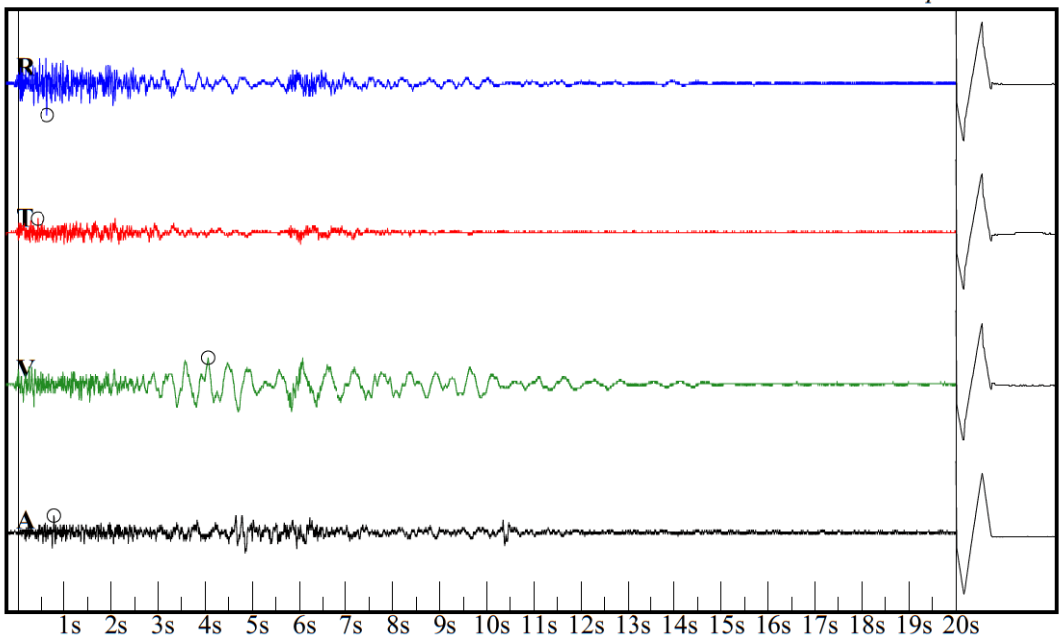
Air

Gain: 1 Trigger: 120 dBL

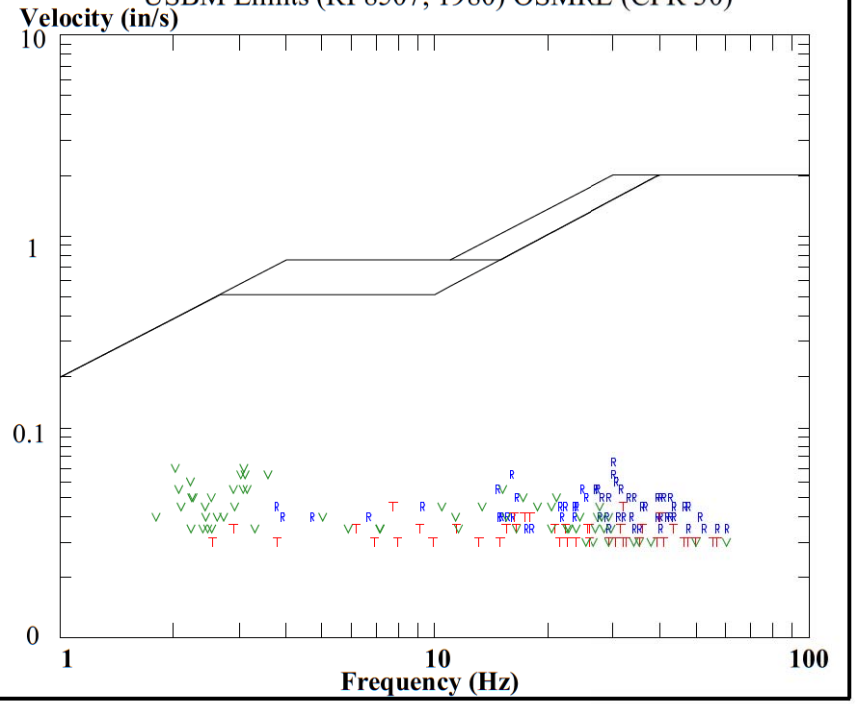
Measurement	Value	Trigger >>> Peak	
psi	.00033	784.7	
dBL	**101**		
Hz	11		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

23-Mar-18 at 13:14:43 PM Event # 67

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.090**	**0.050**	**0.080**
Frequency (Hz)	**23.80**	**6.20**	**2.30**
Displacement (in)	**0.0006**	**0.0013**	**0.0055**
Acceleration (g's)	**0.0348**	**0.0050**	**0.0030**
Trigger >>> Peak	1073.2	1905	4530.5

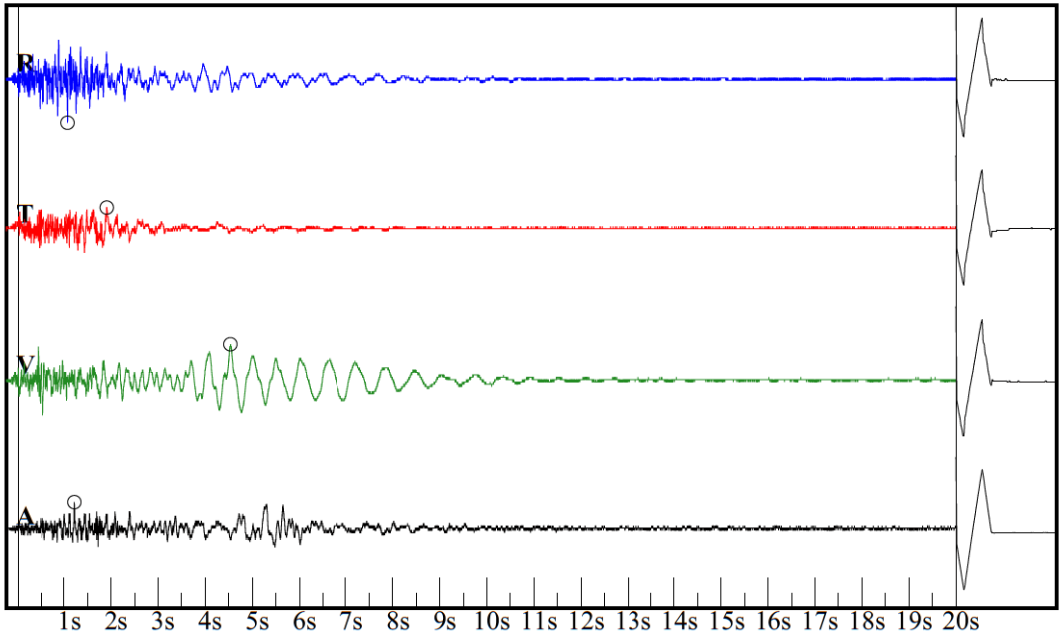
Air

Gain: 1 Trigger: 120 dBL

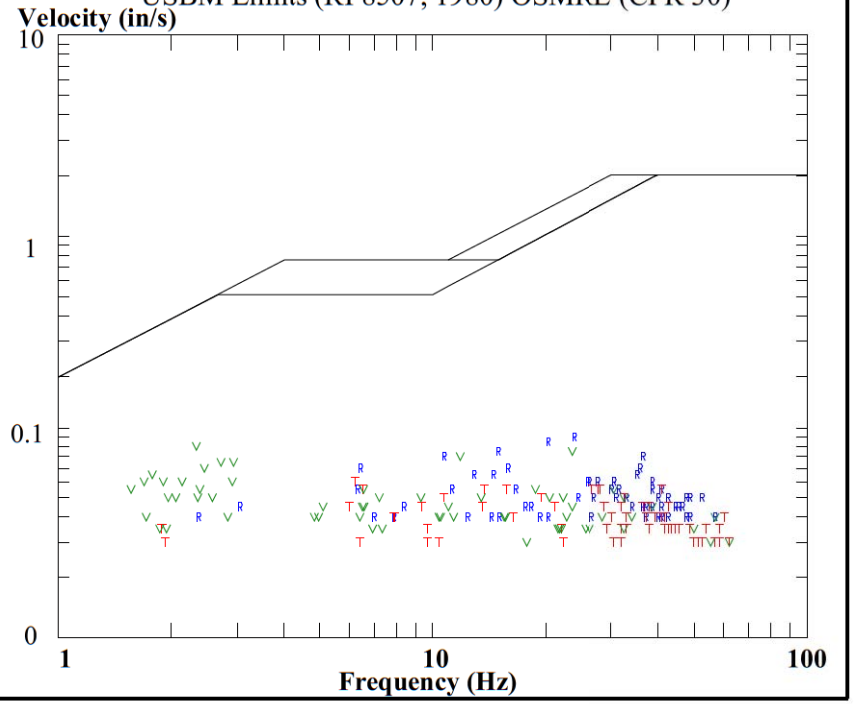
Measurement	Value	Trigger >>> Peak	
psi	.00047	1217.5	
dBL	**104**		
Hz	9.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

26-Mar-18 at 14:29:51 PM Event # 71

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.085**	**0.075**	**0.070**
Frequency (Hz)	**31.50**	**6.70**	**2.40**
Displacement (in)	**0.0004**	**0.0018**	**0.0046**
Acceleration (g's)	**0.0435**	**0.0082**	**0.0027**
Trigger >>> Peak	1844.7	2244.1	3915.3

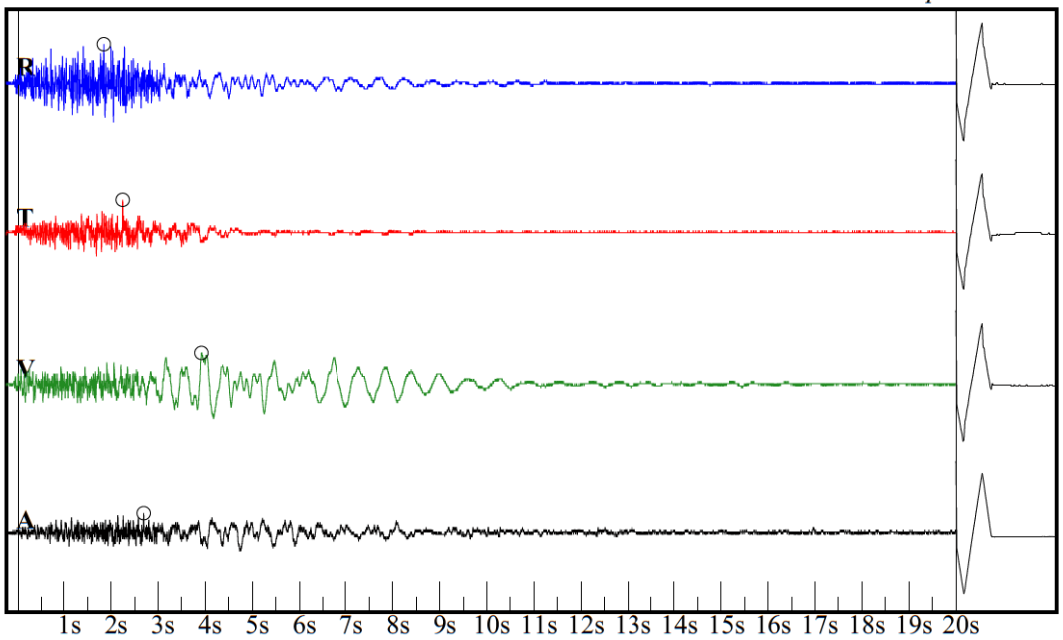
Air

Gain: 1 Trigger: 120 dBL

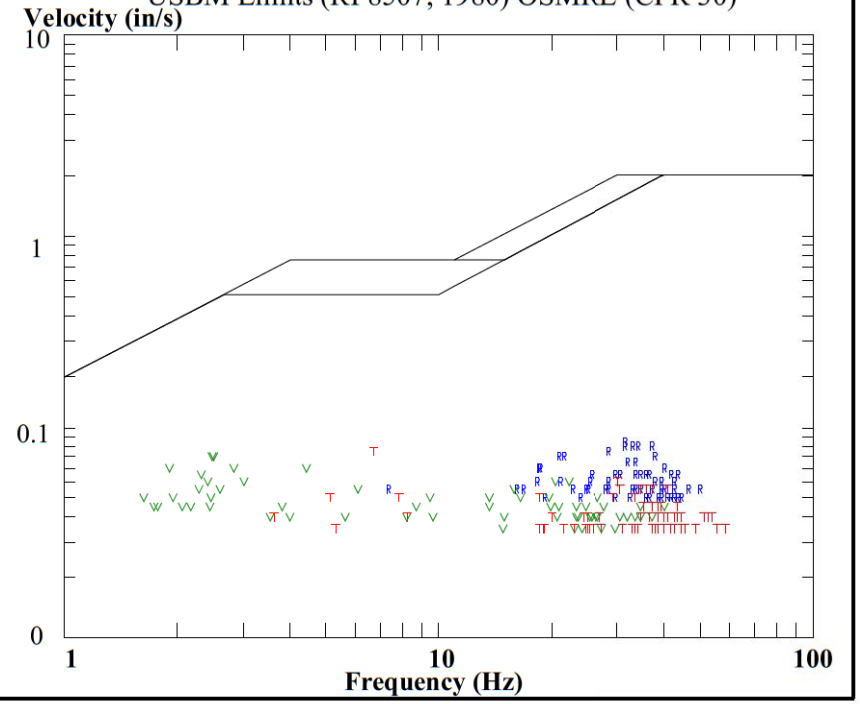
Measurement	Value	Trigger >>> Peak	
psi	.00036	2690.2	
dBL	**102**		
Hz	9.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

29-Mar-18 at 13:17:46 PM Event # 75

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.055**	**0.040**
Frequency (Hz)	**28.00**	**5.30**	**11.10**
Displacement (in)	**0.0002**	**0.0017**	**0.0006**
Acceleration (g's)	**0.0182**	**0.0047**	**0.0072**
Trigger >>> Peak	579.6	1472.4	91.1

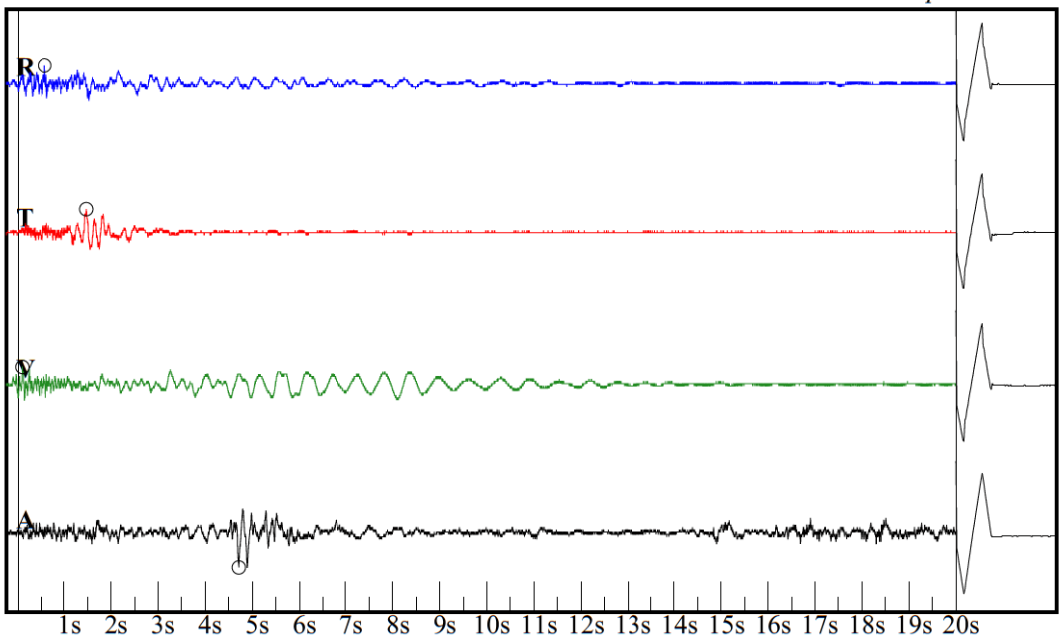
Air

Gain: 1 Trigger: 120 dBL

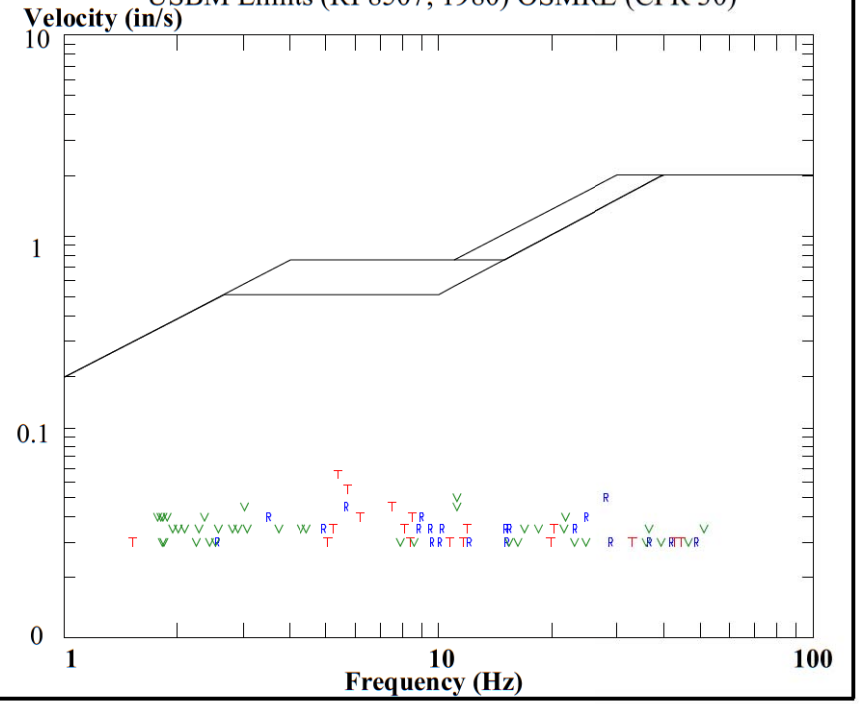
Measurement	Value	Trigger >>> Peak	
psi	.00047	4710.4	
dBL	**104**		
Hz	6.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

30-Mar-18 at 11:30:07 AM Event # 78

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.065**	**0.040**	**0.065**
Frequency (Hz)	**28.40**	**10.70**	**5.00**
Displacement (in)	**0.0004**	**0.0006**	**0.0021**
Acceleration (g's)	**0.0300**	**0.0070**	**0.0053**
Trigger >>> Peak	1068.4	94.7	3381.6

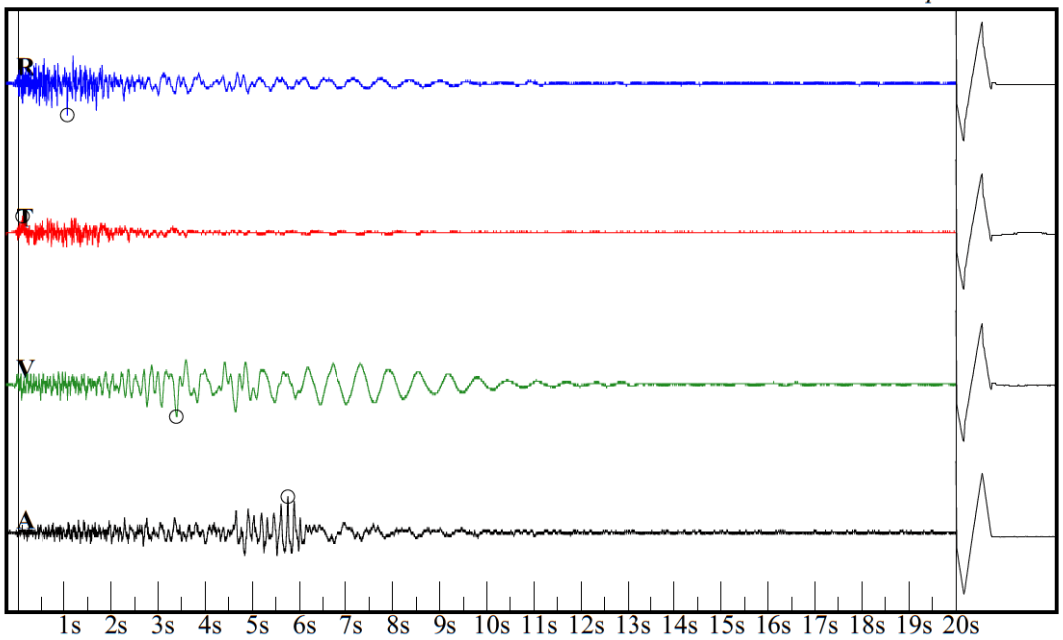
Air

Gain: 1 Trigger: 120 dBL

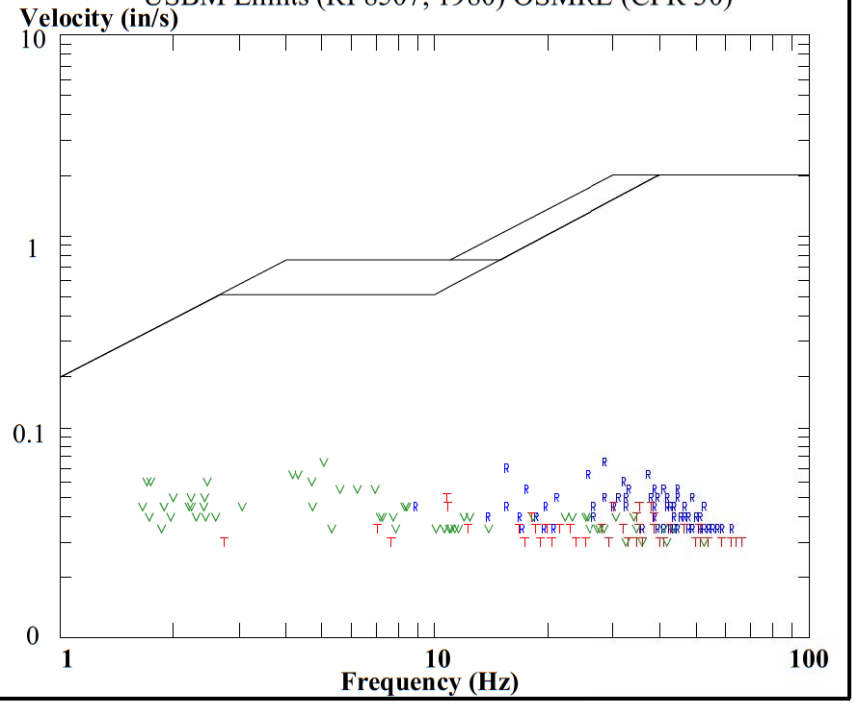
Measurement	Value	Trigger >>> Peak	
psi	.00062	5750.5	
dBL	**107**		
Hz	9.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

03-Apr-18 at 15:01:28 PM Event # 83

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.100**	**0.050**	**0.080**
Frequency (Hz)	**40.10**	**40.90**	**3.60**
Displacement (in)	**0.0004**	**0.0002**	**0.0035**
Acceleration (g's)	**0.0652**	**0.0333**	**0.0047**
Trigger >>> Peak	2148.7	904.3	3811.8

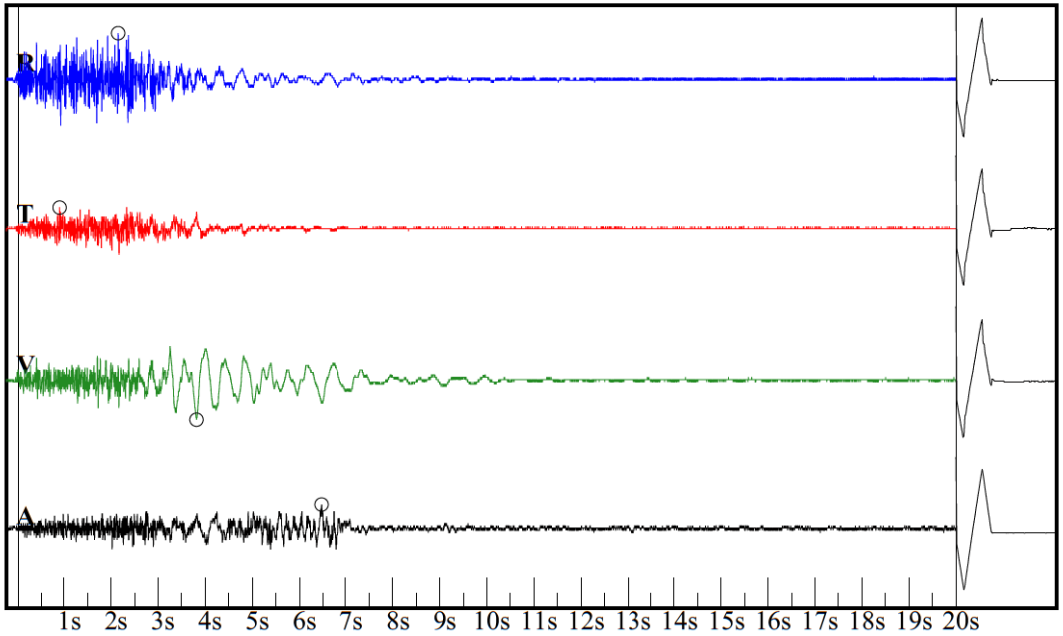
Air

Gain: 1 Trigger: 120 dBL

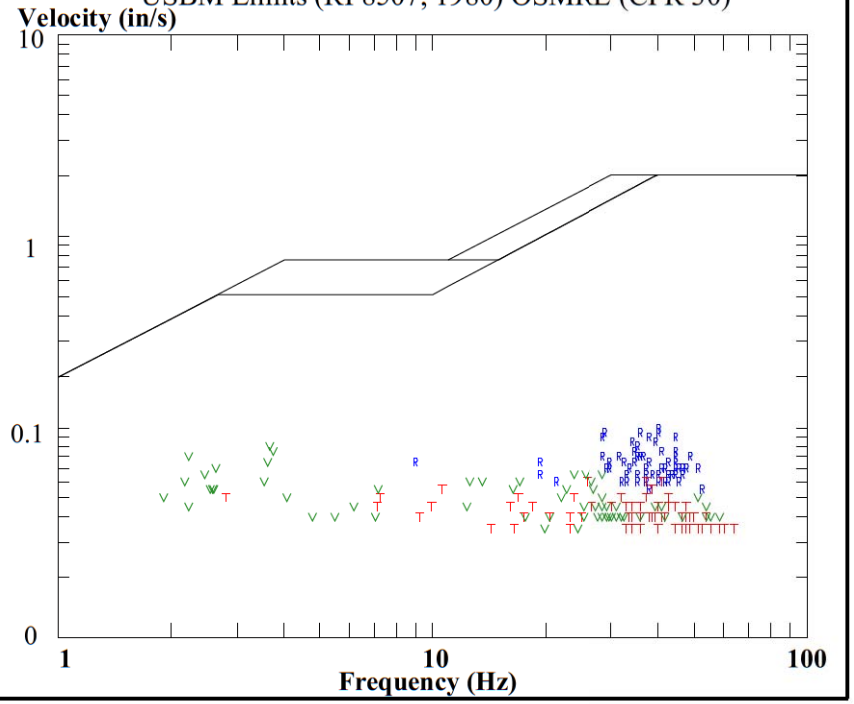
Measurement	Value	Trigger >>> Peak	
psi	.00044	6466.8	
dBL	**104**		
Hz	4.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

05-Apr-18 at 13:59:59 PM Event # 87

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.105**	**0.060**	**0.060**
Frequency (Hz)	**34.70**	**43.50**	**41.70**
Displacement (in)	**0.0005**	**0.0002**	**0.0002**
Acceleration (g's)	**0.0592**	**0.0424**	**0.0407**
Trigger >>> Peak	1353	671.4	181.2

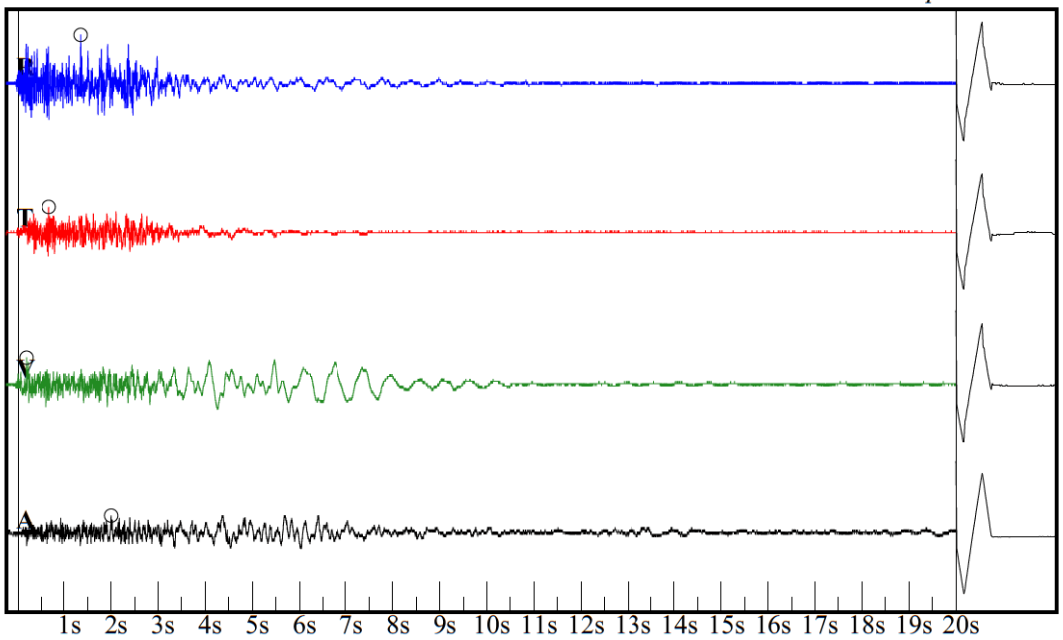
Air

Gain: 1 Trigger: 120 dBL

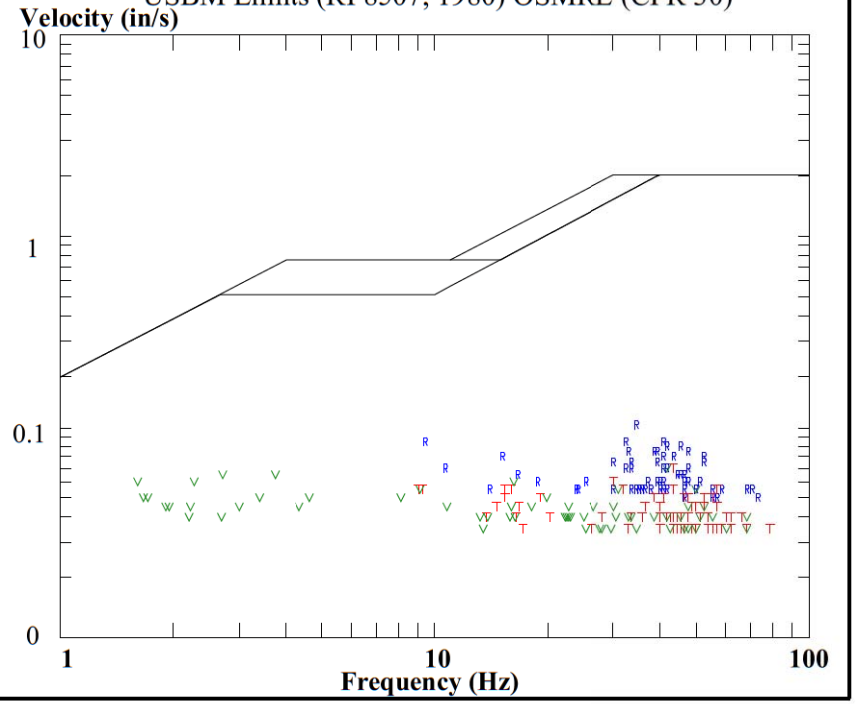
Measurement	Value	Trigger >>> Peak	
psi	.00033	1999	
dBL	**101**		
Hz	8.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Version 4.1.1
Executable Date: 17Dec2015

Nomis Seismographs, Inc.

SuperGraphics - Report

Telephone: (205)592-2488 x 23

Company: RESPEC

Unit #: 13007

4/9/2018 at 13:47:08 Event # 93

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N Wgt. Per Delay: N Scaled Distance: 0.0

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
○ Velocity (in/s)	0.010	0.010	0.025
Frequency (Hz)	0.00	0.00	1.70
Displacement (in)	0	0	0.0023
Acceleration (g's)	0.000	0.000	0.001
Trigger >>> Peak	17.6	22.7	0.2

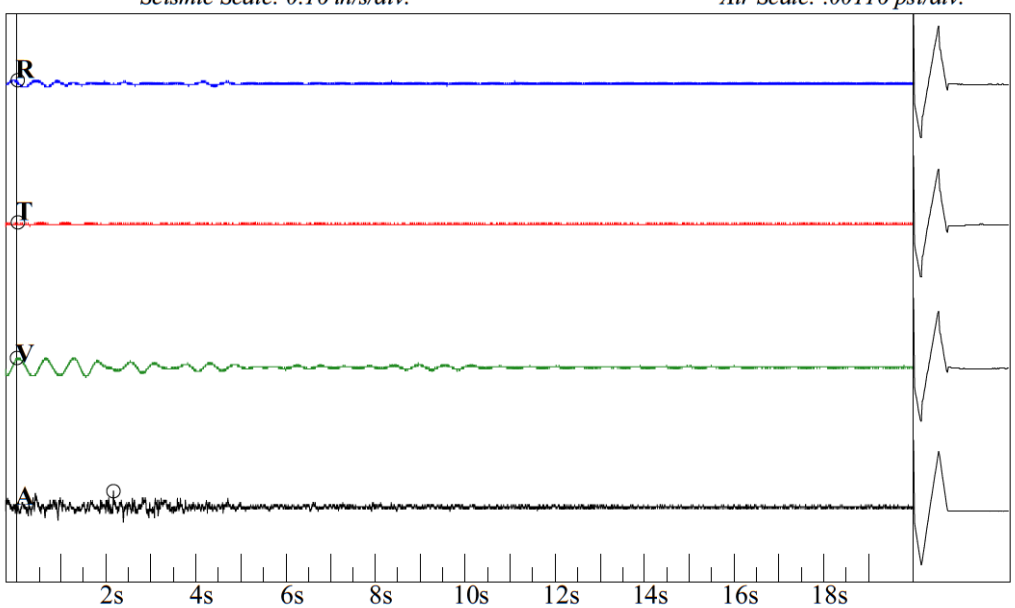
Air

Gain: 1 Air Trigger: 120 dBL

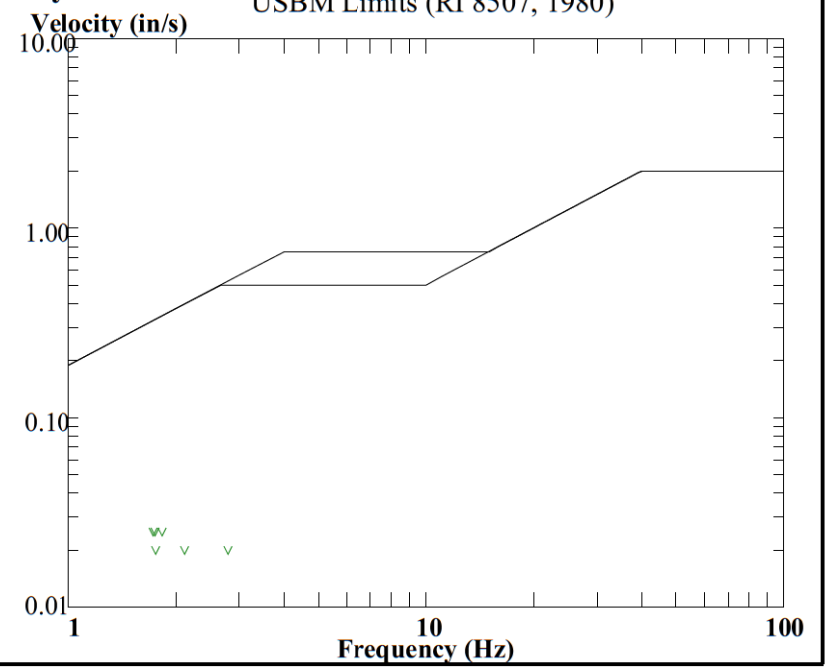
Measurement	Value	Trigger >>> Peak	
		2167.0	
psi	.0003264		
dBL	101.0		
Hz	4.9		

Waveform Analysis / Frequency Plot

Seismic Scale: 0.16 in/s/div. Air Scale: .00116 psi/div.



USBM Limits (RI 8507, 1980)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

10-Apr-18 at 14:00:03 PM Event # 95

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.100**	**0.050**	**0.060**
Frequency (Hz)	**39.30**	**9.10**	**2.40**
Displacement (in)	**0.0004**	**0.0009**	**0.0040**
Acceleration (g's)	**0.0639**	**0.0074**	**0.0023**
Trigger >>> Peak	1036.6	2607.9	4035.2

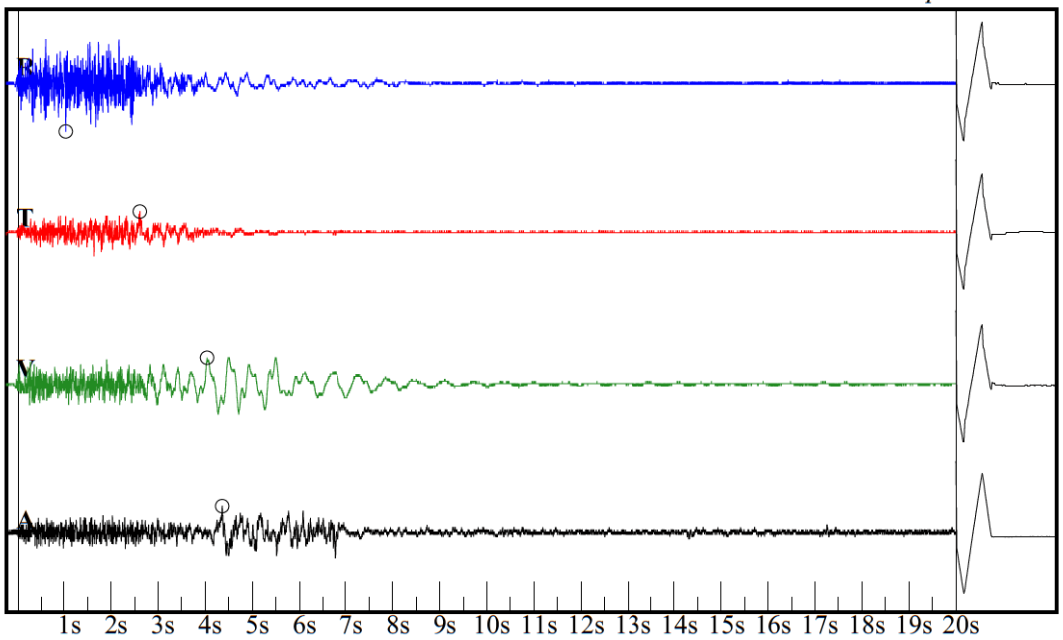
Air

Gain: 1 Trigger: 120 dBL

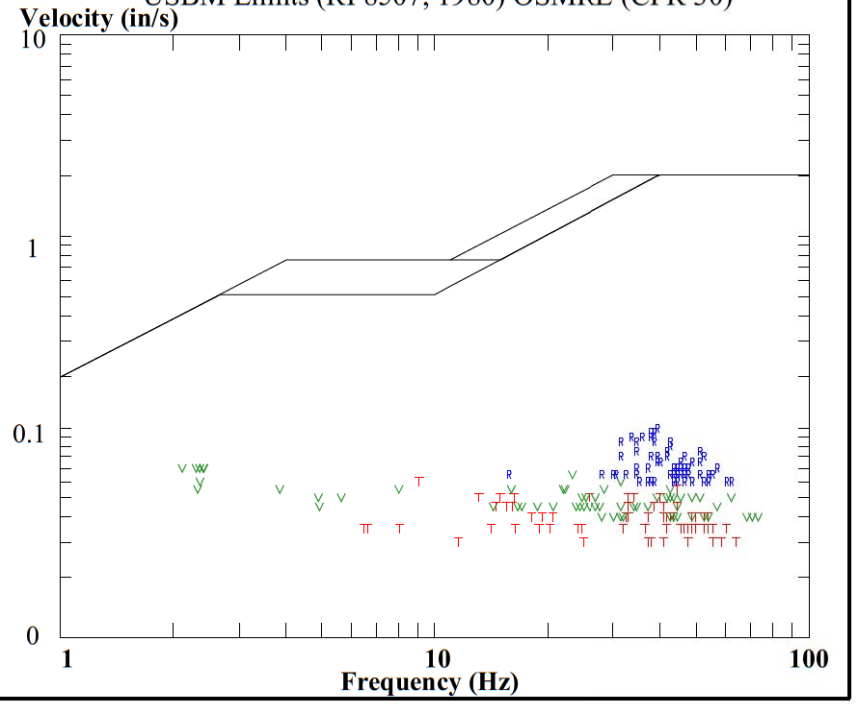
Measurement	Value	Trigger >>> Peak	
psi	.00047	4356.2	
dBL	**104**		
Hz	2.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

12-Apr-18 at 13:30:03 PM Event # 101

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.070**	**0.040**	**0.075**
Frequency (Hz)	**31.00**	**28.80**	**3.60**
Displacement (in)	**0.0004**	**0.0002**	**0.0033**
Acceleration (g's)	**0.0353**	**0.0187**	**0.0044**
Trigger >>> Peak	2098.6	927.5	3347.9

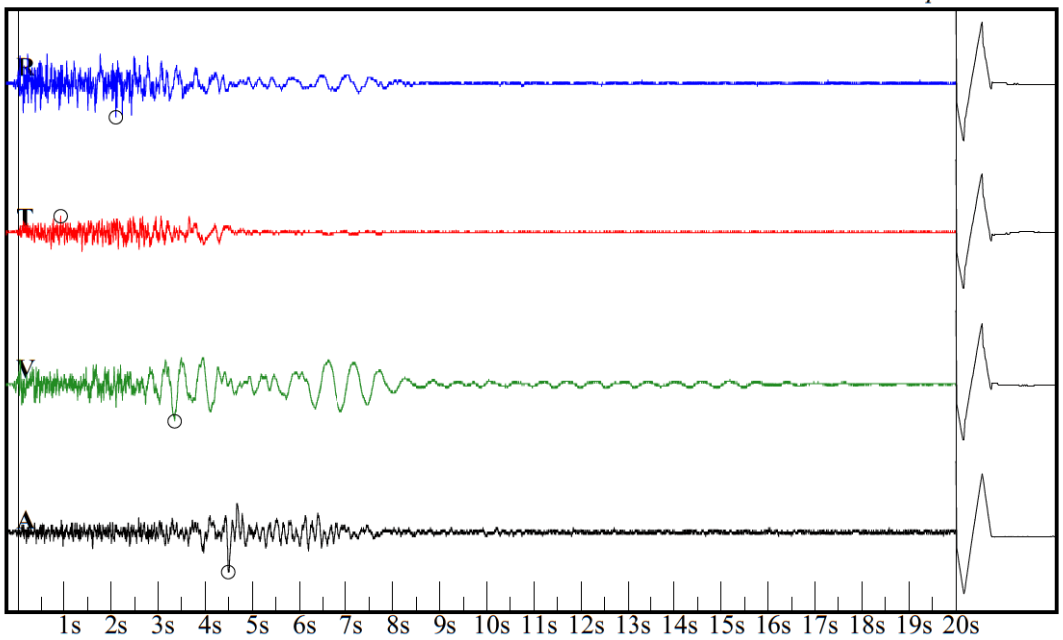
Air

Gain: 1 Trigger: 120 dBL

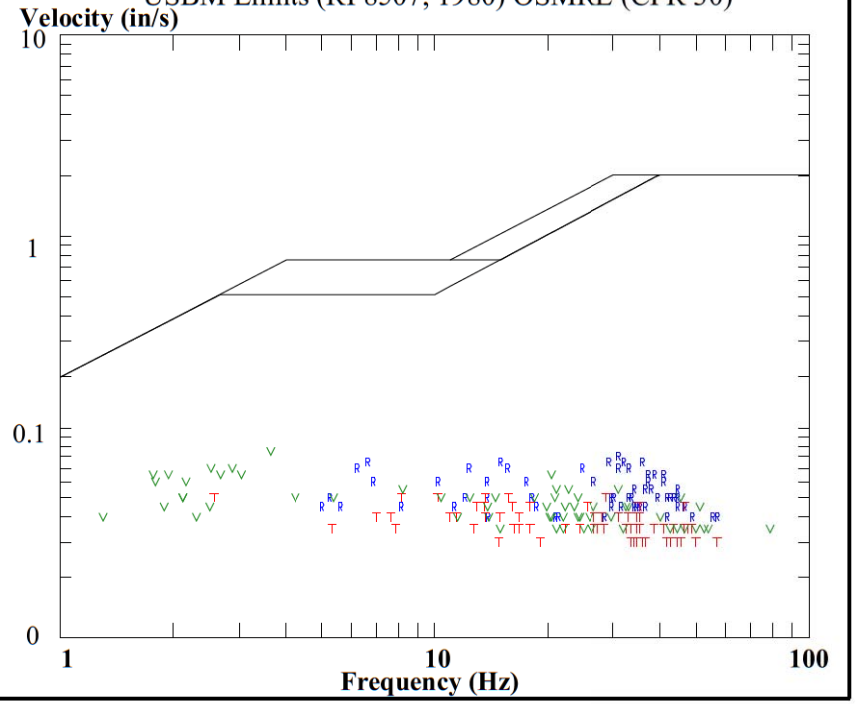
Measurement	Value	Trigger >>> Peak	
psi	.00054	4484.4	
dBL	**105**		
Hz	6.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

13-Apr-18 at 11:30:47 AM Event # 103

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.025**	**0.060**
Frequency (Hz)	**14.40**	**3.30**	**1.90**
Displacement (in)	**0.0003**	**0.0012**	**0.0050**
Acceleration (g's)	**0.0070**	**0.0013**	**0.0019**
Trigger >>> Peak	196.3	1554	5991.9

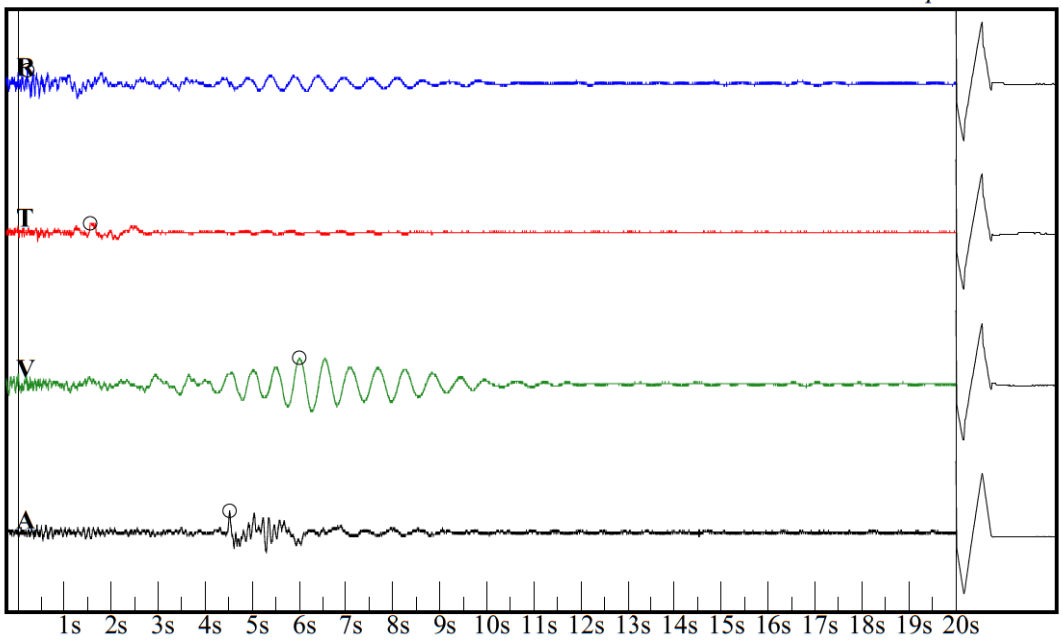
Air

Gain: 1 Trigger: 120 dBL

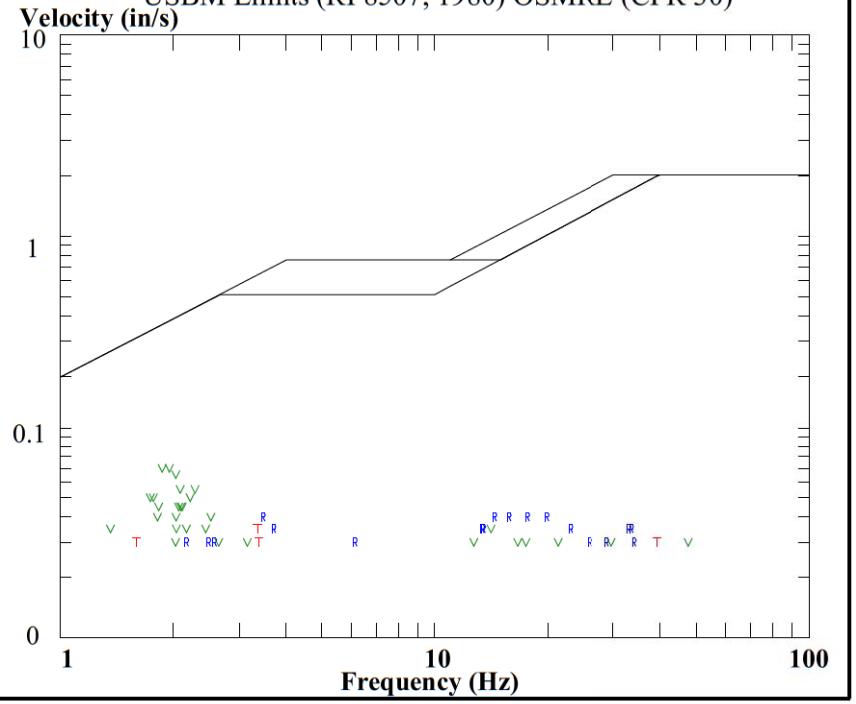
Measurement	Value	Trigger >>> Peak	
psi	.0004	4513.4	
dBL	**103**		
Hz	4.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

17-Apr-18 at 13:30:12 PM Event # 109

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.115**	**0.055**	**0.045**
Frequency (Hz)	**39.30**	**28.40**	**19.80**
Displacement (in)	**0.0005**	**0.0003**	**0.0004**
Acceleration (g's)	**0.0735**	**0.0254**	**0.0145**
Trigger >>> Peak	1078.1	1815.7	389.6

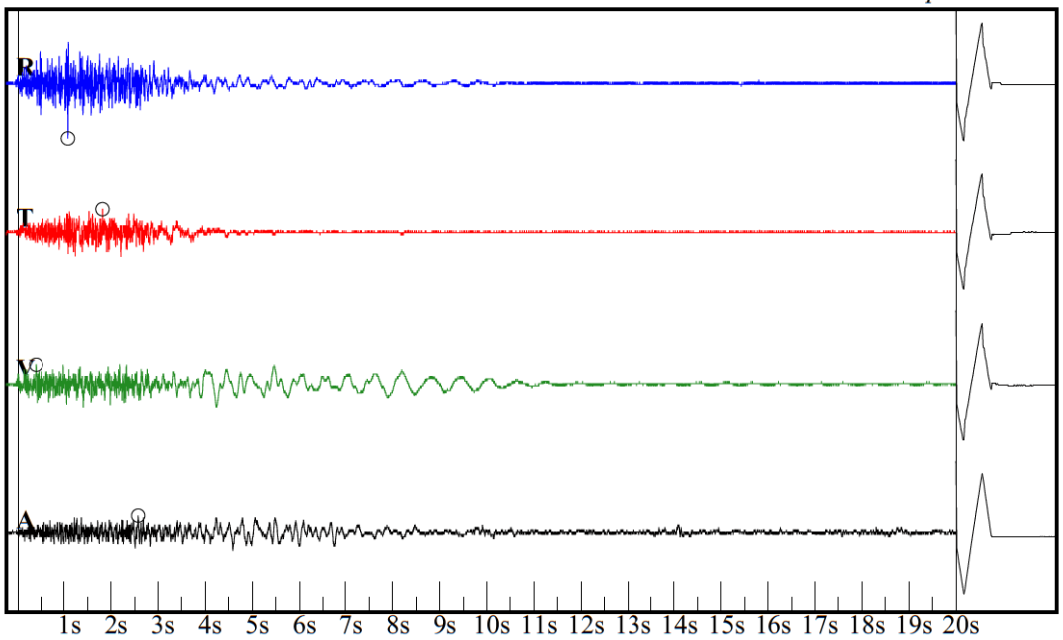
Air

Gain: 1 Trigger: 120 dBL

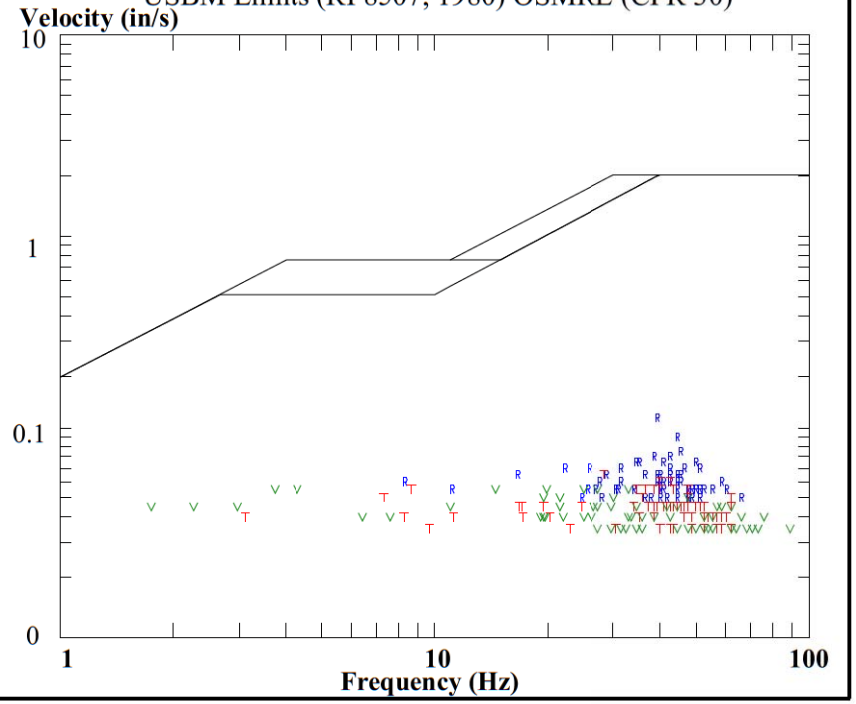
Measurement	Value	Trigger >>> Peak	
psi	.00033	2574.2	
dBL	**101**		
Hz	11.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Version 4.2.2
Executable Date: 10May2017

Nomis Seismographs, Inc.

SuperGraphics - Report

Telephone: (205)592-2488 x 23

Company: RESPEC

Unit #: 13007

4/18/2018 at 13:16:27 Event # 111

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N | Wgt. Per Delay: N | Scaled Distance: 0.0

Seismic

Gain: 1 Trigger: .02 in/s ▽ Vector Sum: 0.03 in/s @ 1.61 Hz

Channel	Radial	Transverse	Vertical
○ Velocity (in/s)	0.010	0.010	0.025
Frequency (Hz)	0.00	0.00	1.90
Displacement (in)	0	0	0.0021
Acceleration (g's)	0.000	0.000	0.001
Trigger >>> Peak	280.8	61.5	0.2

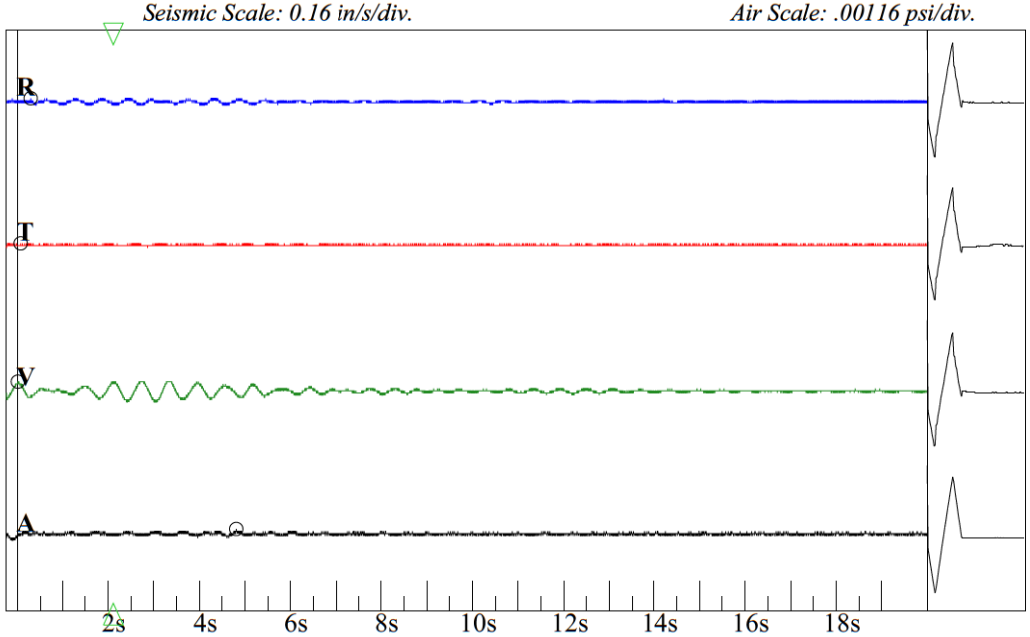
Air

Gain: 1 Air Trigger: 120 dBL

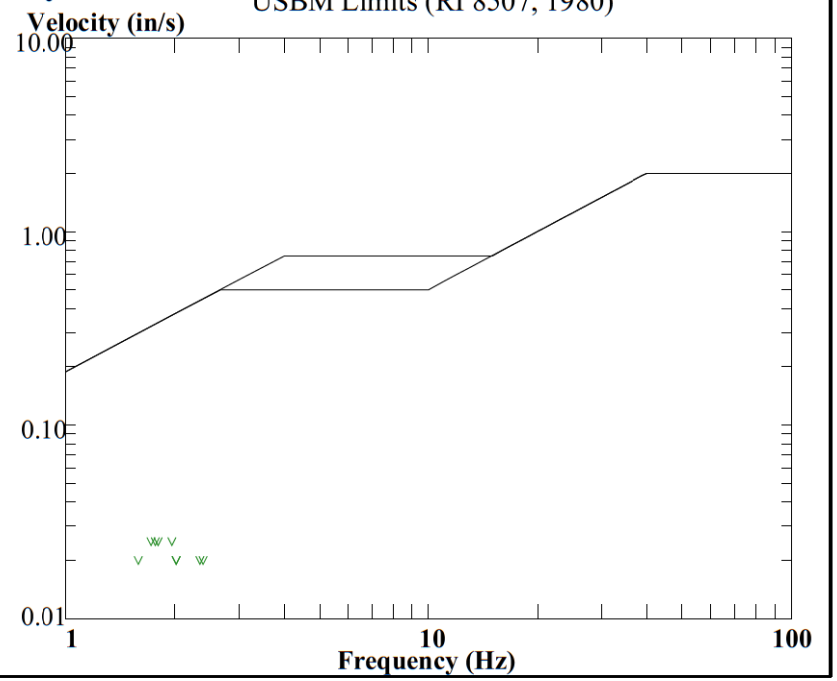
Measurement	Value	Trigger >>> Peak	
		4804.9	
psi	.0001451		
dBL	94.0		
Hz	0		

Waveform Analysis / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

19-Apr-18 at 13:30:10 PM Event # 113

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.070**	**0.045**	**0.045**
Frequency (Hz)	**44.50**	**27.30**	**7.10**
Displacement (in)	**0.0003**	**0.0003**	**0.0010**
Acceleration (g's)	**0.0507**	**0.0200**	**0.0052**
Trigger >>> Peak	215.3	2622.6	1891.1

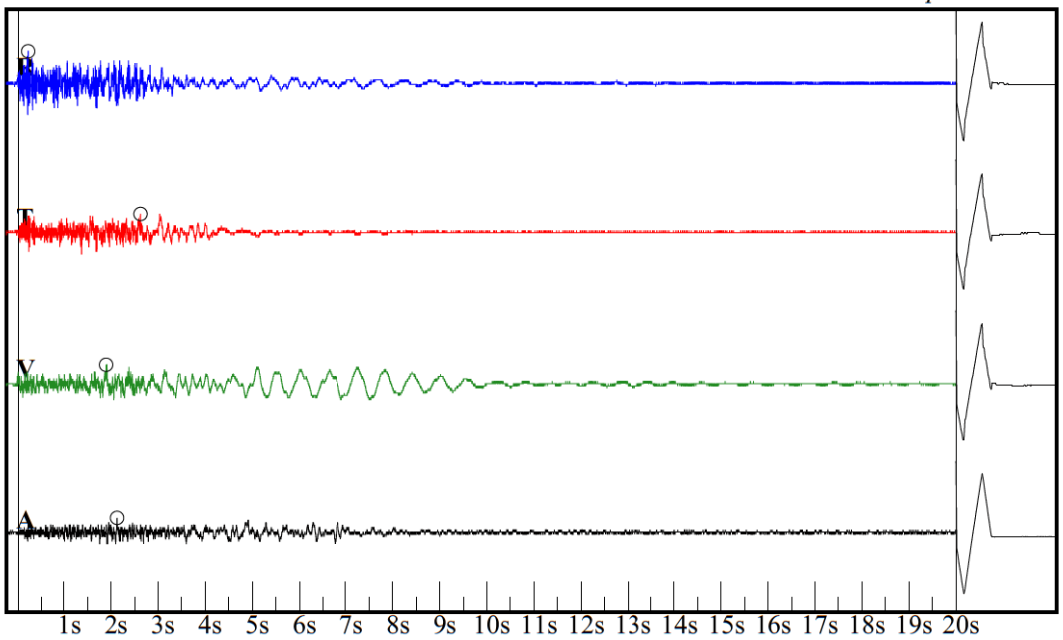
Air

Gain: 1 Trigger: 120 dBL

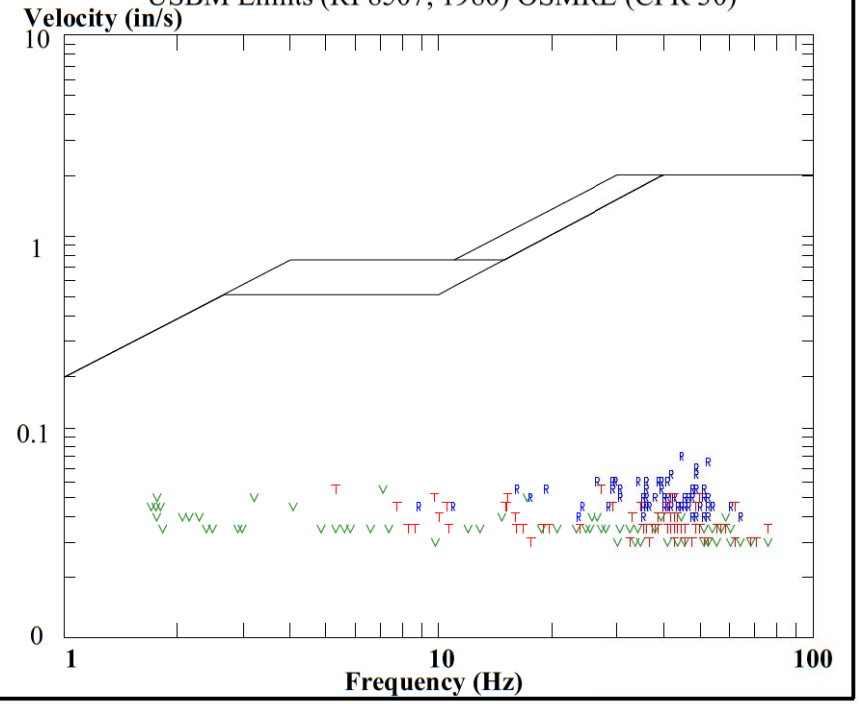
Measurement	Value	Trigger >>> Peak	
psi	.00029	2124.3	
dBL	**100**		
Hz	9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

23-Apr-18 at 14:32:14 PM Event # 120

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.090**	**0.040**	**0.065**
Frequency (Hz)	**34.10**	**6.90**	**3.30**
Displacement (in)	**0.0004**	**0.0009**	**0.0031**
Acceleration (g's)	**0.0499**	**0.0045**	**0.0035**
Trigger >>> Peak	2509.5	3016.8	3091.1

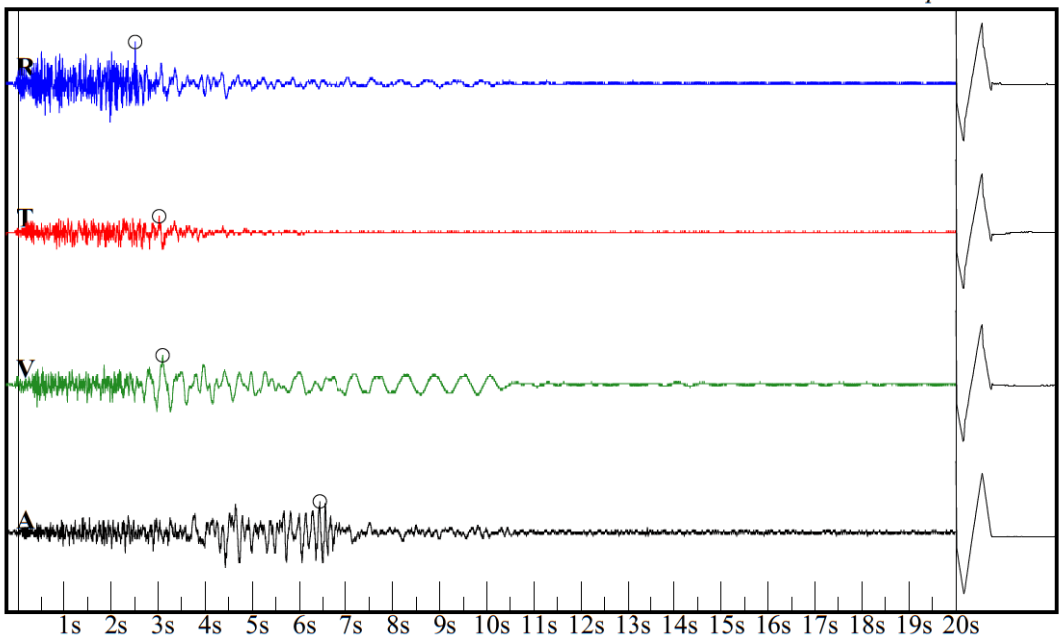
Air

Gain: 1 Trigger: 120 dBL

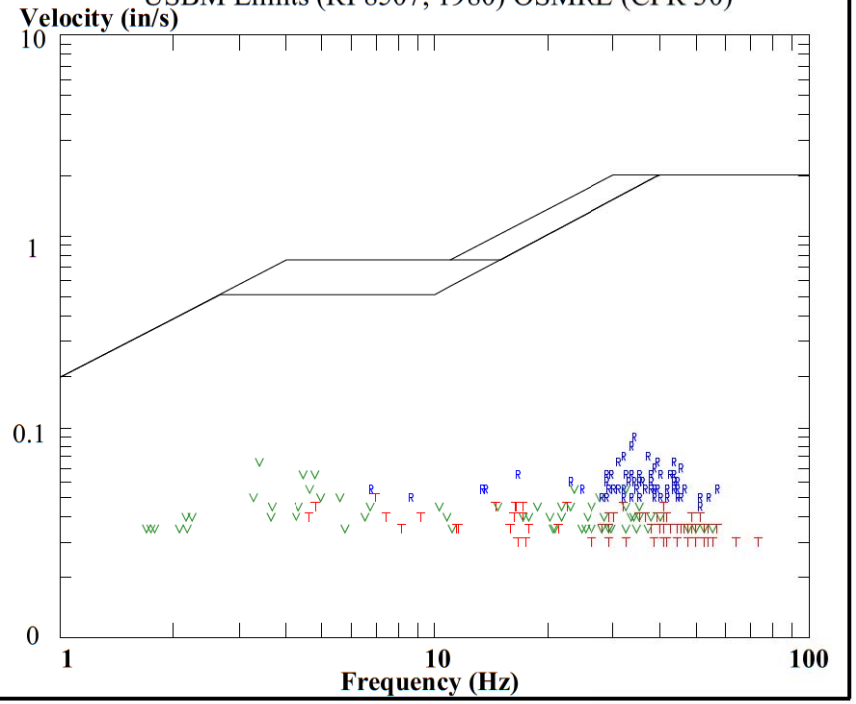
Measurement	Value	Trigger >>> Peak	
psi	.00054	6430.2	
dBL	**105**		
Hz	7.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

24-Apr-18 at 10:34:17 AM Event # 122

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.025**
Frequency (Hz)	**0.00**	**0.00**	**1.80**
Displacement (in)			**0.0022**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0007**
Trigger >>> Peak	0	0	0

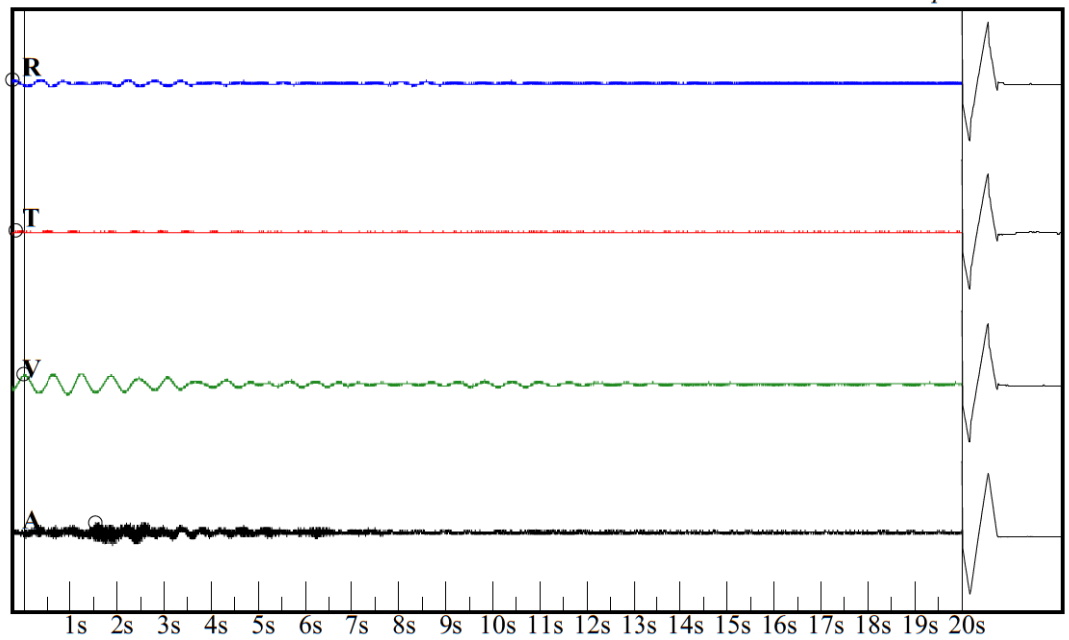
Air

Gain: 1 Trigger: 120 dBL

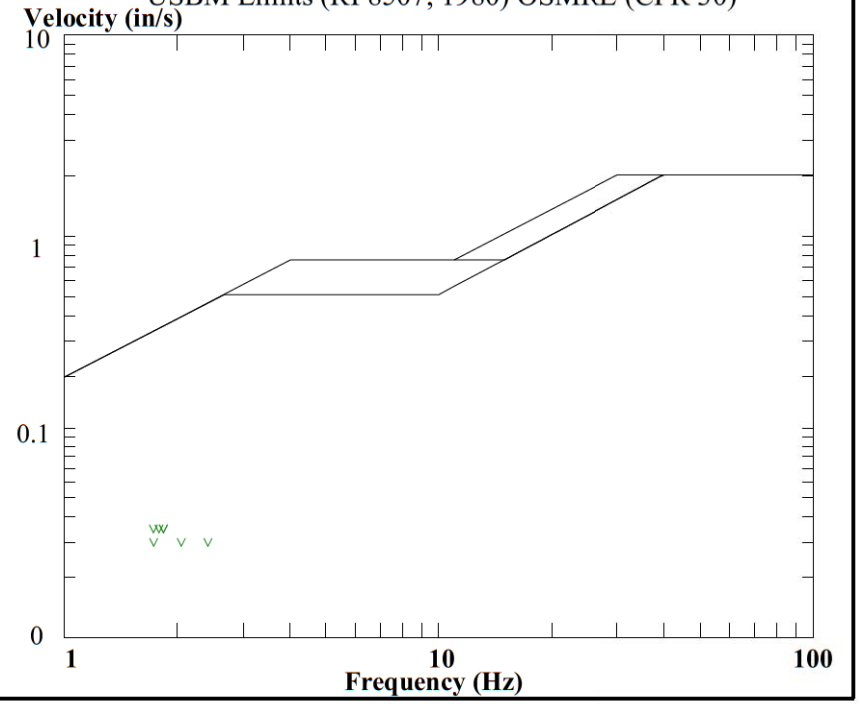
Measurement	Value	Trigger >>> Peak	
psi	.00022	1537.4	
dBL	**98**		
Hz	68.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

25-Apr-18 at 14:30:21 PM Event # 124

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.075**	**0.050**	**0.060**
Frequency (Hz)	**35.30**	**11.90**	**1.70**
Displacement (in)	**0.0003**	**0.0007**	**0.0056**
Acceleration (g's)	**0.0431**	**0.0097**	**0.0017**
Trigger >>> Peak	1024.2	2010	6556.4

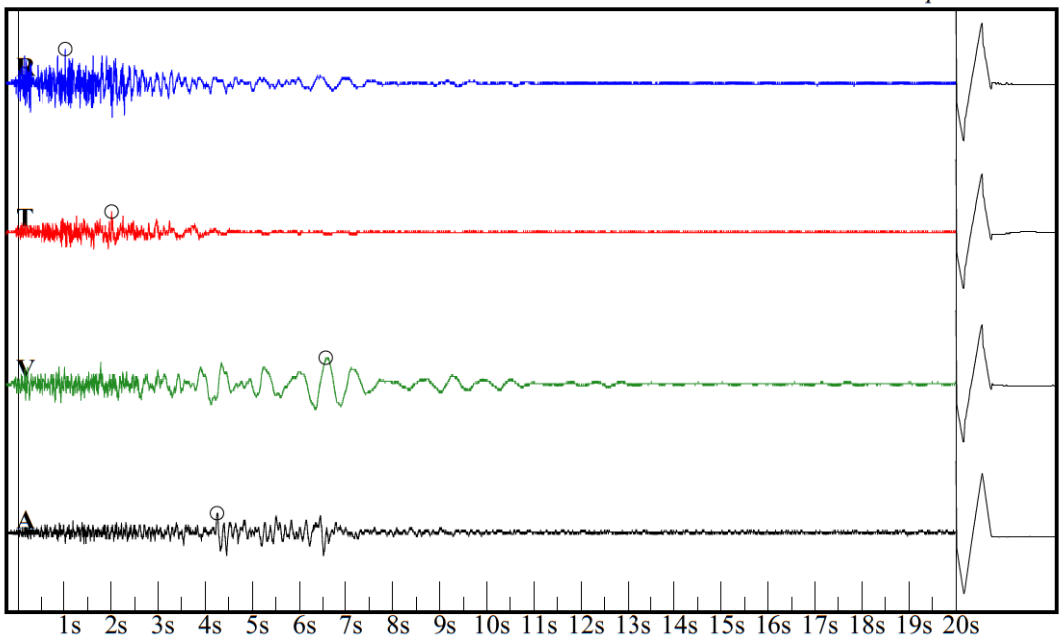
Air

Gain: 1 Trigger: 120 dBL

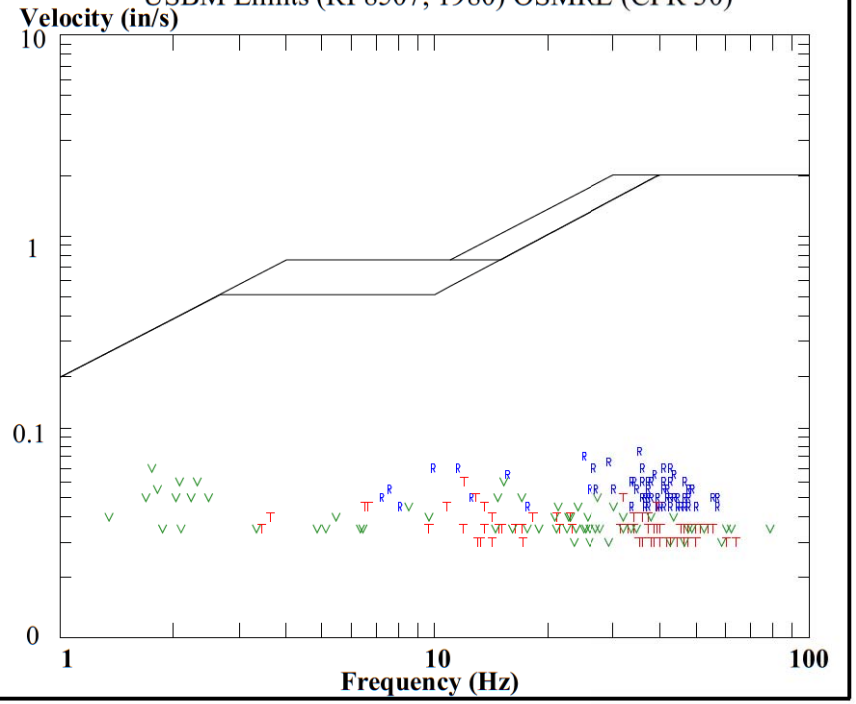
Measurement	Value	Trigger >>> Peak	
psi	.00036	4247.3	
dBL	**102**		
Hz	6.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

01-May-18 at 13:30:34 PM Event # 133

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.030**	**0.035**
Frequency (Hz)	**11.60**	**5.50**	**5.10**
Displacement (in)	**0.0005**	**0.0009**	**0.0011**
Acceleration (g's)	**0.0066**	**0.0027**	**0.0029**
Trigger >>> Peak	598.1	1648.7	1961.7

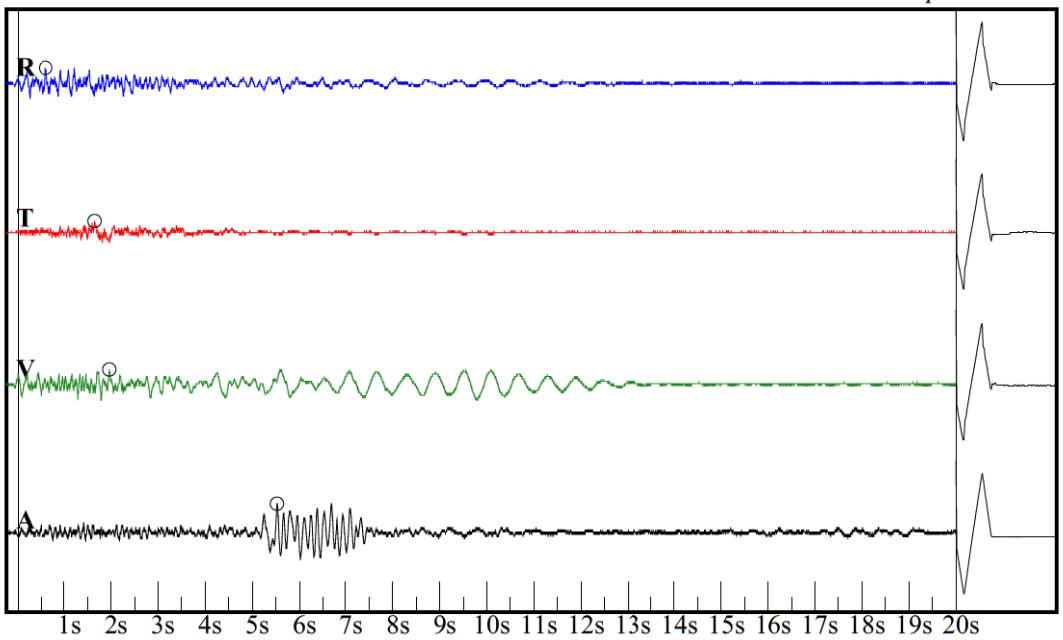
Air

Gain: 1 Trigger: 120 dBL

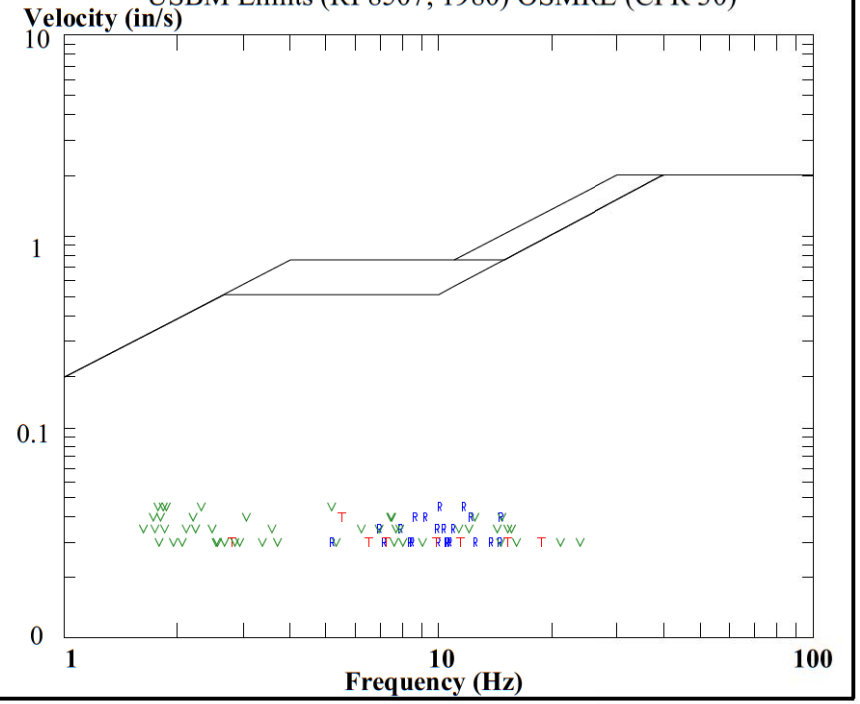
Measurement	Value	Trigger >>> Peak	
psi	.00051	5519.8	
dBL	**105**		
Hz	6.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

02-May-18 at 14:31:00 PM Event # 135

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.030**
Frequency (Hz)	**0.00**	**0.00**	**1.70**
Displacement (in)			**0.0028**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0008**
Trigger >>> Peak	0	0	59.8

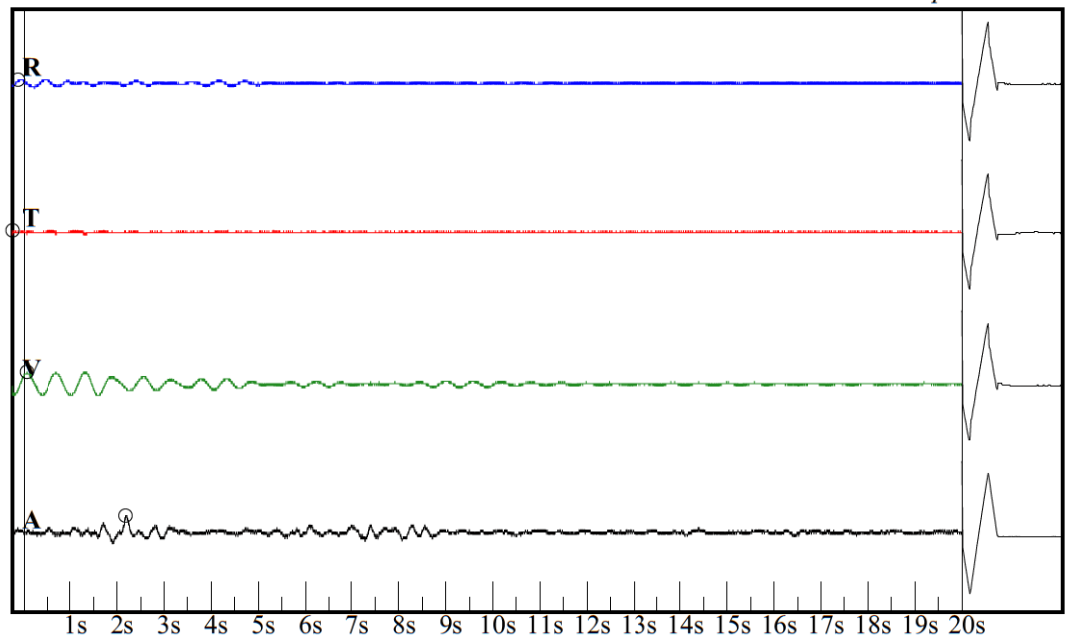
Air

Gain: 1 Trigger: 120 dBL

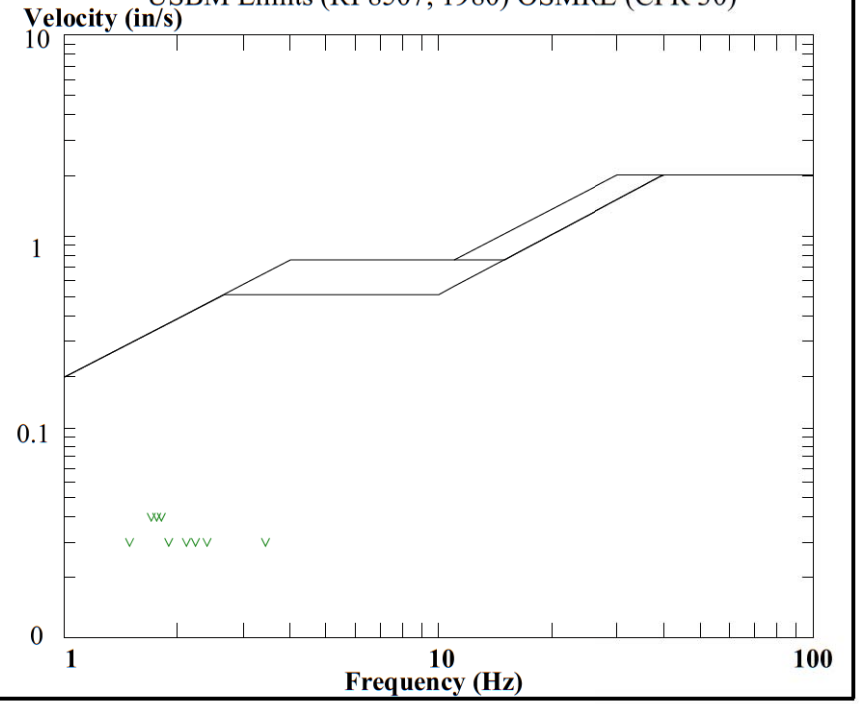
Measurement	Value	Trigger >>> Peak	
psi	.00033	2176.5	
dBL	**101**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

03-May-18 at 13:15:34 PM Event # 137

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.025**	**0.055**
Frequency (Hz)	**8.10**	**6.60**	**2.90**
Displacement (in)	**0.0008**	**0.0006**	**0.0030**
Acceleration (g's)	**0.0053**	**0.0027**	**0.0026**
Trigger >>> Peak	1541.7	2240.5	5085

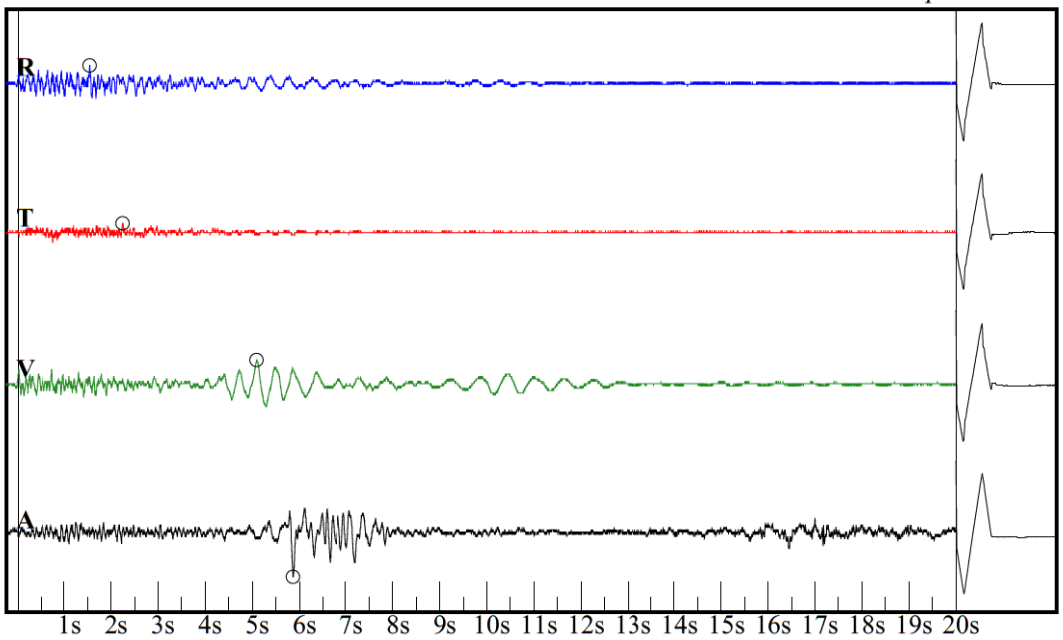
Air

Gain: 1 Trigger: 120 dBL

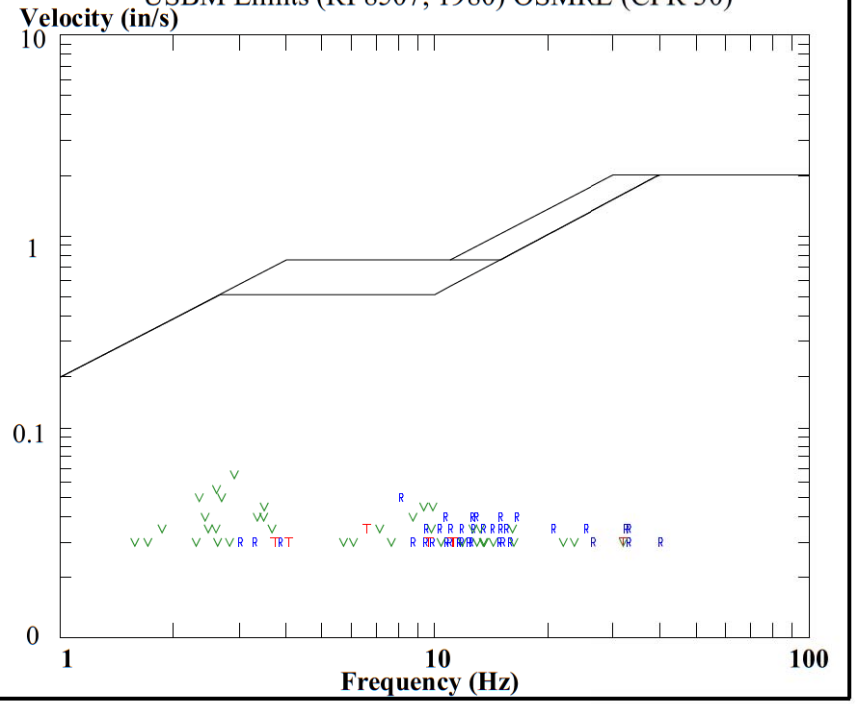
Measurement	Value	Trigger >>> Peak	
psi	.00062	5859.1	
dBL	**107**		
Hz	5.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

08-May-18 at 13:31:49 PM Event # 144

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.050**	**0.025**	**0.075**
Frequency (Hz)	**8.10**	**13.80**	**1.90**
Displacement (in)	**0.0010**	**0.0003**	**0.0063**
Acceleration (g's)	**0.0066**	**0.0056**	**0.0023**
Trigger >>> Peak	2772.5	1635.5	8482.9

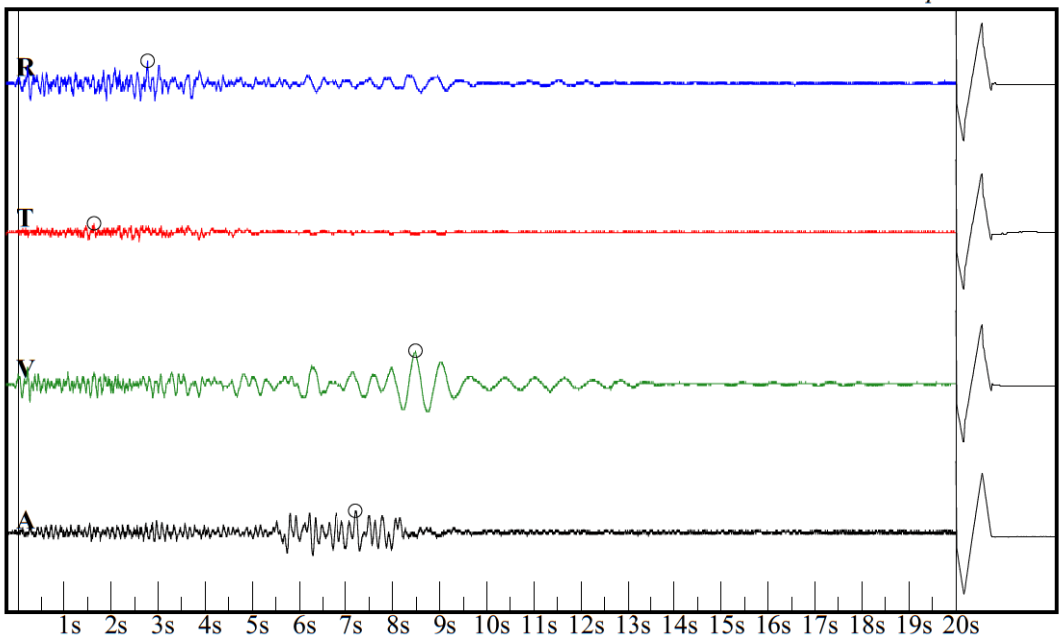
Air

Gain: 1 Trigger: 120 dBL

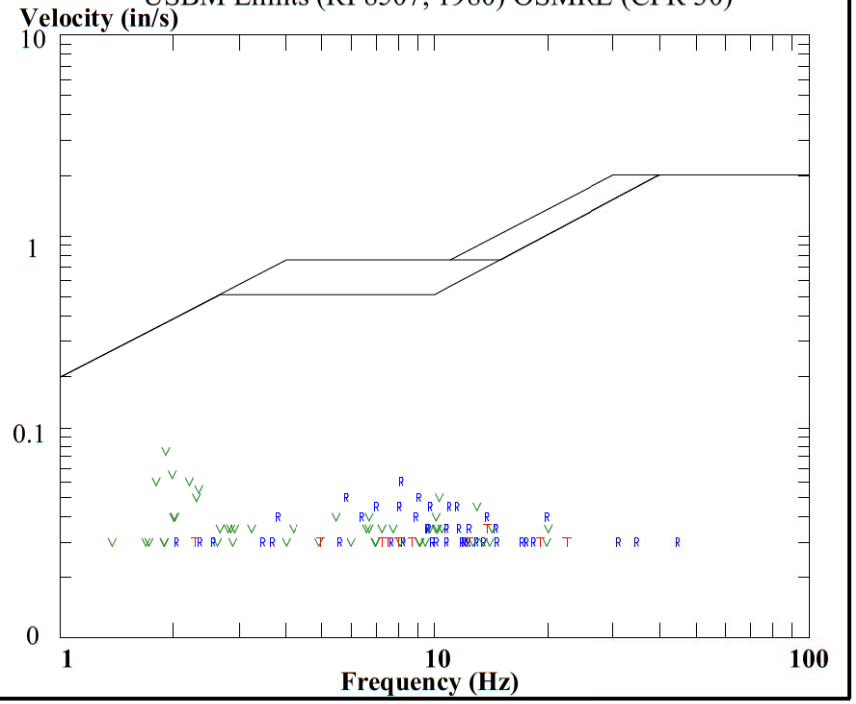
Measurement	Value	Trigger >>> Peak	
psi	.0004	7204.6	
dBL	**103**		
Hz	5.3		

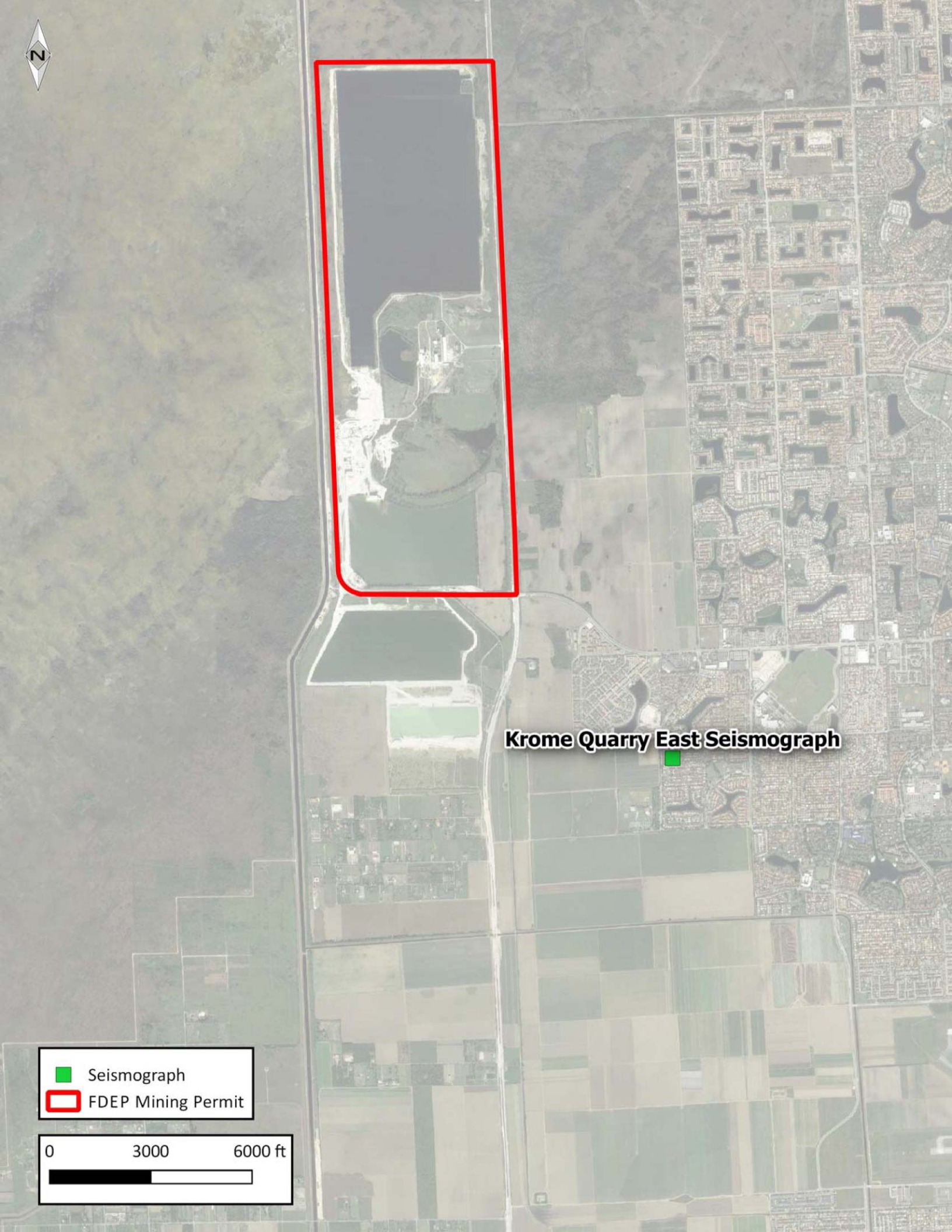
Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)




N
Krome Quarry East Seismograph
Seismograph
FDEP Mining Permit
0
3000
6000 ft

Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

05-Mar-18 at 10:35:11 AM Event # 32

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N | *Wgt. Per Delay: N* | *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.025**	**0.023**
Frequency (Hz)	**38.60**	**66.00**	**22.50**
Displacement (in)	**0.0002**	**0.0001**	**0.0002**
Acceleration (g's)	**0.0282**	**0.0268**	**0.0082**
Trigger >>> Peak	494.4	187.3	79.1

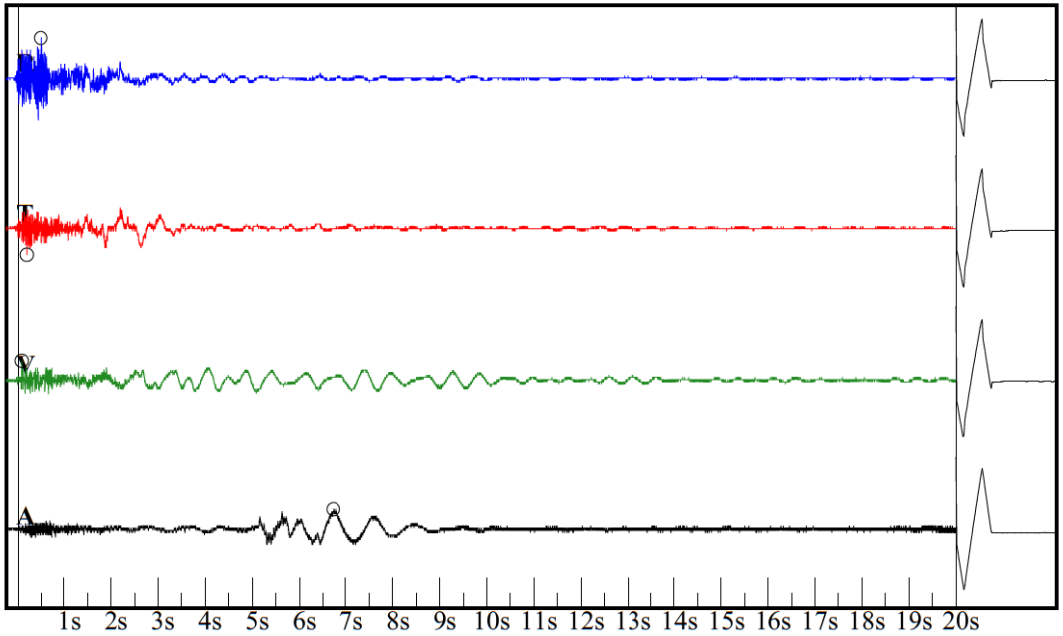
Air

Gain: 1 Trigger: 120 dBL

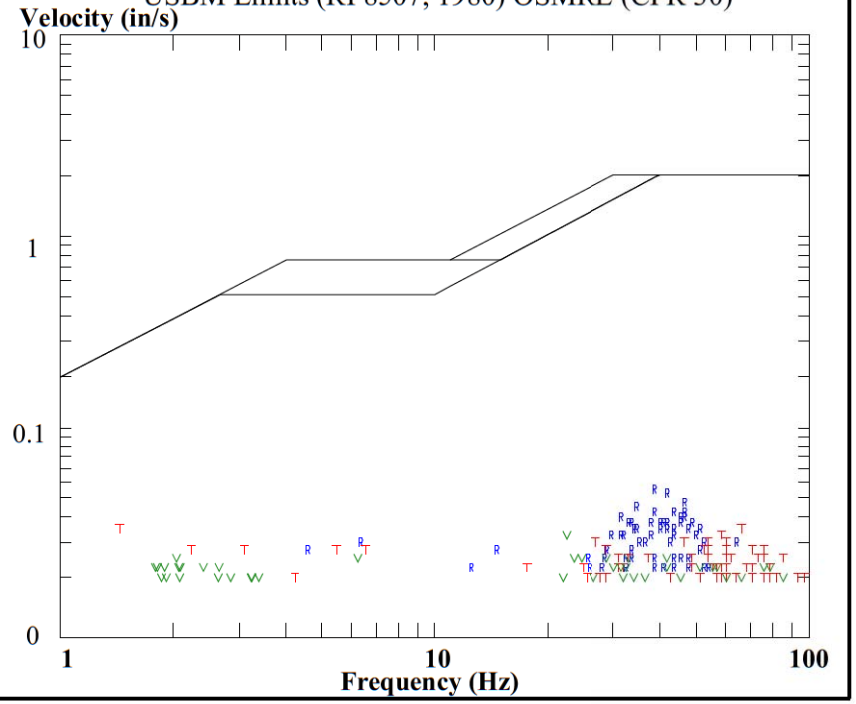
Measurement	Value	Trigger >>> Peak	
psi	.00036	6726.1	
dBL	**102**		
Hz	1.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

08-Mar-18 at 09:59:16 AM Event # 36

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.035**	**0.023**
Frequency (Hz)	**44.50**	**66.00**	**49.90**
Displacement (in)	**0.0001**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0289**	**0.0376**	**0.0183**
Trigger >>> Peak	241	240.2	71

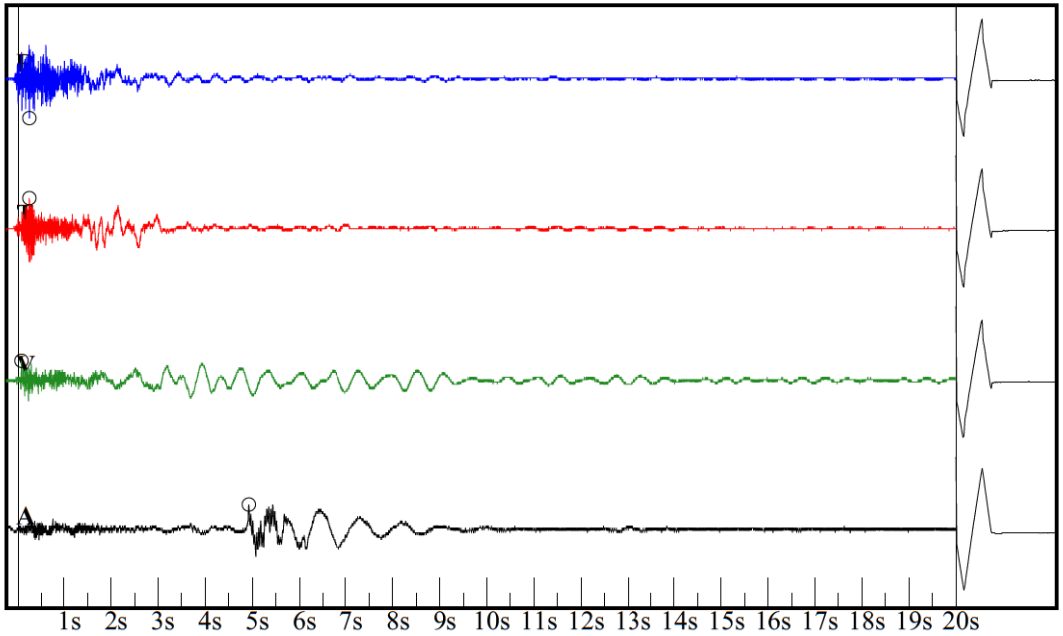
Air

Gain: 1 Trigger: 120 dBL

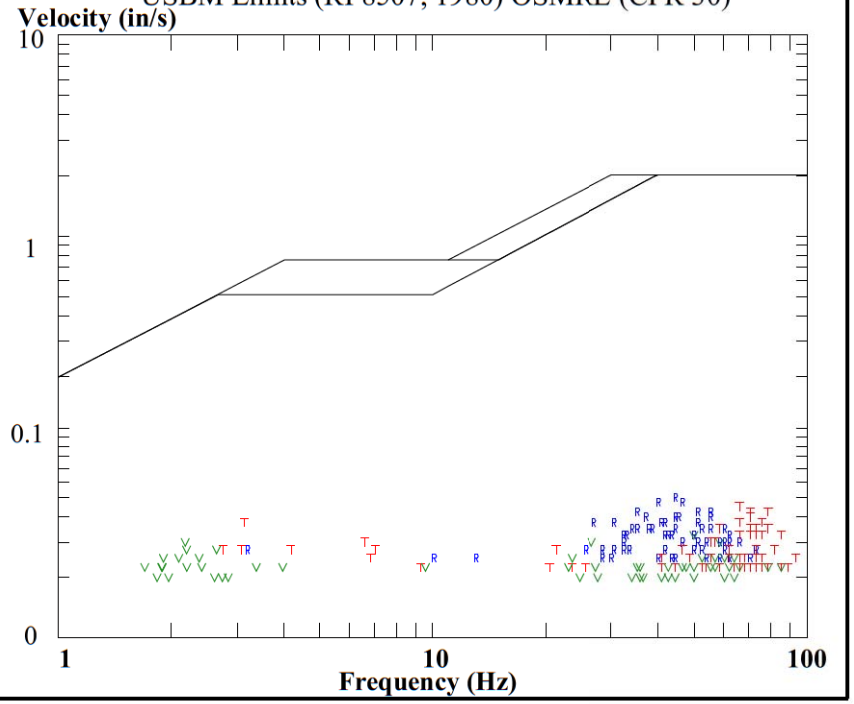
Measurement	Value	Trigger >>> Peak	
psi	.00044	4922.1	
dBL	**104**		
Hz	4.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

13-Mar-18 at 12:33:16 PM Event # 67

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.043**	**0.035**	**0.028**
Frequency (Hz)	**28.00**	**66.00**	**2.70**
Displacement (in)	**0.0002**	**0.0001**	**0.0016**
Acceleration (g's)	**0.0194**	**0.0376**	**0.0012**
Trigger >>> Peak	158	246.3	3358.9

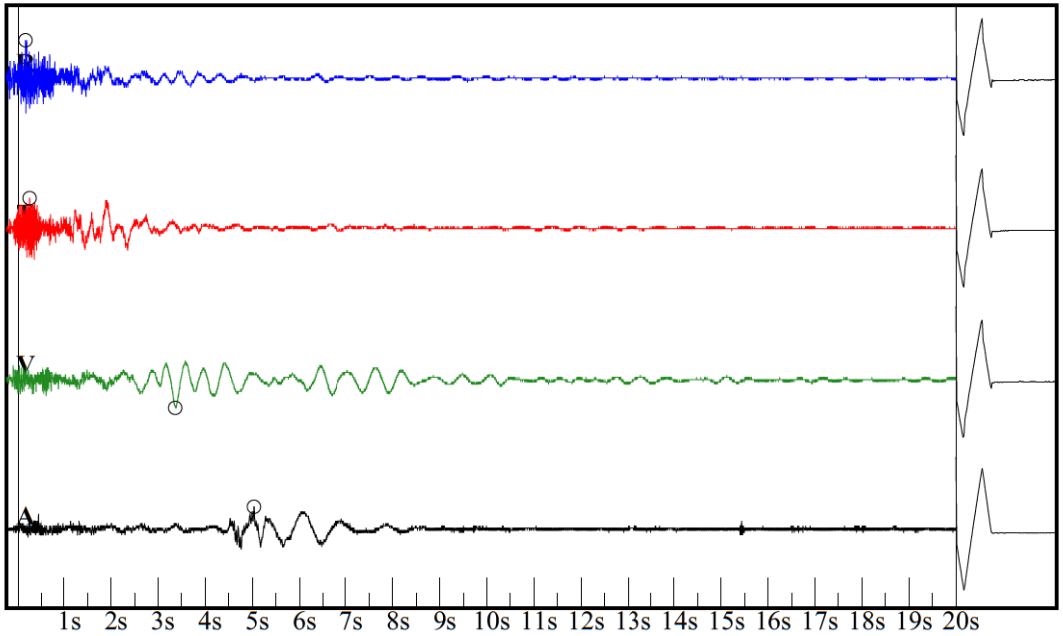
Air

Gain: 1 Trigger: 120 dBL

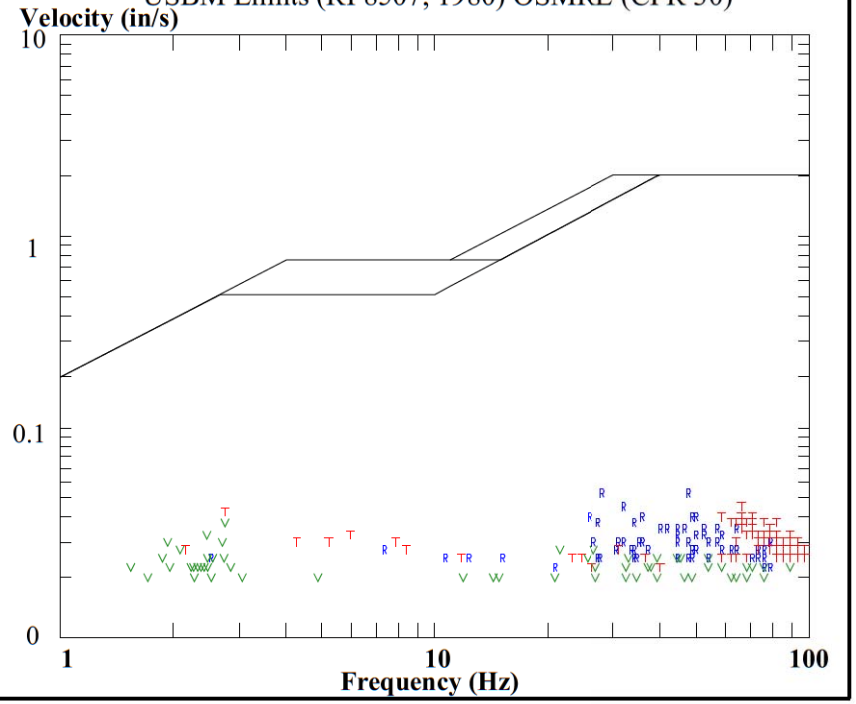
Measurement	Value	Trigger >>> Peak	
psi	.0004	5031	
dBL	**103**		
Hz	1.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

15-Mar-18 at 12:59:27 PM Event # 71

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.045**	**0.035**	**0.030**
Frequency (Hz)	**51.20**	**2.80**	**2.60**
Displacement (in)	**0.0001**	**0.0020**	**0.0018**
Acceleration (g's)	**0.0375**	**0.0016**	**0.0013**
Trigger >>> Peak	518.8	1937.5	3140.1

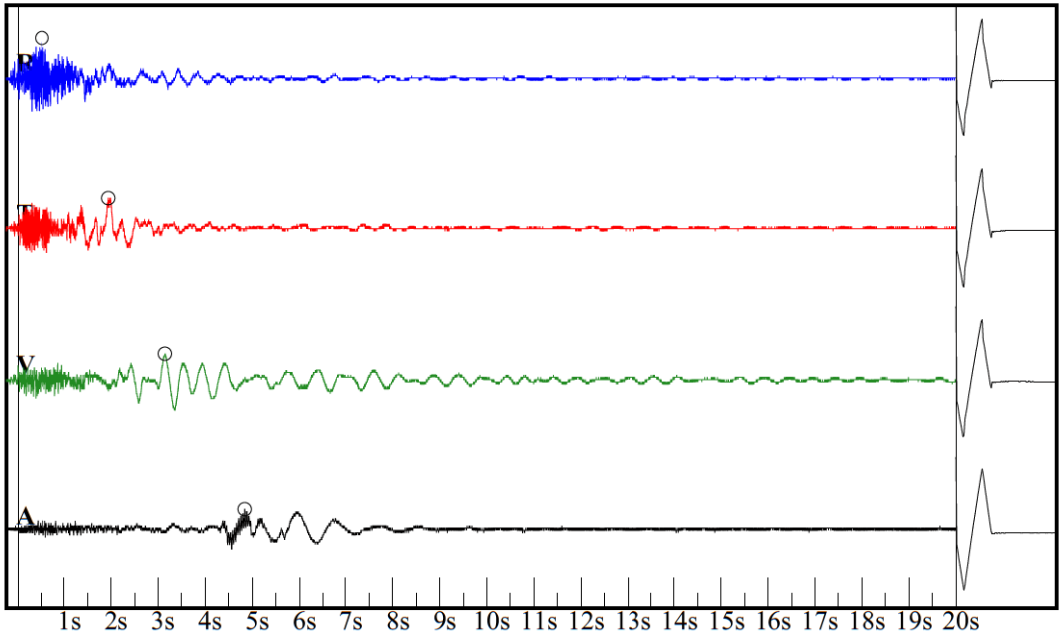
Air

Gain: 1 Trigger: 120 dBL

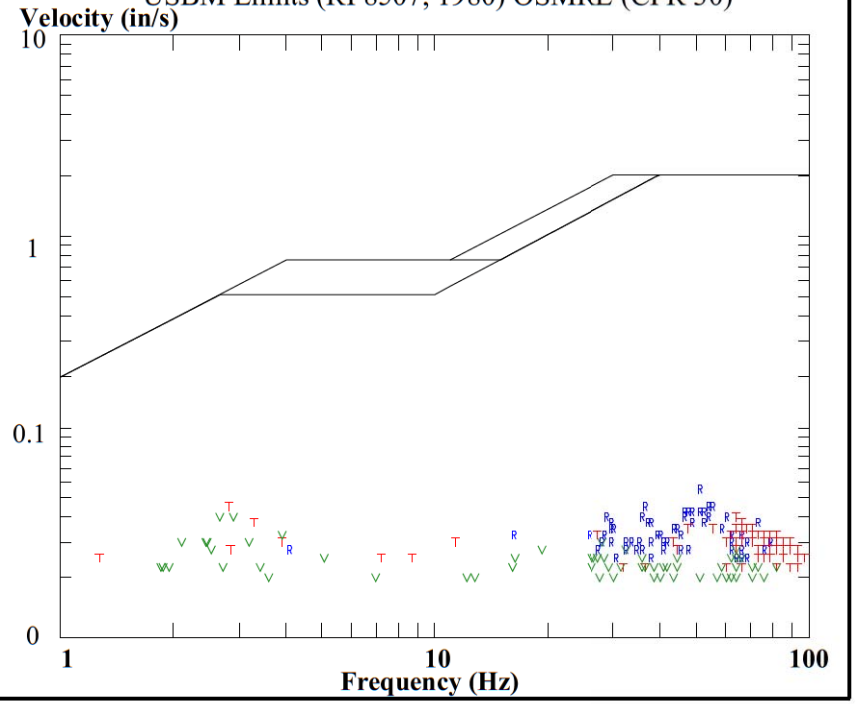
Measurement	Value	Trigger >>> Peak	
psi	.00036	4835.4	
dBL	**102**		
Hz	2.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

20-Mar-18 at 10:17:50 AM Event # 86

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.033**	**0.035**
Frequency (Hz)	**53.80**	**2.60**	**2.40**
Displacement (in)	**0.0001**	**0.0020**	**0.0023**
Acceleration (g's)	**0.0350**	**0.0014**	**0.0014**
Trigger >>> Peak	277.1	1877.7	2939

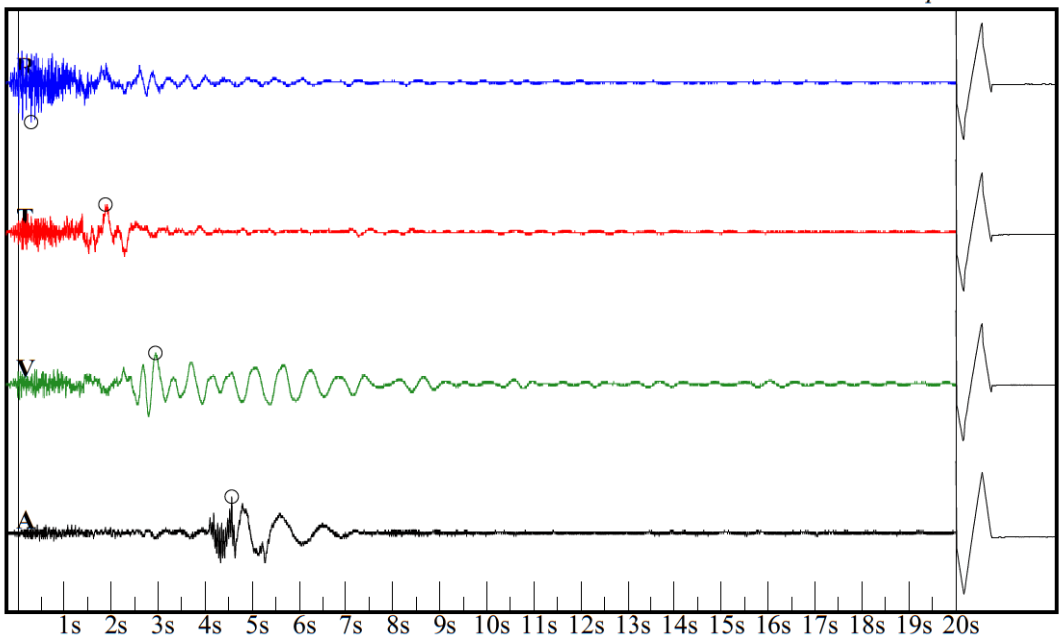
Air

Gain: 1 Trigger: 120 dBL

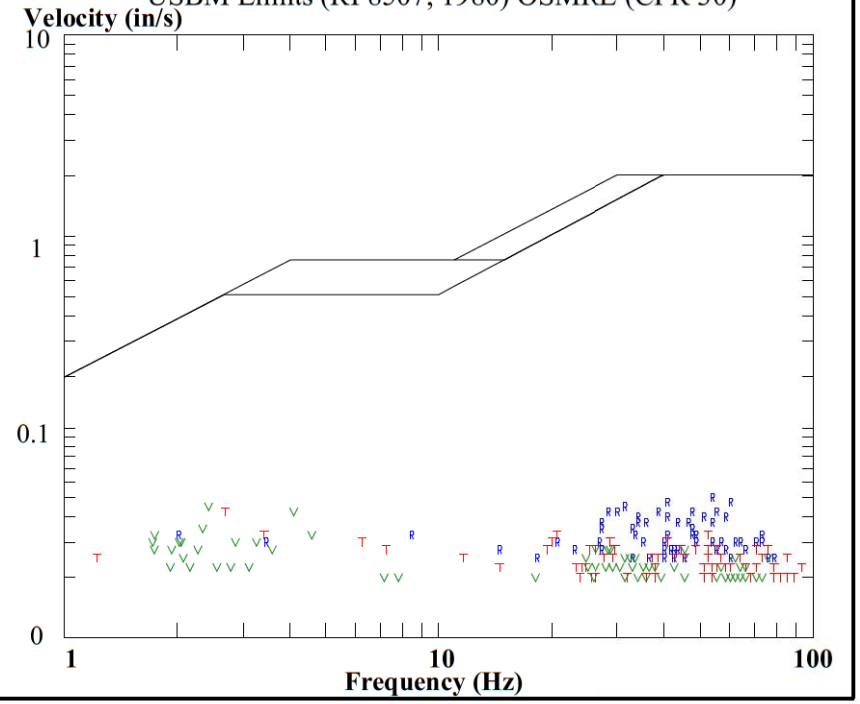
Measurement	Value	Trigger >>> Peak	
psi	.00062	4559.3	
dBL	**107**		
Hz	15.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

20-Mar-18 at 16:13:56 PM Event # 89

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.020**	**0.025**	**0.013**
Frequency (Hz)	**256.00**	**170.60**	**107.70**
Displacement (in)	**0.0000**	**0.0000**	**0.0000**
Acceleration (g's)	**0.0833**	**0.0694**	**0.0219**
Trigger >>> Peak	102.1	99.1	2.2

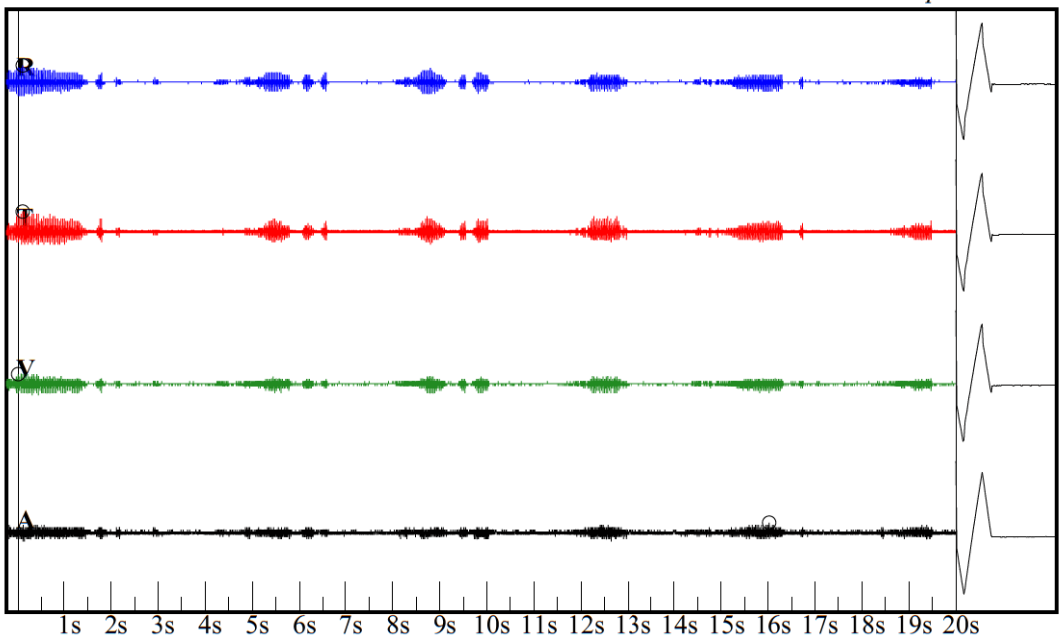
Air

Gain: 1 Trigger: 120 dBL

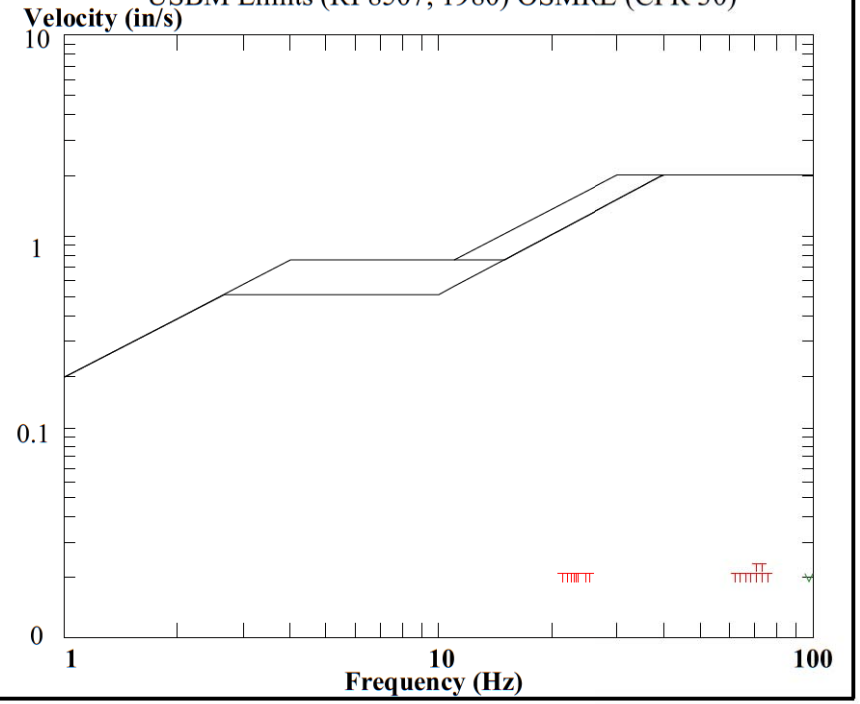
Measurement	Value	Trigger >>> Peak	
psi	.00022	16023.9	
dBL	**98**		
Hz	157.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

22-Mar-18 at 10:29:04 AM Event # 99

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.015**	**0.015**
Frequency (Hz)	**48.70**	**2.90**	**3.00**
Displacement (in)	**0.0001**	**0.0008**	**0.0008**
Acceleration (g's)	**0.0178**	**0.0007**	**0.0007**
Trigger >>> Peak	0	2024.4	3829.1

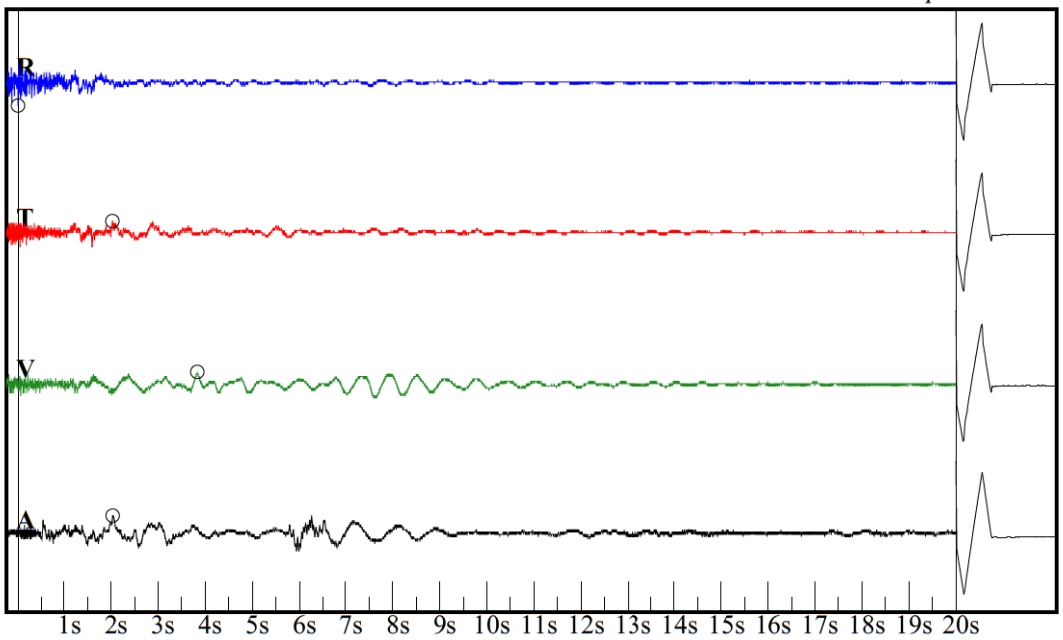
Air

Gain: 1 Trigger: 120 dBL

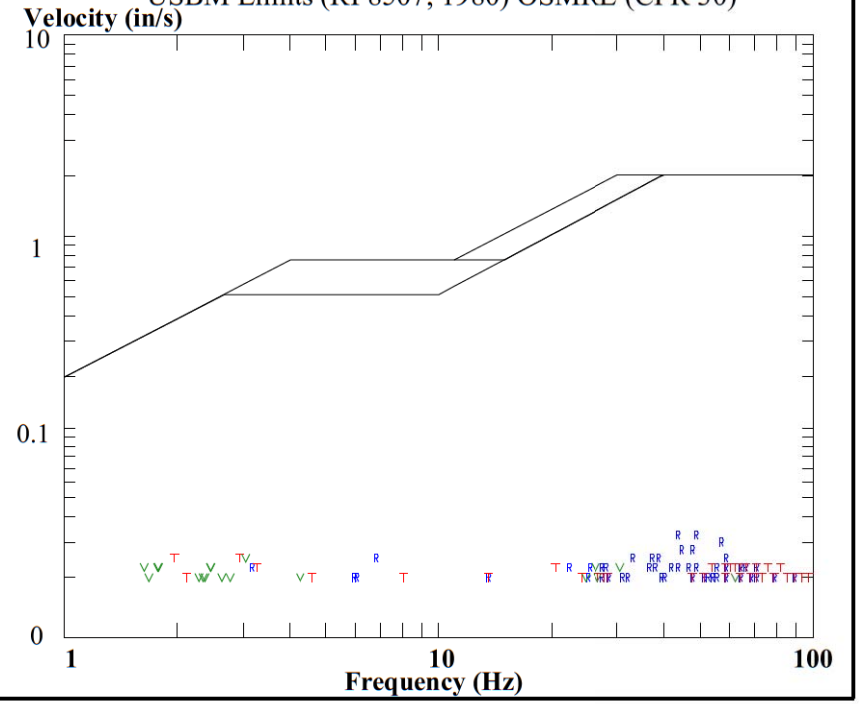
Measurement	Value	Trigger >>> Peak	
psi	.00033	2030.3	
dBL	**101**		
Hz	1.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

26-Mar-18 at 11:30:41 AM Event # 106

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.023**	**0.023**
Frequency (Hz)	**49.90**	**62.00**	**19.50**
Displacement (in)	**0.0001**	**0.0001**	**0.0002**
Acceleration (g's)	**0.0243**	**0.0227**	**0.0071**
Trigger >>> Peak	137	181.9	0

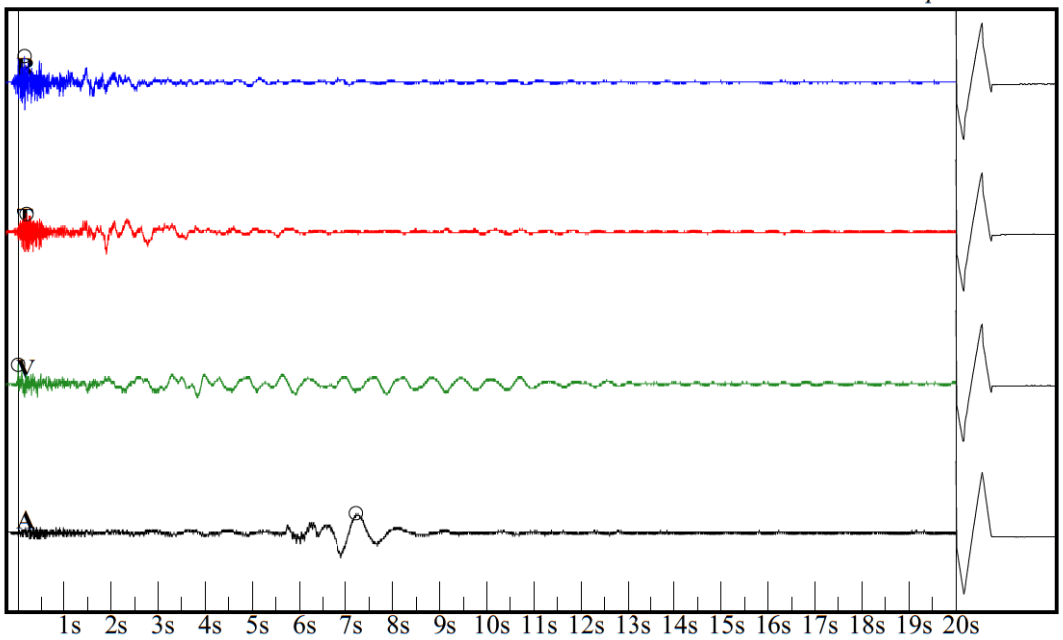
Air

Gain: 1 Trigger: 120 dBL

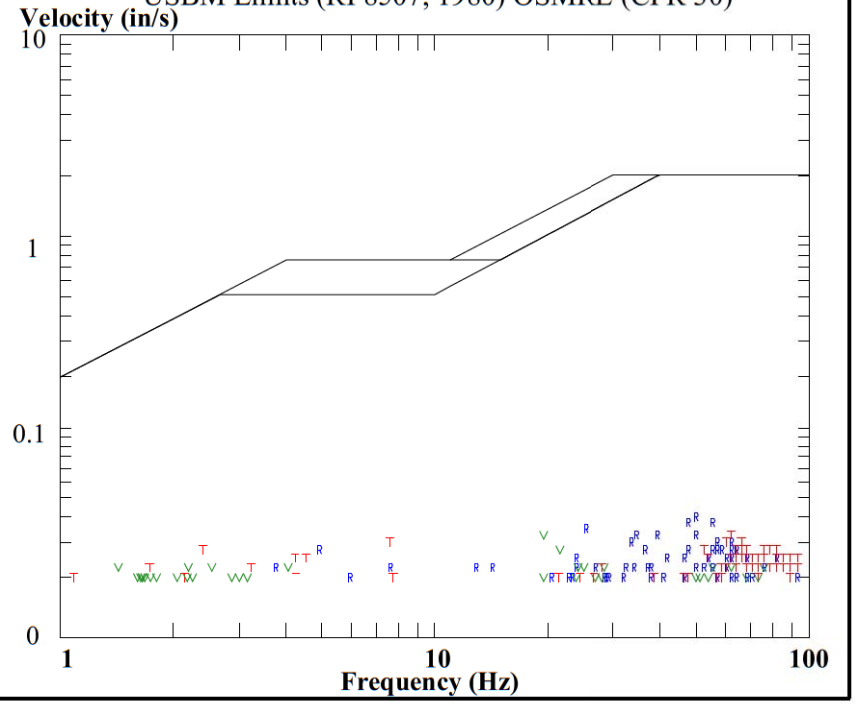
Measurement	Value	Trigger >>> Peak	
psi	.00036	7218	
dBL	**102**		
Hz	1.2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

28-Mar-18 at 14:50:40 PM Event # 110

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.043**	**0.025**	**0.025**
Frequency (Hz)	**39.30**	**60.20**	**24.30**
Displacement (in)	**0.0002**	**0.0001**	**0.0002**
Acceleration (g's)	**0.0272**	**0.0245**	**0.0099**
Trigger >>> Peak	214.8	214.6	1.2

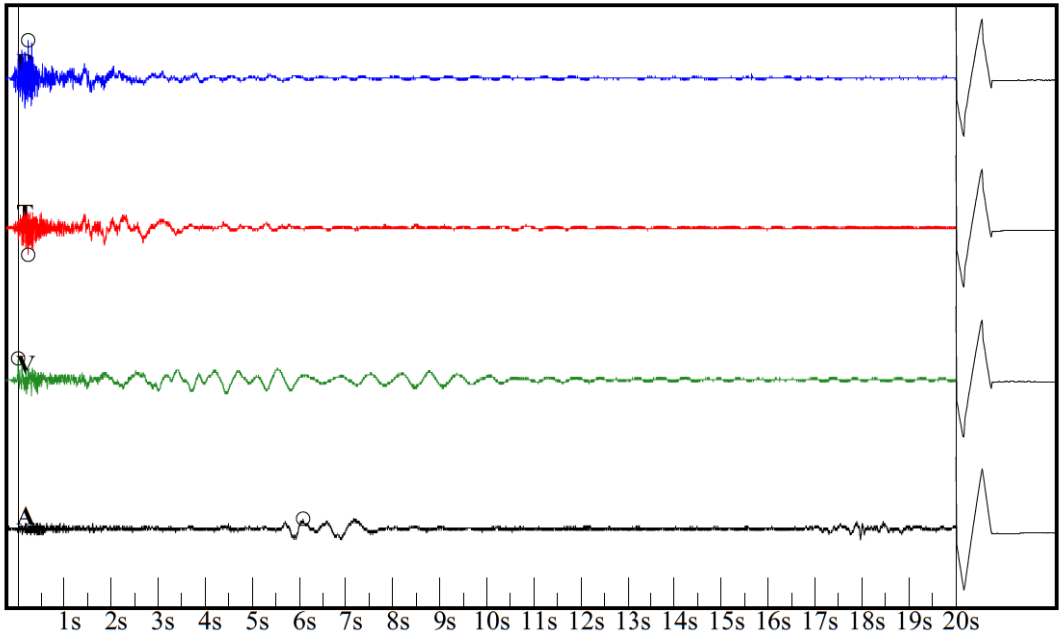
Air

Gain: 1 Trigger: 120 dBL

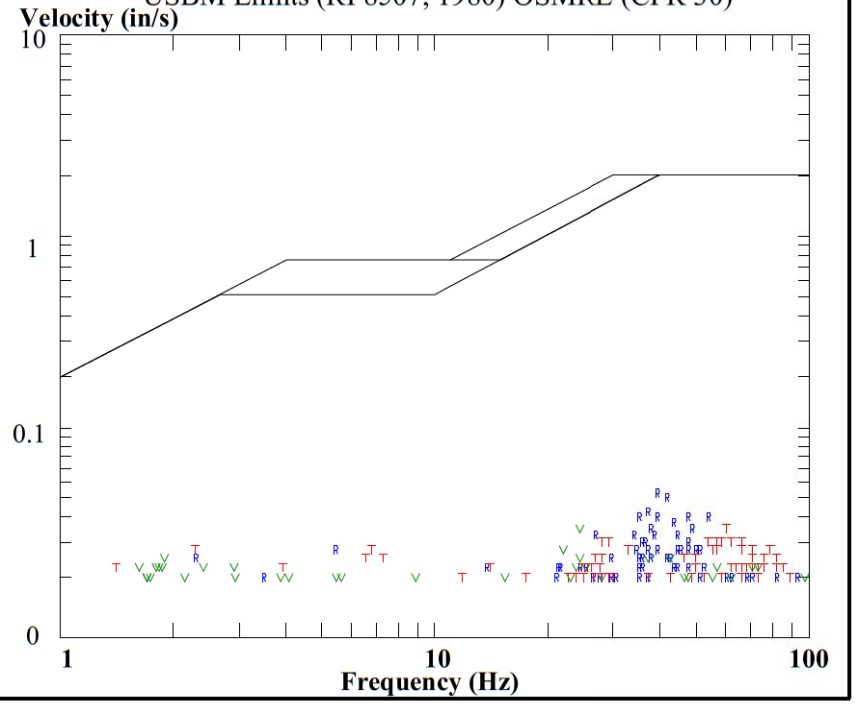
Measurement	Value	Trigger >>> Peak	
psi	.00022	6074.5	
dBL	**98**		
Hz	1.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

03-Apr-18 at 10:34:57 AM Event # 117

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.030**	**0.023**	**0.023**
Frequency (Hz)	**52.50**	**39.30**	**18.20**
Displacement (in)	**0.0001**	**0.0001**	**0.0002**
Acceleration (g's)	**0.0256**	**0.0144**	**0.0067**
Trigger >>> Peak	276.9	50	0

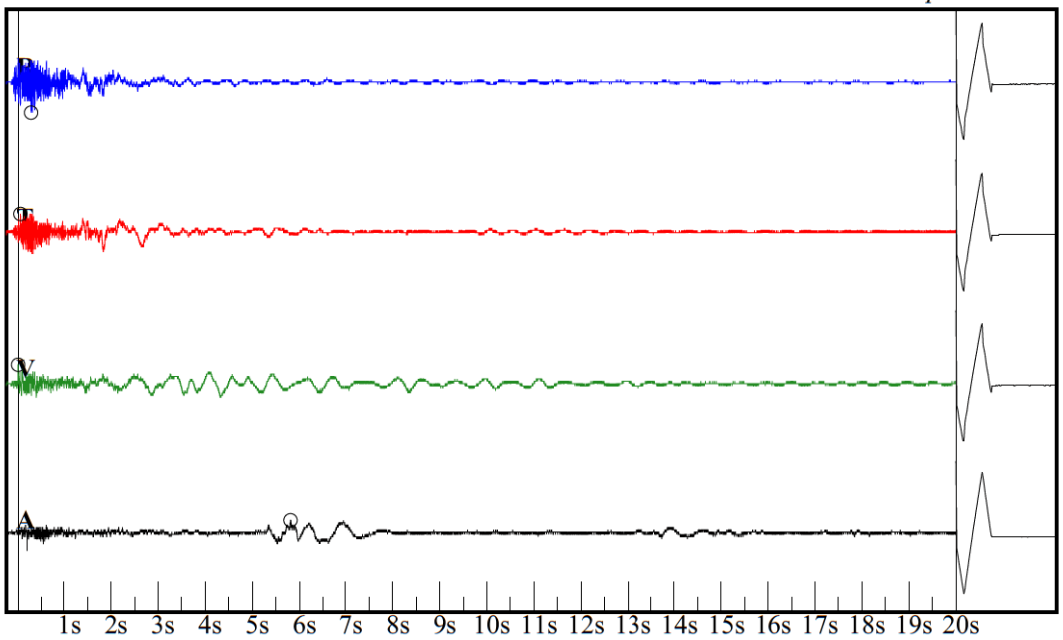
Air

Gain: 1 Trigger: 120 dBL

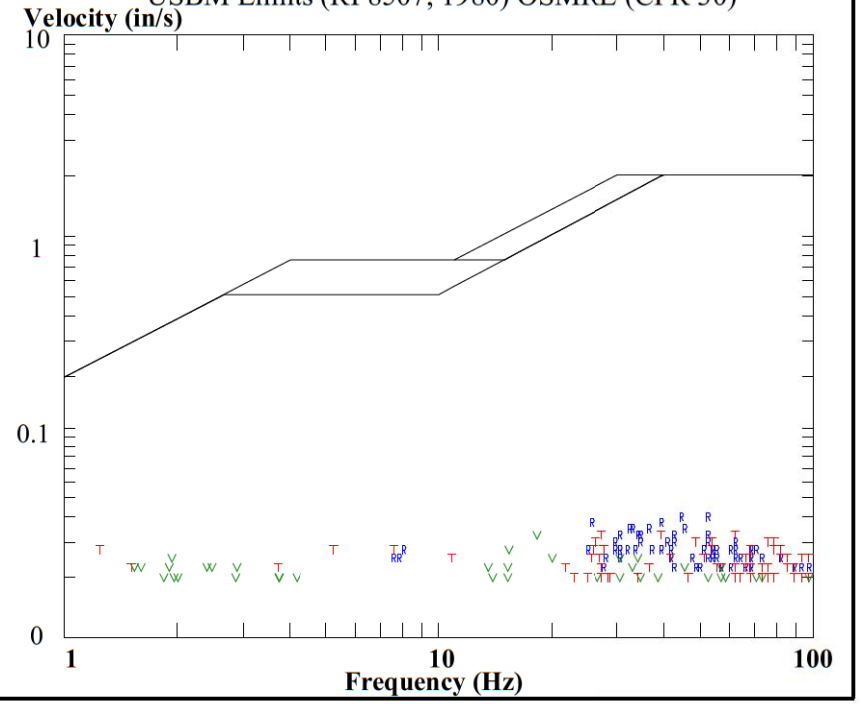
Measurement	Value	Trigger >>> Peak	
psi	.00025	5807.1	
dBL	**99**		
Hz	2		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

05-Apr-18 at 10:44:29 AM Event # 120

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.043**	**0.023**	**0.023**
Frequency (Hz)	**38.60**	**44.50**	**21.30**
Displacement (in)	**0.0002**	**0.0001**	**0.0002**
Acceleration (g's)	**0.0267**	**0.0163**	**0.0078**
Trigger >>> Peak	465.1	95	47.4

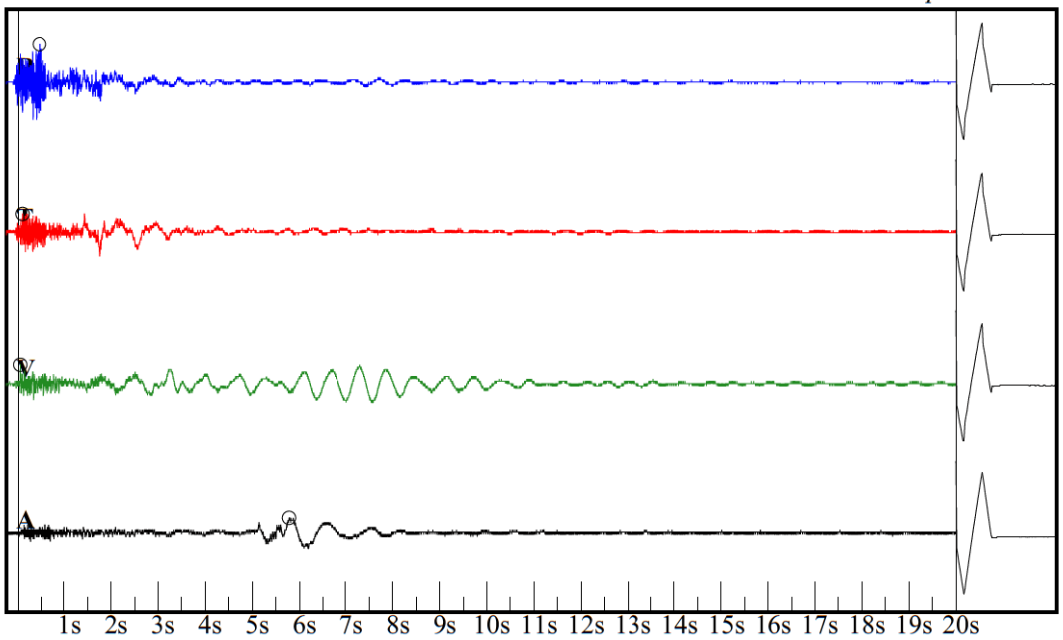
Air

Gain: 1 Trigger: 120 dBL

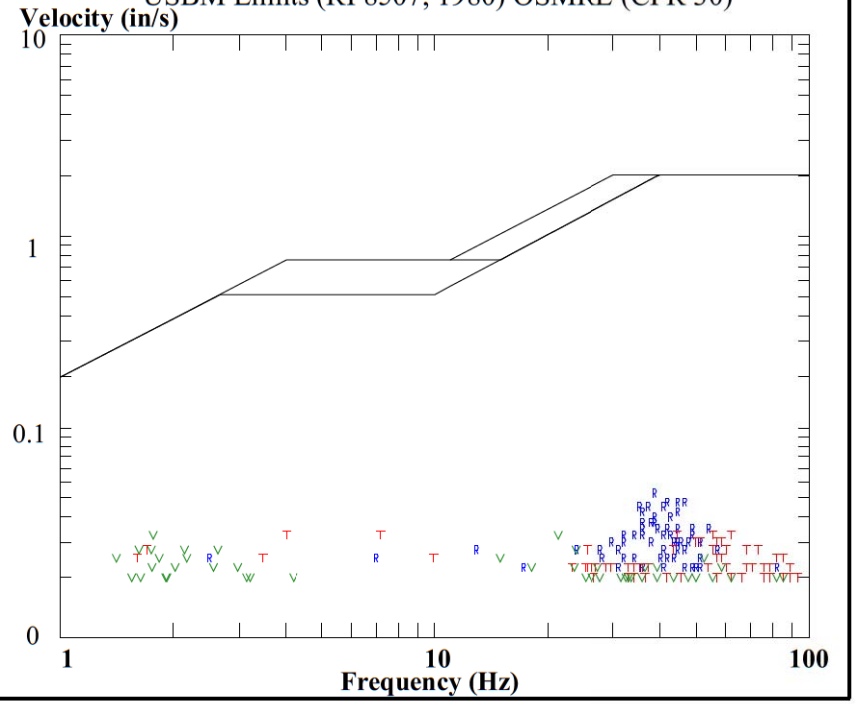
Measurement	Value	Trigger >>> Peak	
psi	.00029	5775.1	
dBL	**100**		
Hz	1.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

10-Apr-18 at 10:31:31 AM Event # 126

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.048**	**0.028**	**0.030**
Frequency (Hz)	**39.30**	**60.20**	**2.70**
Displacement (in)	**0.0002**	**0.0001**	**0.0018**
Acceleration (g's)	**0.0304**	**0.0269**	**0.0013**
Trigger >>> Peak	174.8	143.8	3091.3

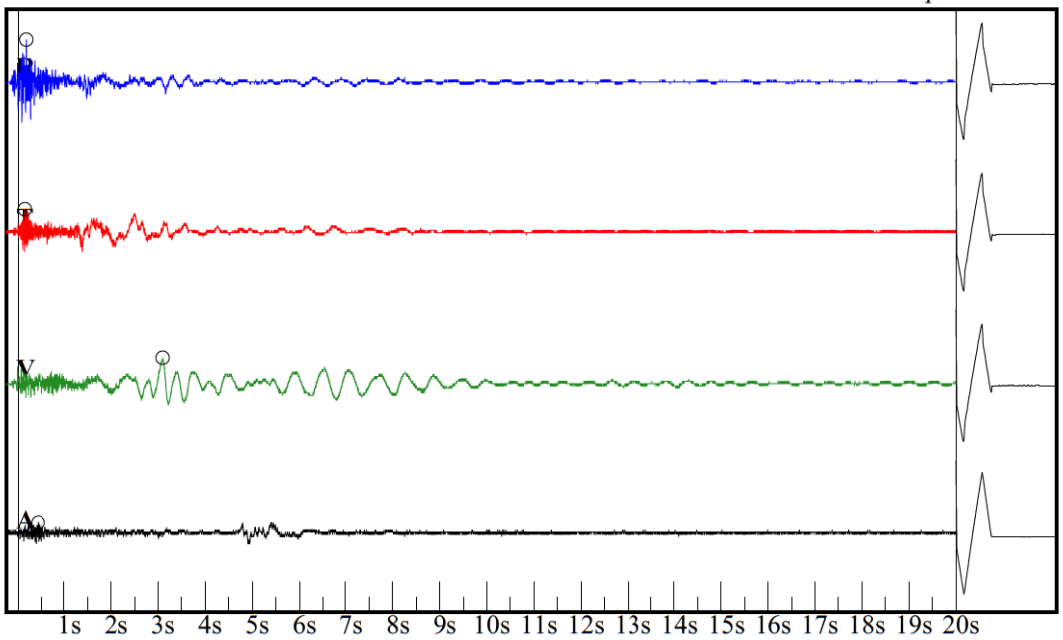
Air

Gain: 1 Trigger: 120 dBL

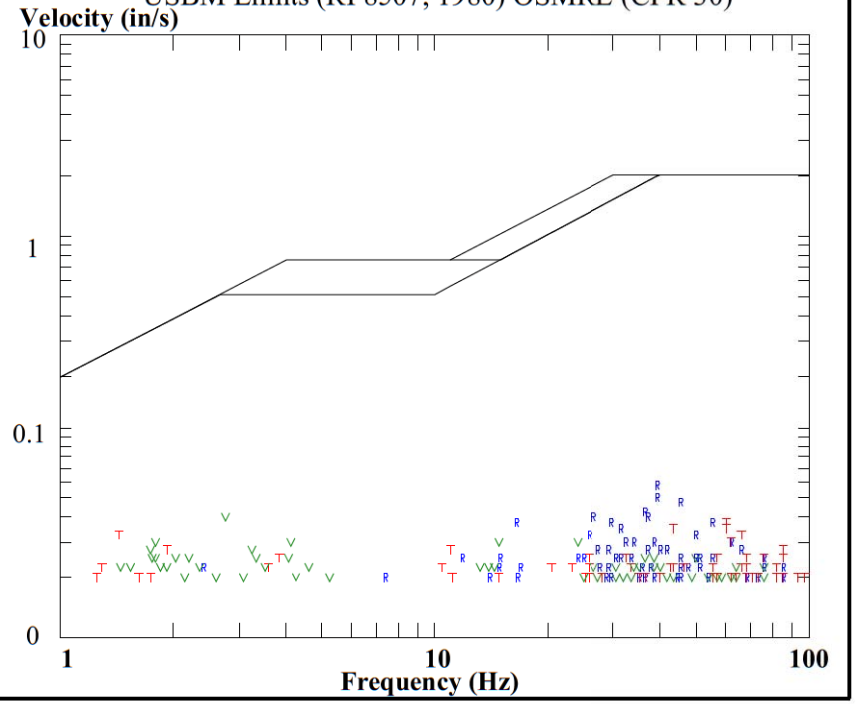
Measurement	Value	Trigger >>> Peak	
psi	.00022	435.1	
dBL	**98**		
Hz	53.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

12-Apr-18 at 14:11:48 PM Event # 131

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.038**	**0.028**	**0.020**
Frequency (Hz)	**40.90**	**68.20**	**24.90**
Displacement (in)	**0.0001**	**0.0001**	**0.0001**
Acceleration (g's)	**0.0249**	**0.0305**	**0.0081**
Trigger >>> Peak	186	168	1.2

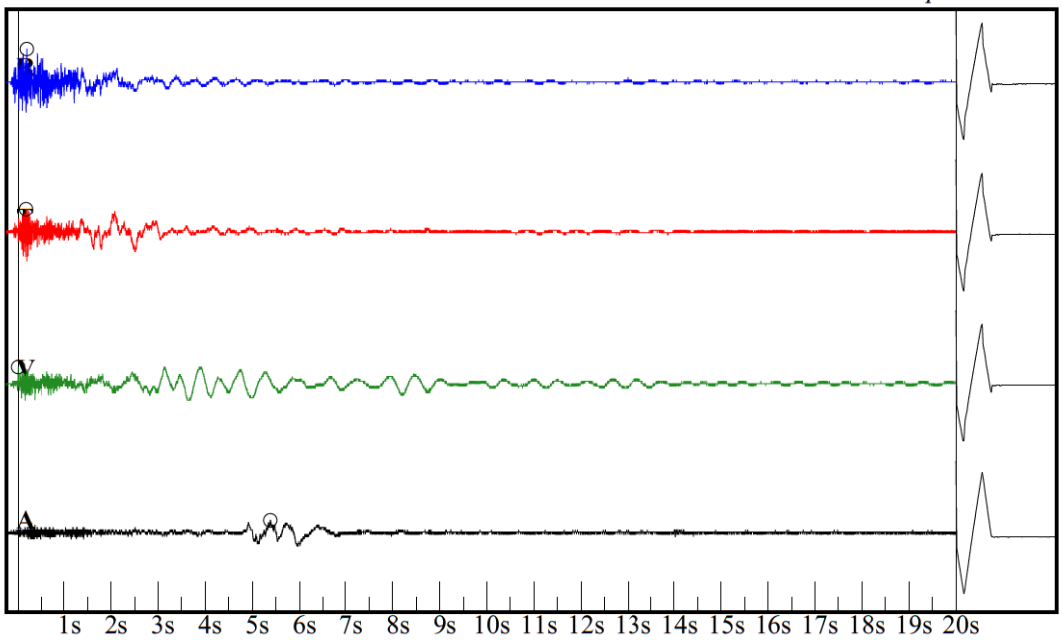
Air

Gain: 1 Trigger: 120 dBL

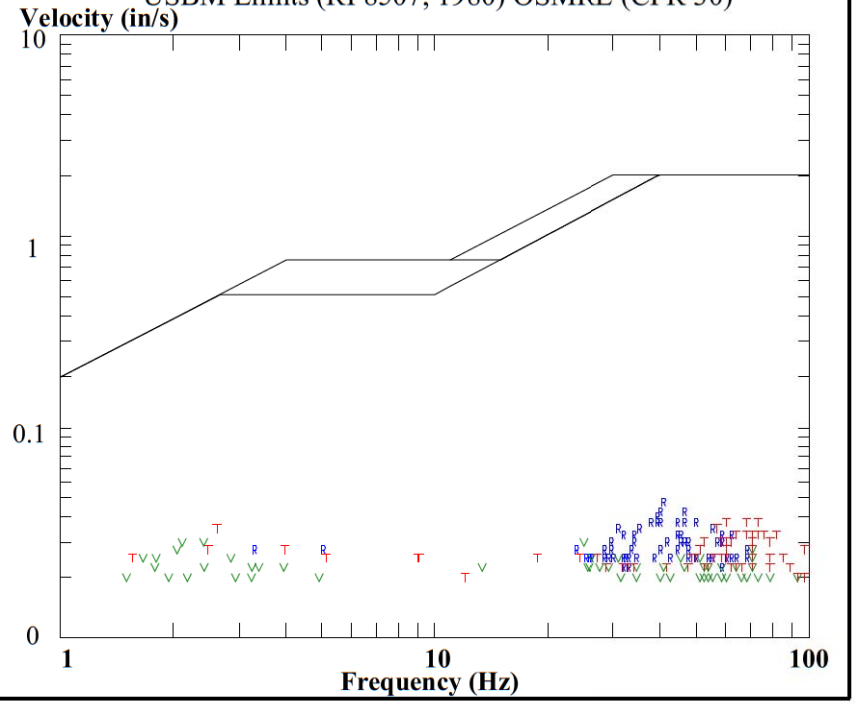
Measurement	Value	Trigger >>> Peak	
psi	.00025	5378.4	
dBL	**99**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

19-Apr-18 at 10:30:43 AM Event # 139

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.038**	**0.038**	**0.023**
Frequency (Hz)	**29.20**	**60.20**	**1.90**
Displacement (in)	**0.0002**	**0.0001**	**0.0019**
Acceleration (g's)	**0.0178**	**0.0367**	**0.0007**
Trigger >>> Peak	174.1	185.1	4496.6

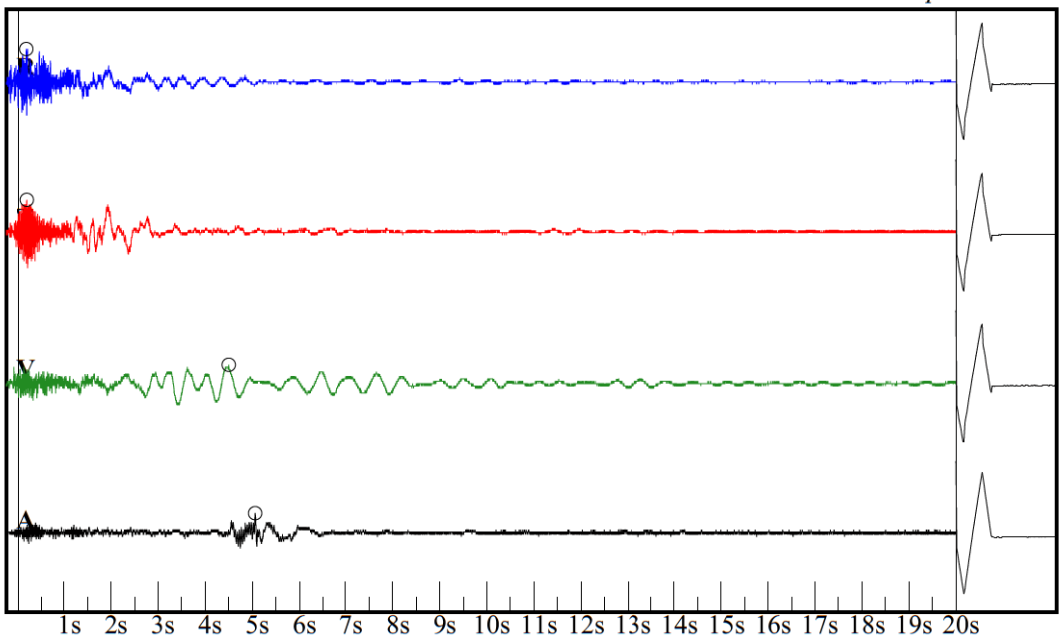
Air

Gain: 1 Trigger: 120 dBL

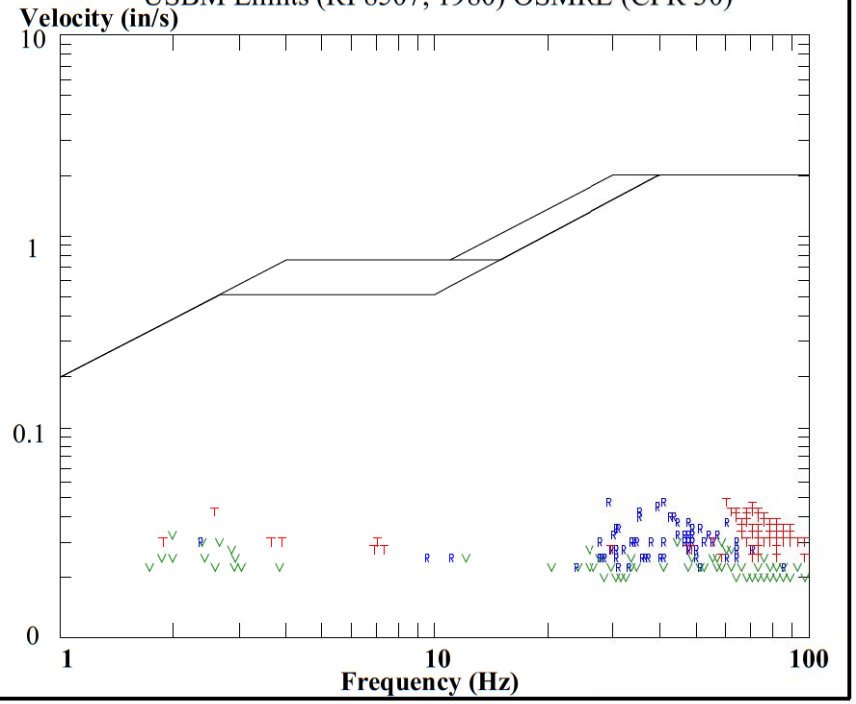
Measurement	Value	Trigger >>> Peak	
psi	.00036	5057.6	
dBL	**102**		
Hz	12.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

25-Apr-18 at 10:50:53 AM Event # 146

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.043**	**0.025**	**0.025**
Frequency (Hz)	**30.50**	**8.80**	**17.60**
Displacement (in)	**0.0002**	**0.0005**	**0.0002**
Acceleration (g's)	**0.0211**	**0.0036**	**0.0072**
Trigger >>> Peak	4225.6	1376.7	65.2

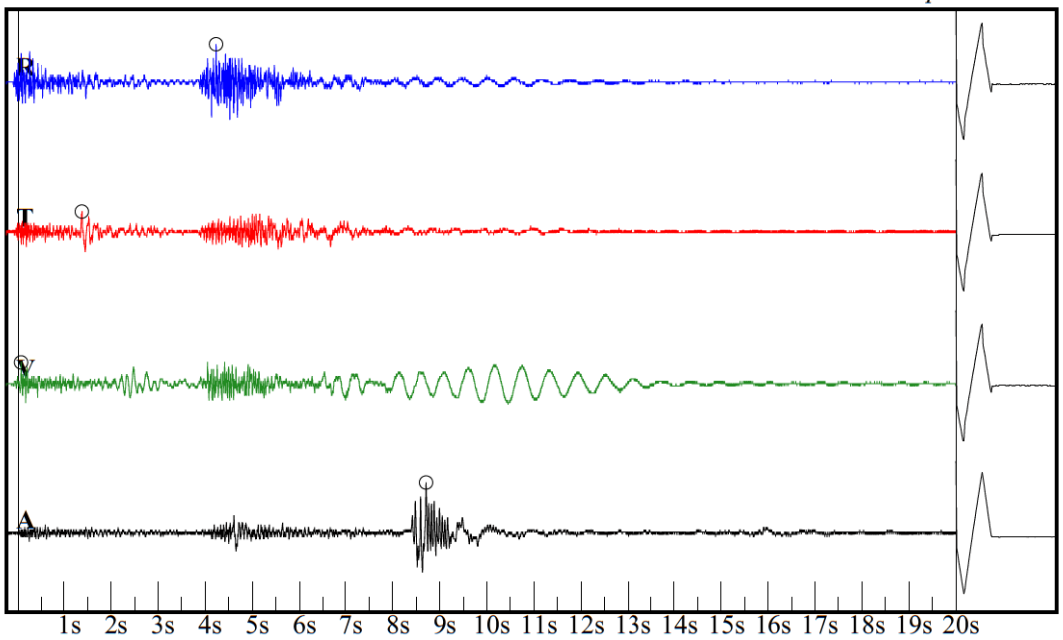
Air

Gain: 1 Trigger: 120 dBL

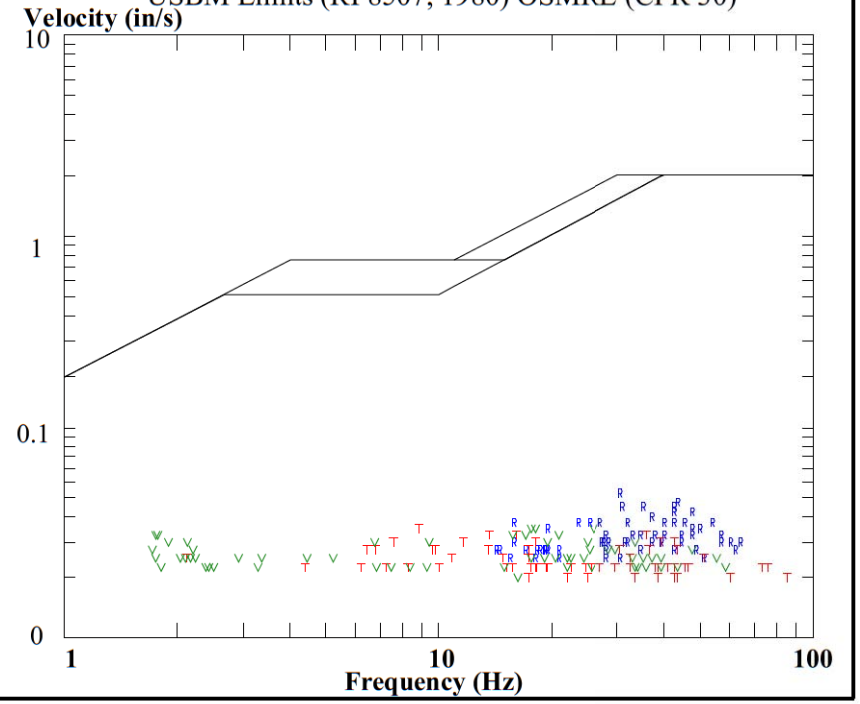
Measurement	Value	Trigger >>> Peak	
psi	.00083	8708.5	
dBL	**109**		
Hz	9.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 12759

01-May-18 at 11:08:02 AM Event # 153

Location: Krome Quarry East Seismograph

Operator: RESPEC

Notes: 25.67516293 -80.46449248

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.053**	**0.033**	**0.030**
Frequency (Hz)	**37.20**	**12.00**	**24.00**
Displacement (in)	**0.0002**	**0.0004**	**0.0002**
Acceleration (g's)	**0.0318**	**0.0063**	**0.0117**
Trigger >>> Peak	489.3	1219.7	296.6

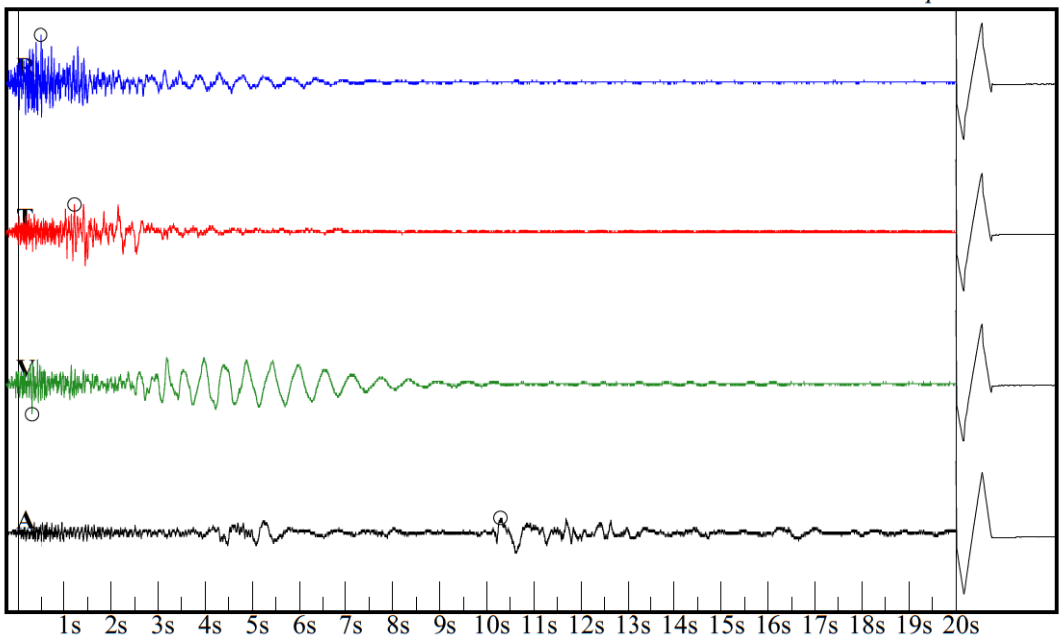
Air

Gain: 1 Trigger: 120 dBL

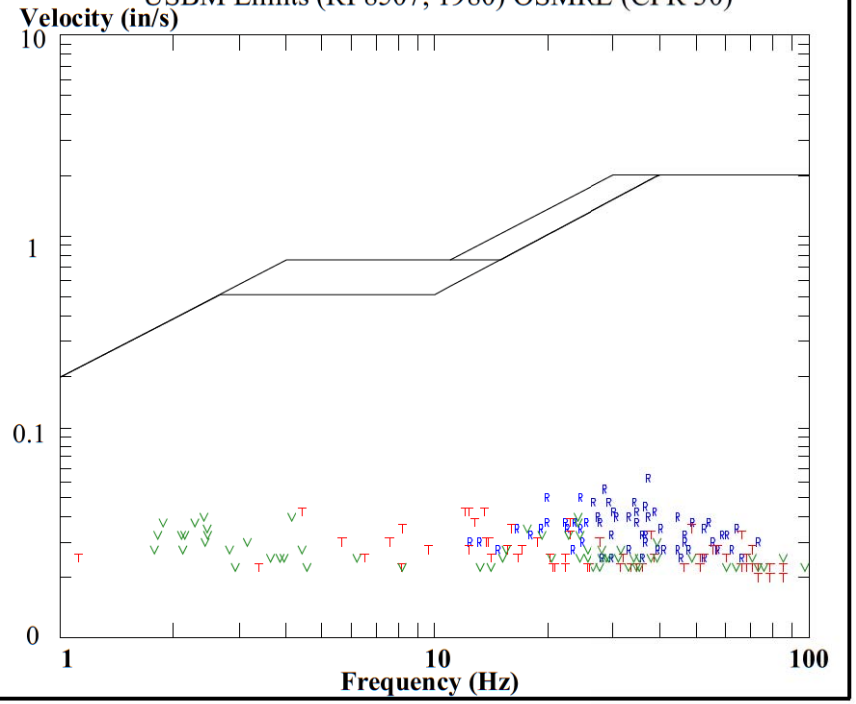
Measurement	Value	Trigger >>> Peak	
psi	.00029	10284.9	
dBL	**100**		
Hz	1.8		

Amplitudes / Frequencies / Frequency Plot

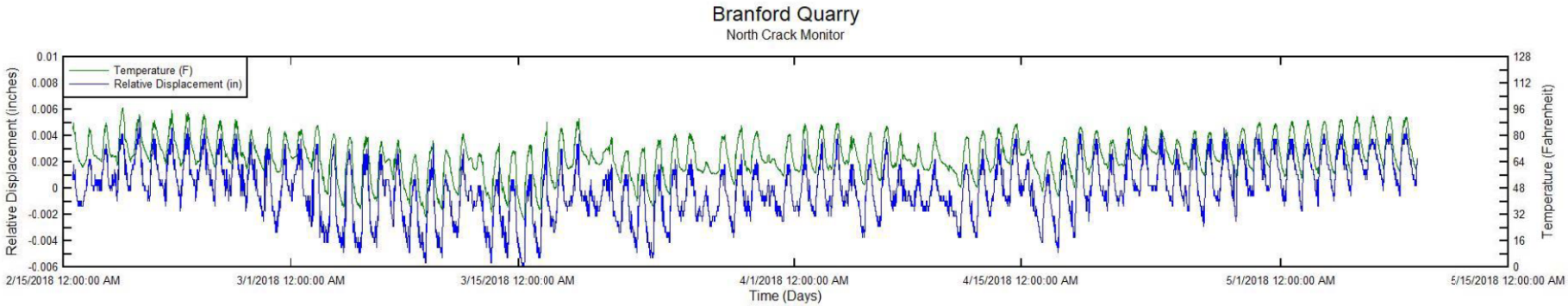
Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)

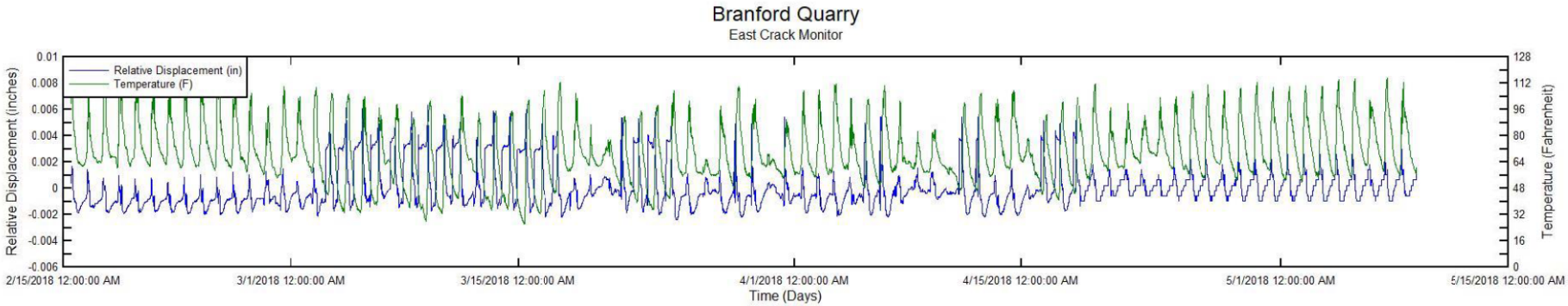


Branford Quarry North



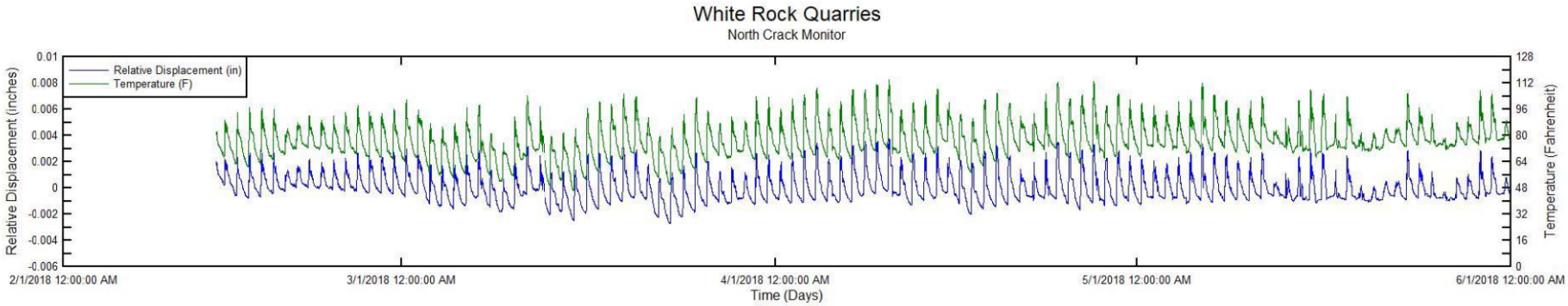
Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
Branford Quarry North	11:34	2/21/2018	0.048	32	0.0059	0.0002	1	0.0000	0.0000
Branford Quarry North	11:39	2/21/2018	0.025	32	0.0059	0.0002	1	0.0000	0.0000
Branford Quarry North	11:35	3/8/2018	0.030	31	0.0059	0.0002	0	0.0004	0.0000
Branford Quarry North	11:22	3/26/2018	0.188	7	0.0031	0.0004	1	0.0000	0.0000
Branford Quarry North	12:42	3/27/2018	0.045	23	0.0043	0.0002	0	0.0000	0.0000
Branford Quarry North	11:16	3/29/2018	0.163	26	0.0047	0.0002	0	0.0000	0.0000
Branford Quarry North	11:51	4/3/2018	0.028	29	0.0063	0.0002	0	-0.0004	0.0000
Branford Quarry North	13:06	4/16/2018	0.488	24	0.0055	0.0002	1	0.0004	0.0004
Branford Quarry North	13:11	4/16/2018	0.065	24	0.0055	0.0002	1	0.0000	0.0000
Branford Quarry North	14:01	4/16/2018	0.033	24	0.0055	0.0002	1	0.0004	0.0004
Branford Quarry North	14:13	4/16/2018	0.050	24	0.0055	0.0002	0	0.0000	0.0000
Branford Quarry North	11:38	4/30/2018	0.263	26	0.0039	0.0002	1	0.0000	0.0000
Average Values			0.119	25.167	0.0052	0.000	0.583	0.0001	0.0001

Branford Quarry East



Location	Blast Time	Blast Date	PPV (ips)	Min. Temp (F)	Max. Temp (F)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
Branford Quarry East	11:35	2/21/2018	0.030	62	113	51	0.0023	0.0000	14	0.0002	0.0000
Branford Quarry East	11:40	2/21/2018	0.020	62	113	51	0.0023	0.0000	8	0.0002	0.0000
Branford Quarry East	11:36	3/8/2018	0.018	35	91	56	0.0073	0.0001	0	-0.0002	0.0000
Branford Quarry East	11:22	3/26/2018	0.343	56	66	10	0.0020	0.0002	0	0.0000	0.0000
Branford Quarry East	12:42	3/27/2018	0.040	56	98	42	0.0033	0.0001	2	-0.0003	-0.0002
Branford Quarry East	12:56	3/27/2018	0.023	56	98	42	0.0033	0.0001	1	0.0002	0.0002
Branford Quarry East	11:16	3/29/2018	0.173	54	102	48	0.0067	0.0001	-2	0.0000	0.0000
Branford Quarry East	11:51	4/3/2018	0.020	56	111	55	0.0034	0.0001	1	-0.0002	-0.0002
Branford Quarry East	13:06	4/16/2018	0.140	44	93	49	0.0063	0.0001	1	0.0000	0.0000
Branford Quarry East	13:11	4/16/2018	0.035	44	93	49	0.0063	0.0001	0	0.0000	0.0000
Branford Quarry East	14:02	4/16/2018	0.023	44	93	49	0.0063	0.0001	-2	-0.0007	0.0003
Branford Quarry East	14:13	4/16/2018	0.030	44	93	49	0.0063	0.0001	-1	-0.0001	0.0001
Average Values			0.075	51	97	46	0.0046	0.0001	2	-0.0001	0.0000

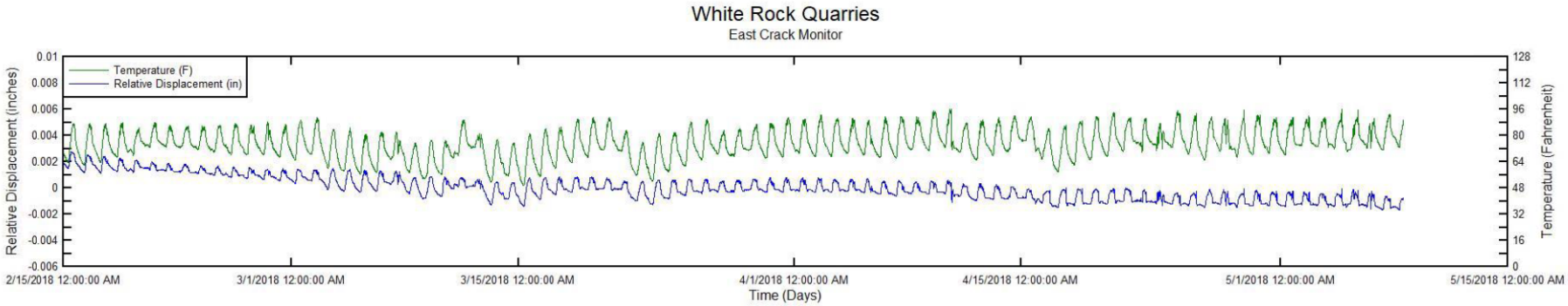
White Rock Quarries North



Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
White Rock Quarries North	13:13	2/13/2018	0.075						
White Rock Quarries North	11:29	2/16/2018	0.075	36	0.0034	0.0001	0	0.0000	0.0000
White Rock Quarries North	13:59	2/19/2018	0.050	16	0.0017	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:14	2/20/2018	0.030	15	0.0017	0.0001	2	0.0000	0.0000
White Rock Quarries North	13:30	2/22/2018	0.060	18	0.0020	0.0001	0	0.0001	0.0000
White Rock Quarries North	13:59	2/26/2018	0.045	27	0.0031	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:32	2/27/2018	0.030	27	0.0028	0.0001	-2	-0.0002	0.0001
White Rock Quarries North	13:59	3/5/2018	0.055	33	0.0033	0.0001	1	-0.0001	-0.0001
White Rock Quarries North	11:35	3/7/2018	0.025	35	0.0037	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:15	3/9/2018	0.040	23	0.0024	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:18	3/19/2018	0.065	39	0.0041	0.0001	0	0.0000	0.0000
White Rock Quarries North	11:44	3/20/2018	0.065	35	0.0037	0.0001	-3	-0.0004	0.0001
White Rock Quarries North	13:14	3/23/2018	0.090	35	0.0039	0.0001	-1	-0.0001	0.0001
White Rock Quarries North	14:29	3/26/2018	0.085	32	0.0034	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:17	3/29/2017	0.055	19	0.0020	0.0001	1	0.0001	0.0001
White Rock Quarries North	11:30	3/30/2018	0.065	39	0.0039	0.0001	-4	-0.0005	0.0001
White Rock Quarries North	15:01	4/3/2018	0.100	41	0.0044	0.0001	0	-0.0001	0.0000
White Rock Quarries North	13:59	4/5/2018	0.105	30	0.0032	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:47	4/9/2018	0.025	40	0.0040	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:00	4/10/2018	0.100	46	0.0044	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:30	4/12/2018	0.075	36	0.0040	0.0001	0	-0.0001	0.0000
White Rock Quarries North	11:30	4/13/2018	0.060	32	0.0036	0.0001	0	-0.0001	0.0000
White Rock Quarries North	13:30	4/17/2018	0.115	33	0.0039	0.0001	0	0.0000	0.0000
White Rock Quarries North	13:16	4/18/2018	0.025	41	0.0043	0.0001	-1	0.0000	0.0000

White Rock Quarries North	13:30	4/19/2018	0.070	42	0.0046	0.0001	-1	0.0000	0.0000
White Rock Quarries North	14:32	4/23/2018	0.090	34	0.0035	0.0001	-1	-0.0001	0.0001
White Rock Quarries North	10:34	4/24/2018	0.025	41	0.0043	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:30	4/25/2018	0.075	35	0.0039	0.0001	0	0.0000	0.0000
Average Values			0.063	33	0.0035	0.0001	0	-0.0001	0.0000

White Rock Quarries East



Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
White Rock Quarries East	13:15	2/13/2018	0.108						0.0000
White Rock Quarries East	13:36	2/14/2018	0.025						0.0000
White Rock Quarries East	11:29	2/16/2018	0.063	25	0.0013	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:59	2/19/2018	0.105	18	0.0009	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:15	2/20/2018	0.060	15	0.0007	0.0000	1	0.0000	0.0000
White Rock Quarries East	13:31	2/22/2018	0.115	13	0.0007	0.0001	1	0.0000	0.0000
White Rock Quarries East	13:59	2/26/2018	0.115	18	0.0009	0.0000	1	0.0000	0.0000
White Rock Quarries East	14:00	3/5/2018	0.085	24	0.0017	0.0001	-1	0.0001	-0.0001
White Rock Quarries East	11:36	3/7/2018	0.040	17	0.0011	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:15	3/9/2018	0.083	23	0.0017	0.0001	0	0.0000	0.0000
White Rock Quarries East	14:19	3/19/2018	0.095	24	0.0010	0.0000	1	0.0001	0.0001
White Rock Quarries East	11:45	3/20/2018	0.080	20	0.0009	0.0000	1	0.0000	0.0000
White Rock Quarries East	13:15	3/23/2018	0.110	29	0.0019	0.0001	0	0.0000	0.0000
White Rock Quarries East	14:30	3/26/2018	0.068	25	0.0011	0.0000	1	0.0002	0.0002
White Rock Quarries East	11:30	3/30/2018	0.070	21	0.0011	0.0001	3	0.0000	0.0000
White Rock Quarries East	15:02	4/3/2018	0.060	23	0.0010	0.0000	0	0.0000	0.0000
White Rock Quarries East	14:00	4/5/2018	0.043	21	0.0011	0.0001	-1	0.0000	0.0000
White Rock Quarries East	13:47	4/9/2018	0.030	24	0.0010	0.0000	0	-0.0001	0.0000
White Rock Quarries East	14:00	4/10/2018	0.053	25	0.0017	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:30	4/12/2018	0.063	24	0.0013	0.0001	3	0.0002	0.0001
White Rock Quarries East	11:31	4/13/2018	0.043	23	0.0011	0.0000	-1	0.0000	0.0000
White Rock Quarries East	13:30	4/17/2018	0.063	28	0.0015	0.0001	1	0.0000	0.0000
White Rock Quarries East	13:30	4/19/2018	0.033	26	0.0012	0.0000	2	0.0000	0.0000
White Rock Quarries East	14:33	4/23/2018	0.045	16	0.0012	0.0001	0	-0.0001	0.0000
White Rock Quarries East	14:31	4/25/2018	0.043	25	0.0011	0.0000	1	0.0000	0.0000

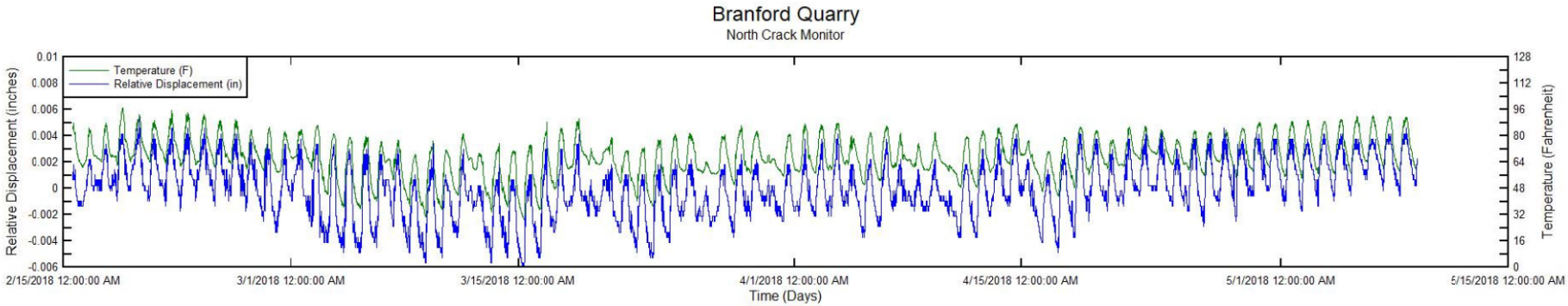
Phase 2 Monitoring Program – Original Seismograph Monitoring Location North of White Rock Quarries

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mc (dB)	Unit Calibration	Comments
White Rock Quarries North Seismograph	13007	146	11:41	5/9/2018	0.010			0.010			0.030	1.7		94.0	0.0	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	148	15:00	5/10/2018	0.050	8.0	13.4	0.020	25.2	3.7	0.050	1.7	16.7	105.0	2.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	150	10:31	5/11/2018	0.010			0.010			0.025	1.7		94.0	1.6	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	155	14:01	5/15/2018	0.040	7.6	11.7	0.025	11.6	3.0	0.080	2.1	15.4	108.0	6.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	158	10:46	5/16/2018	0.010			0.010			0.030	1.7		94.0	0.8	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	166	13:46	5/18/2018	0.010			0.010			0.030	1.7		94.0	1.5	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	170	13:31	5/21/2018	0.015			0.020	22.0		0.035	1.7		98.0	1.5	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	172	13:15	5/22/2018	0.055	9.7	11.6	0.025	13.5	3.8	0.045	10.2	16.1	111.0	5.9	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	174	13:17	5/23/2018	0.010			0.010			0.025	2.1		94.0	0.0	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	177	14:31	5/24/2018	0.035	16.3	13.6	0.020	15.7	4.1	0.060	2.6	15.6	106.0	5.0	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	187	13:15	5/31/2018	0.060	8.1		0.025	14.8		0.045	11.1		107.0	7.8	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.

Phase 2 Monitoring Program – New Seismograph Monitoring Location North of White Rock Quarries

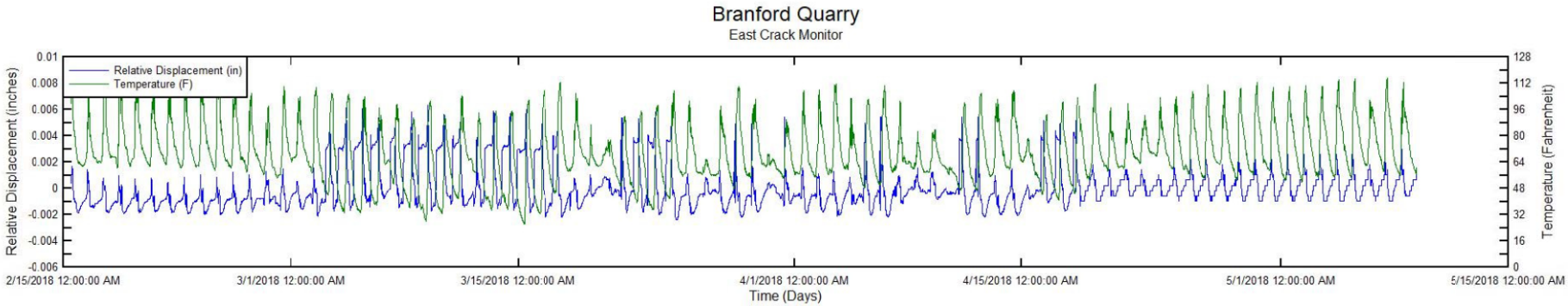
Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mc (dB)	Unit Calibration	Comments
White Rock Quarries North Seismograph B	20268	46	11:40	5/9/2018	0.031	7.5		0.026	1.4		0.076	1.6		103.0	1.7	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	48	15:00	5/10/2018	0.075	19.3	9.3	0.060	7.4	9.5	0.111	2.5	12.5	111.0	5.0	0.02	120	2/23/2018	
White Rock Quarries North Seismograph B	20268	51	10:30	5/11/2018	0.010	2.0		0.027	11.1		0.047	1.6		96.0	2.1	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	71	14:00	5/15/2018	0.062	2.4	10.7	0.047	10.2	10.0	0.104	1.9	14.3	112.0	4.4	0.02	120	2/23/2018	
White Rock Quarries North Seismograph B	20268	76	10:45	5/16/2018	0.010	2.0		0.028	27.3		0.052	1.6		101.0	4.3	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	81	13:45	5/18/2018	0.010	4.4		0.029	22.5		0.054	1.6		98.0	2.7	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	85	11:05	5/21/2018	0.028	2.3		0.014	1.4		0.013	1.1		89.0	2.1	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	86	13:30	5/21/2018	0.009	3.6		0.021	17.6		0.064	1.6		97.0	1.9	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	88	13:14	5/22/2018	0.119	16.0	9.1	0.060	19.8	9.1	0.114	3.9	12.5	110.0	4.4	0.02	120	2/23/2018	
White Rock Quarries North Seismograph B	20268	90	13:16	5/23/2018	0.023	44.5		0.021	1.6		0.063	1.7		106.0	2.4	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph B	20268	92	14:30	5/24/2018	0.075	2.4	9.5	0.051	11.1	7.8	0.144	3.1	13.2	110.0	3.6	0.02	120	2/23/2018	
White Rock Quarries North Seismograph B	20268	144	13:14	5/31/2018	0.079	2.3	10.9	0.047	11.5	8.7	0.156	2.9	11.2	111.0	11.1	0.02	120	2/23/2018	

Branford Quarry North



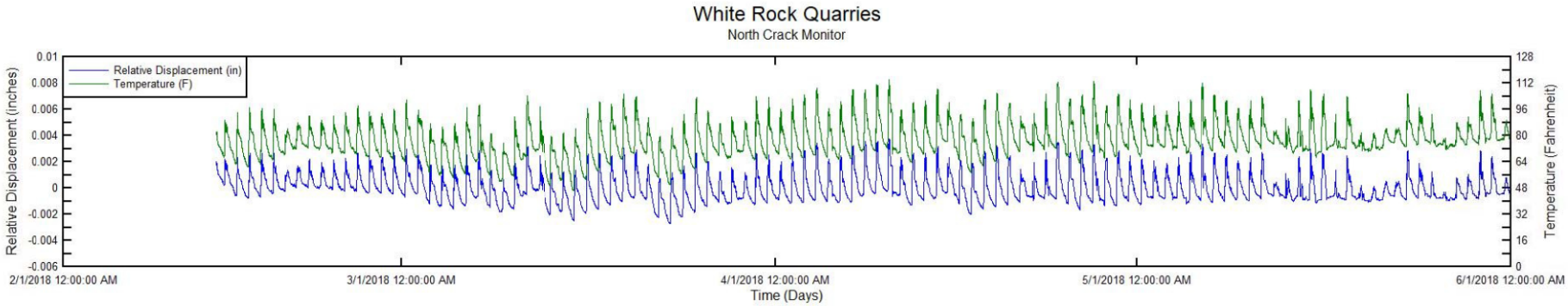
Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
Branford Quarry North	11:34	2/21/2018	0.048	32	0.0059	0.0002	1	0.0000	0.0000
Branford Quarry North	11:39	2/21/2018	0.025	32	0.0059	0.0002	1	0.0000	0.0000
Branford Quarry North	11:35	3/8/2018	0.030	31	0.0059	0.0002	0	0.0004	0.0000
Branford Quarry North	11:22	3/26/2018	0.188	7	0.0031	0.0004	1	0.0000	0.0000
Branford Quarry North	12:42	3/27/2018	0.045	23	0.0043	0.0002	0	0.0000	0.0000
Branford Quarry North	11:16	3/29/2018	0.163	26	0.0047	0.0002	0	0.0000	0.0000
Branford Quarry North	11:51	4/3/2018	0.028	29	0.0063	0.0002	0	-0.0004	0.0000
Branford Quarry North	13:06	4/16/2018	0.488	24	0.0055	0.0002	1	0.0004	0.0004
Branford Quarry North	13:11	4/16/2018	0.065	24	0.0055	0.0002	1	0.0000	0.0000
Branford Quarry North	14:01	4/16/2018	0.033	24	0.0055	0.0002	1	0.0004	0.0004
Branford Quarry North	14:13	4/16/2018	0.050	24	0.0055	0.0002	0	0.0000	0.0000
Branford Quarry North	11:38	4/30/2018	0.263	26	0.0039	0.0002	1	0.0000	0.0000
Average Values			0.119	25.167	0.0052	0.000	0.583	0.0001	0.0001

Branford Quarry East



Location	Blast Time	Blast Date	PPV (ips)	Min. Temp (F)	Max. Temp (F)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
Branford Quarry East	11:35	2/21/2018	0.030	62	113	51	0.0023	0.0000	14	0.0002	0.0000
Branford Quarry East	11:40	2/21/2018	0.020	62	113	51	0.0023	0.0000	8	0.0002	0.0000
Branford Quarry East	11:36	3/8/2018	0.018	35	91	56	0.0073	0.0001	0	-0.0002	0.0000
Branford Quarry East	11:22	3/26/2018	0.343	56	66	10	0.0020	0.0002	0	0.0000	0.0000
Branford Quarry East	12:42	3/27/2018	0.040	56	98	42	0.0033	0.0001	2	-0.0003	-0.0002
Branford Quarry East	12:56	3/27/2018	0.023	56	98	42	0.0033	0.0001	1	0.0002	0.0002
Branford Quarry East	11:16	3/29/2018	0.173	54	102	48	0.0067	0.0001	-2	0.0000	0.0000
Branford Quarry East	11:51	4/3/2018	0.020	56	111	55	0.0034	0.0001	1	-0.0002	-0.0002
Branford Quarry East	13:06	4/16/2018	0.140	44	93	49	0.0063	0.0001	1	0.0000	0.0000
Branford Quarry East	13:11	4/16/2018	0.035	44	93	49	0.0063	0.0001	0	0.0000	0.0000
Branford Quarry East	14:02	4/16/2018	0.023	44	93	49	0.0063	0.0001	-2	-0.0007	0.0003
Branford Quarry East	14:13	4/16/2018	0.030	44	93	49	0.0063	0.0001	-1	-0.0001	0.0001
Average Values			0.075	51	97	46	0.0046	0.0001	2	-0.0001	0.0000

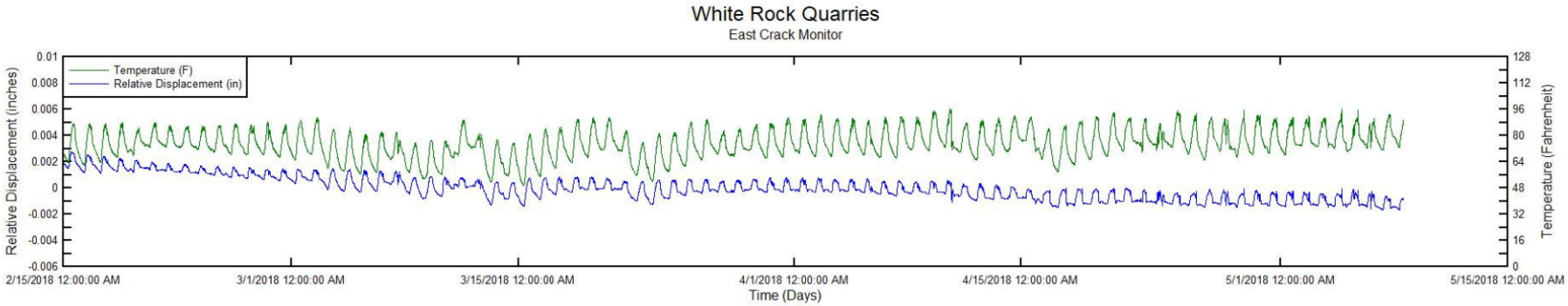
White Rock Quarries North



Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
White Rock Quarries North	13:13	2/13/2018	0.075						
White Rock Quarries North	11:29	2/16/2018	0.075	36	0.0034	0.0001	0	0.0000	0.0000
White Rock Quarries North	13:59	2/19/2018	0.050	16	0.0017	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:14	2/20/2018	0.030	15	0.0017	0.0001	2	0.0000	0.0000
White Rock Quarries North	13:30	2/22/2018	0.060	18	0.0020	0.0001	0	0.0001	0.0000
White Rock Quarries North	13:59	2/26/2018	0.045	27	0.0031	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:32	2/27/2018	0.030	27	0.0028	0.0001	-2	-0.0002	0.0001
White Rock Quarries North	13:59	3/5/2018	0.055	33	0.0033	0.0001	1	-0.0001	-0.0001
White Rock Quarries North	11:35	3/7/2018	0.025	35	0.0037	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:15	3/9/2018	0.040	23	0.0024	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:18	3/19/2018	0.065	39	0.0041	0.0001	0	0.0000	0.0000
White Rock Quarries North	11:44	3/20/2018	0.065	35	0.0037	0.0001	-3	-0.0004	0.0001
White Rock Quarries North	13:14	3/23/2018	0.090	35	0.0039	0.0001	-1	-0.0001	0.0001
White Rock Quarries North	14:29	3/26/2018	0.085	32	0.0034	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:17	3/29/2017	0.055	19	0.0020	0.0001	1	0.0001	0.0001
White Rock Quarries North	11:30	3/30/2018	0.065	39	0.0039	0.0001	-4	-0.0005	0.0001
White Rock Quarries North	15:01	4/3/2018	0.100	41	0.0044	0.0001	0	-0.0001	0.0000
White Rock Quarries North	13:59	4/5/2018	0.105	30	0.0032	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:47	4/9/2018	0.025	40	0.0040	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:00	4/10/2018	0.100	46	0.0044	0.0001	1	0.0000	0.0000
White Rock Quarries North	13:30	4/12/2018	0.075	36	0.0040	0.0001	0	-0.0001	0.0000
White Rock Quarries North	11:30	4/13/2018	0.060	32	0.0036	0.0001	0	-0.0001	0.0000
White Rock Quarries North	13:30	4/17/2018	0.115	33	0.0039	0.0001	0	0.0000	0.0000
White Rock Quarries North	13:16	4/18/2018	0.025	41	0.0043	0.0001	-1	0.0000	0.0000

White Rock Quarries North	13:30	4/19/2018	0.070	42	0.0046	0.0001	-1	0.0000	0.0000
White Rock Quarries North	14:32	4/23/2018	0.090	34	0.0035	0.0001	-1	-0.0001	0.0001
White Rock Quarries North	10:34	4/24/2018	0.025	41	0.0043	0.0001	0	0.0000	0.0000
White Rock Quarries North	14:30	4/25/2018	0.075	35	0.0039	0.0001	0	0.0000	0.0000
Average Values			0.063	33	0.0035	0.0001	0	-0.0001	0.0000

White Rock Quarries East



Location	Blast Time	Blast Date	PPV (ips)	Total Daily Temp. Range (F)	Total Daily Disp. Range (in)	Total Daily Disp.in)/ Total Daily Temp. Change (F)	Temp. Change (F)	Disp. Change (in)	Pre/Post Blast Points Disp.(in)/ Temp. Change (F)
White Rock Quarries East	13:15	2/13/2018	0.108						0.0000
White Rock Quarries East	13:36	2/14/2018	0.025						0.0000
White Rock Quarries East	11:29	2/16/2018	0.063	25	0.0013	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:59	2/19/2018	0.105	18	0.0009	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:15	2/20/2018	0.060	15	0.0007	0.0000	1	0.0000	0.0000
White Rock Quarries East	13:31	2/22/2018	0.115	13	0.0007	0.0001	1	0.0000	0.0000
White Rock Quarries East	13:59	2/26/2018	0.115	18	0.0009	0.0000	1	0.0000	0.0000
White Rock Quarries East	14:00	3/5/2018	0.085	24	0.0017	0.0001	-1	0.0001	-0.0001
White Rock Quarries East	11:36	3/7/2018	0.040	17	0.0011	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:15	3/9/2018	0.083	23	0.0017	0.0001	0	0.0000	0.0000
White Rock Quarries East	14:19	3/19/2018	0.095	24	0.0010	0.0000	1	0.0001	0.0001
White Rock Quarries East	11:45	3/20/2018	0.080	20	0.0009	0.0000	1	0.0000	0.0000
White Rock Quarries East	13:15	3/23/2018	0.110	29	0.0019	0.0001	0	0.0000	0.0000
White Rock Quarries East	14:30	3/26/2018	0.068	25	0.0011	0.0000	1	0.0002	0.0002
White Rock Quarries East	11:30	3/30/2018	0.070	21	0.0011	0.0001	3	0.0000	0.0000
White Rock Quarries East	15:02	4/3/2018	0.060	23	0.0010	0.0000	0	0.0000	0.0000
White Rock Quarries East	14:00	4/5/2018	0.043	21	0.0011	0.0001	-1	0.0000	0.0000
White Rock Quarries East	13:47	4/9/2018	0.030	24	0.0010	0.0000	0	-0.0001	0.0000
White Rock Quarries East	14:00	4/10/2018	0.053	25	0.0017	0.0001	0	0.0000	0.0000
White Rock Quarries East	13:30	4/12/2018	0.063	24	0.0013	0.0001	3	0.0002	0.0001
White Rock Quarries East	11:31	4/13/2018	0.043	23	0.0011	0.0000	-1	0.0000	0.0000
White Rock Quarries East	13:30	4/17/2018	0.063	28	0.0015	0.0001	1	0.0000	0.0000
White Rock Quarries East	13:30	4/19/2018	0.033	26	0.0012	0.0000	2	0.0000	0.0000
White Rock Quarries East	14:33	4/23/2018	0.045	16	0.0012	0.0001	0	-0.0001	0.0000
White Rock Quarries East	14:31	4/25/2018	0.043	25	0.0011	0.0000	1	0.0000	0.0000

Phase 2 Monitoring Program – Original Seismograph Monitoring Location North of White Rock Quarries

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mc (dB)	Unit Calibration	Comments
White Rock Quarries North Seismograph	13007	146	11:41	5/9/2018	0.010			0.010			0.030	1.7		94.0	0.0	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	148	15:00	5/10/2018	0.050	8.0	13.4	0.020	25.2	3.7	0.050	1.7	16.7	105.0	2.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	150	10:31	5/11/2018	0.010			0.010			0.025	1.7		94.0	1.6	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	155	14:01	5/15/2018	0.040	7.6	11.7	0.025	11.6	3.0	0.080	2.1	15.4	108.0	6.6	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	158	10:46	5/16/2018	0.010			0.010			0.030	1.7		94.0	0.8	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	166	13:46	5/18/2018	0.010			0.010			0.030	1.7		94.0	1.5	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	170	13:31	5/21/2018	0.015			0.020	22.0		0.035	1.7		98.0	1.5	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	172	13:15	5/22/2018	0.055	9.7	11.6	0.025	13.5	3.8	0.045	10.2	16.1	111.0	5.9	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	174	13:17	5/23/2018	0.010			0.010			0.025	2.1		94.0	0.0	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quarries North Seismograph	13007	177	14:31	5/24/2018	0.035	16.3	13.6	0.020	15.7	4.1	0.060	2.6	15.6	106.0	5.0	0.02	120	12/13/2017	
White Rock Quarries North Seismograph	13007	187	13:15	5/31/2018	0.060	8.1		0.025	14.8		0.045	11.1		107.0	7.8	0.02	120	12/13/2017	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.

Phase 2 Monitoring Program – New Seismograph Monitoring Location North of White Rock Quarries (White Rock Quarries North Seismograph 2)

Seismograph Location	Unit #	Event #	Blast Time	Blast Date	PPV Long (ips)	ZC Freq. Long (Hz)	Duration Long (s)	PPV Trans (ips)	ZC Freq. Trans (Hz)	Duration Trans (s)	PPV Vert (ips)	ZC Freq. Vert (Hz)	Duration Vert (s)	Actual Air Blast (db)	ZC Freq. (Hz)	Trigger Geo. (ips)	Trigger Mc (dB)	Unit Calibration	Comments
White Rock Quaries North Seismograph 2	20268	46	11:40	5/9/2018	0.031	7.5		0.026	1.4		0.076	1.6		103.0	1.7	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	48	15:00	5/10/2018	0.075	19.3	9.3	0.060	7.4	9.5	0.111	2.5	12.5	111.0	5.0	0.02	120	2/23/2018	
White Rock Quaries North Seismograph 2	20268	51	10:30	5/11/2018	0.010	2.0		0.027	11.1		0.047	1.6		96.0	2.1	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	71	14:00	5/15/2018	0.062	2.4	10.7	0.047	10.2	10.0	0.104	1.9	14.3	112.0	4.4	0.02	120	2/23/2018	
White Rock Quaries North Seismograph 2	20268	76	10:45	5/16/2018	0.010	2.0		0.028	27.3		0.052	1.6		101.0	4.3	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	81	13:45	5/18/2018	0.010	4.4		0.029	22.5		0.054	1.6		98.0	2.7	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	85	11:05	5/21/2018	0.028	2.3		0.014	1.4		0.013	1.1		89.0	2.1	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	86	13:30	5/21/2018	0.009	3.6		0.021	17.6		0.064	1.6		97.0	1.9	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	88	13:14	5/22/2018	0.119	16.0	9.1	0.060	19.8	9.1	0.114	3.9	12.5	110.0	4.4	0.02	120	2/23/2018	
White Rock Quaries North Seismograph 2	20268	90	13:16	5/23/2018	0.023	44.5		0.021	1.6		0.063	1.7		106.0	2.4	0.02	120	2/23/2018	Durations were not estimated because seismograph did not trigger immediately due to the low amplitude vibration.
White Rock Quaries North Seismograph 2	20268	92	14:30	5/24/2018	0.075	2.4	9.5	0.051	11.1	7.8	0.144	3.1	13.2	110.0	3.6	0.02	120	2/23/2018	
White Rock Quaries North Seismograph 2	20268	144	13:14	5/31/2018	0.079	2.3	10.9	0.047	11.5	8.7	0.156	2.9	11.2	111.0	11.1	0.02	120	2/23/2018	

N
White Rock Quarries
North Seismograph
White Rock Quarries
North Seismograph 2
Seismograph
Seismograph and Crack Monitor
FDEP Mining Permit
0
1000
2000 ft

Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

09-May-18 at 11:41:08 AM Event # 146

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.030**
Frequency (Hz)	**0.00**	**0.00**	**1.70**
Displacement (in)			**0.0028**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0008**
Trigger >>> Peak	0	0	599.4

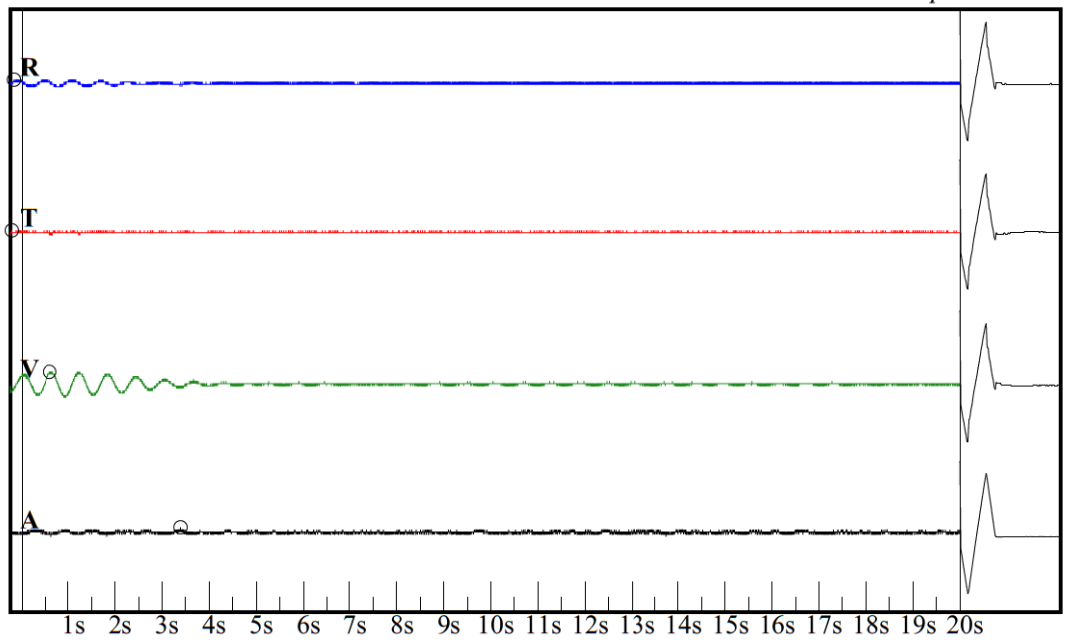
Air

Gain: 1 Trigger: 120 dBL

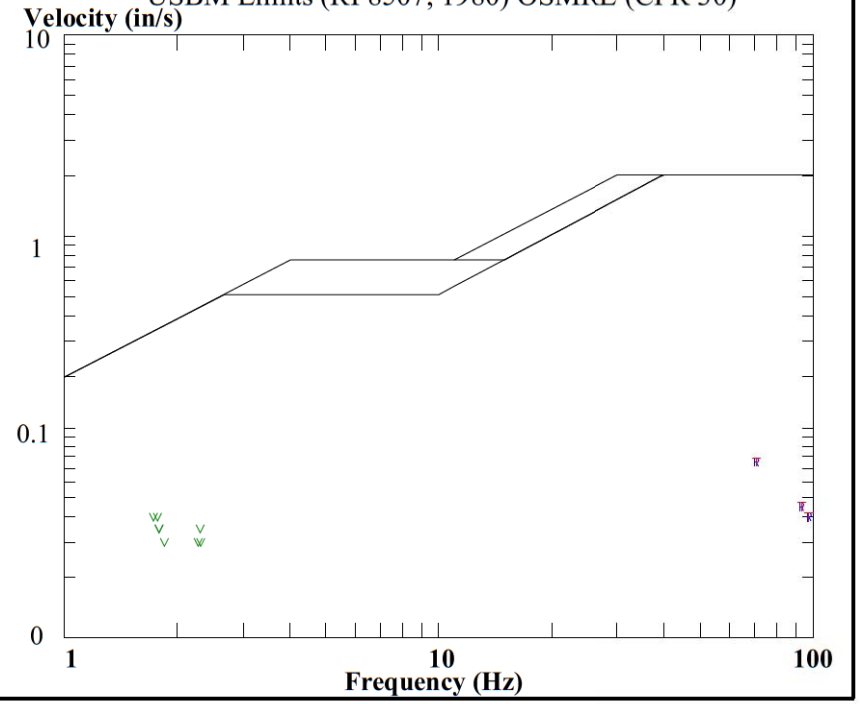
Measurement	Value	Trigger >>> Peak	
psi	.00015	3388.7	
dBL	**94**		
Hz	0		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

10-May-18 at 15:00:43 PM Event # 148

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.050**	**0.020**	**0.050**
Frequency (Hz)	**8.00**	**25.20**	**1.70**
Displacement (in)	**0.0010**	**0.0001**	**0.0047**
Acceleration (g's)	**0.0065**	**0.0082**	**0.0014**
Trigger >>> Peak	1181.6	1473.1	9214.1

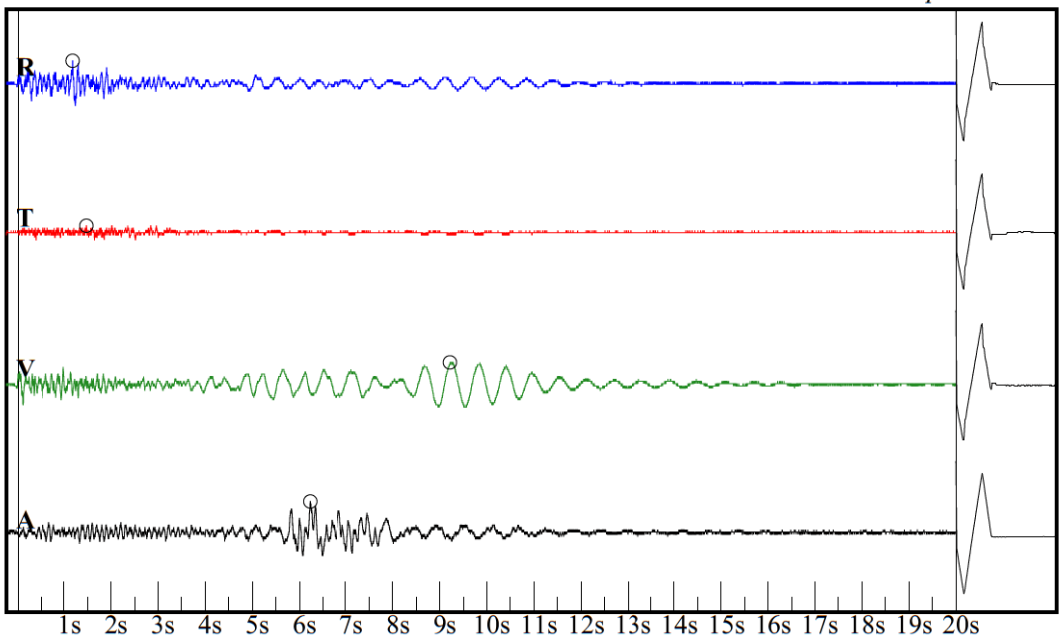
Air

Gain: 1 Trigger: 120 dBL

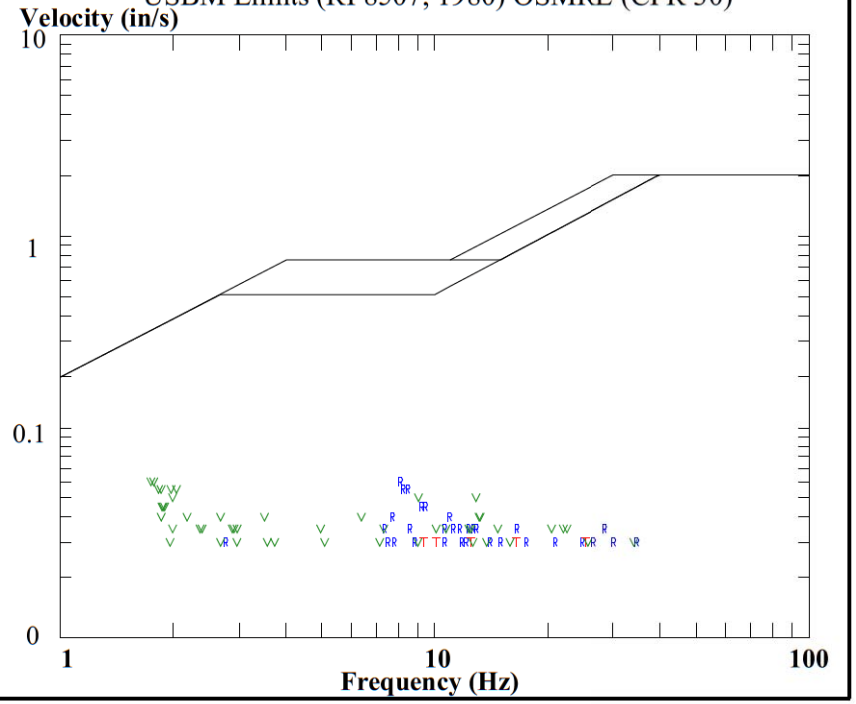
Measurement	Value	Trigger >>> Peak	
psi	.00054	6228	
dBL	**105**		
Hz	2.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

11-May-18 at 10:31:07 AM Event # 150

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.025**
Frequency (Hz)	**0.00**	**0.00**	**1.70**
Displacement (in)			**0.0023**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0007**
Trigger >>> Peak	0	0	0

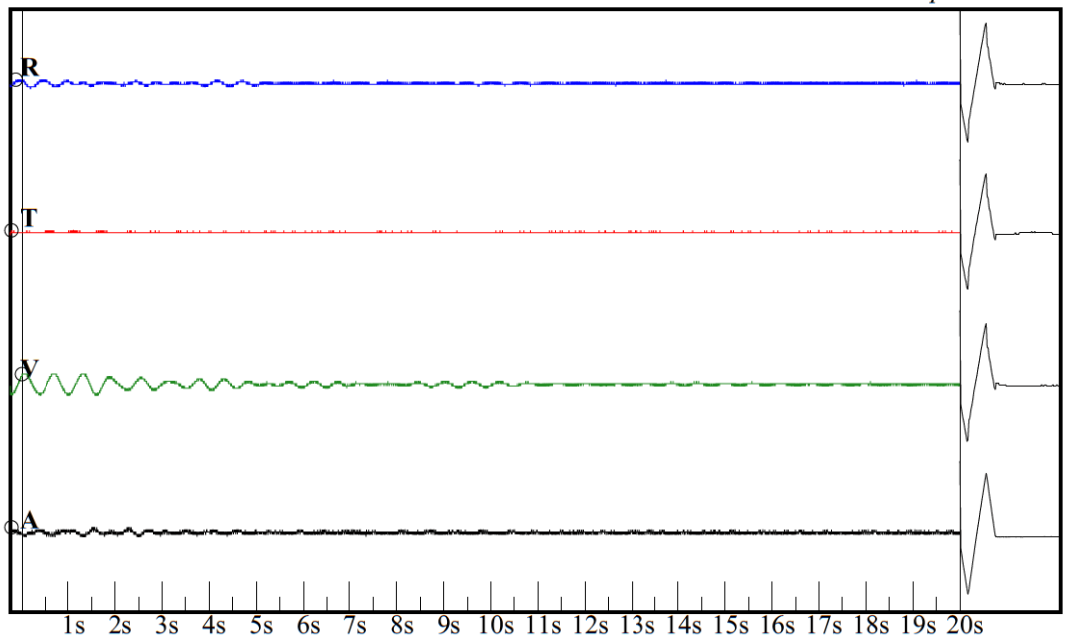
Air

Gain: 1 Trigger: 120 dBL

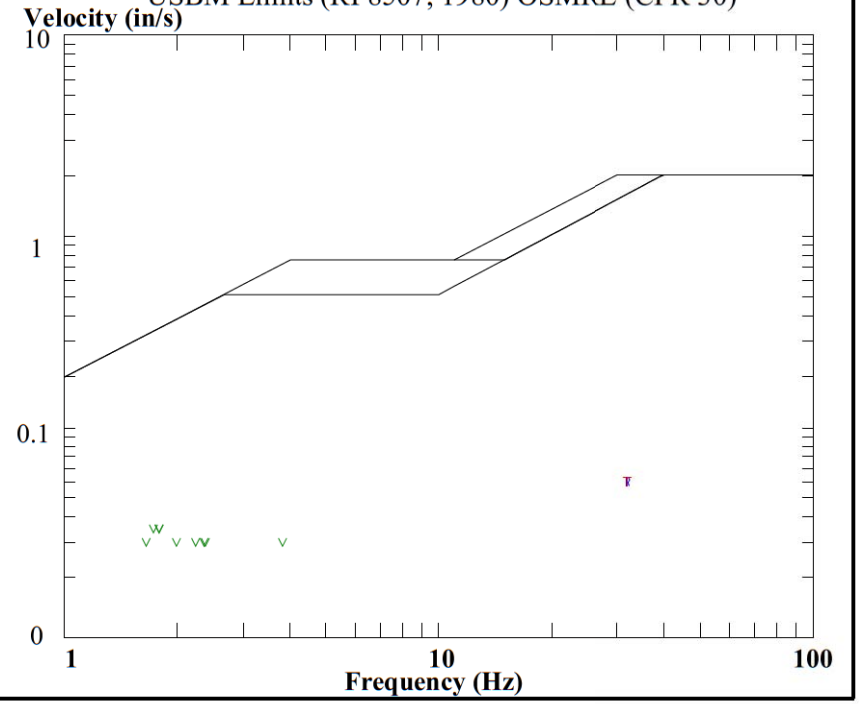
Measurement	Value	Trigger >>> Peak	
psi	.00015	0	
dBL	**94**		
Hz	1.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

15-May-18 at 14:01:13 PM Event # 155

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.040**	**0.025**	**0.080**
Frequency (Hz)	**7.60**	**11.60**	**2.10**
Displacement (in)	**0.0008**	**0.0003**	**0.0061**
Acceleration (g's)	**0.0049**	**0.0047**	**0.0027**
Trigger >>> Peak	2005.4	950.9	7063.7

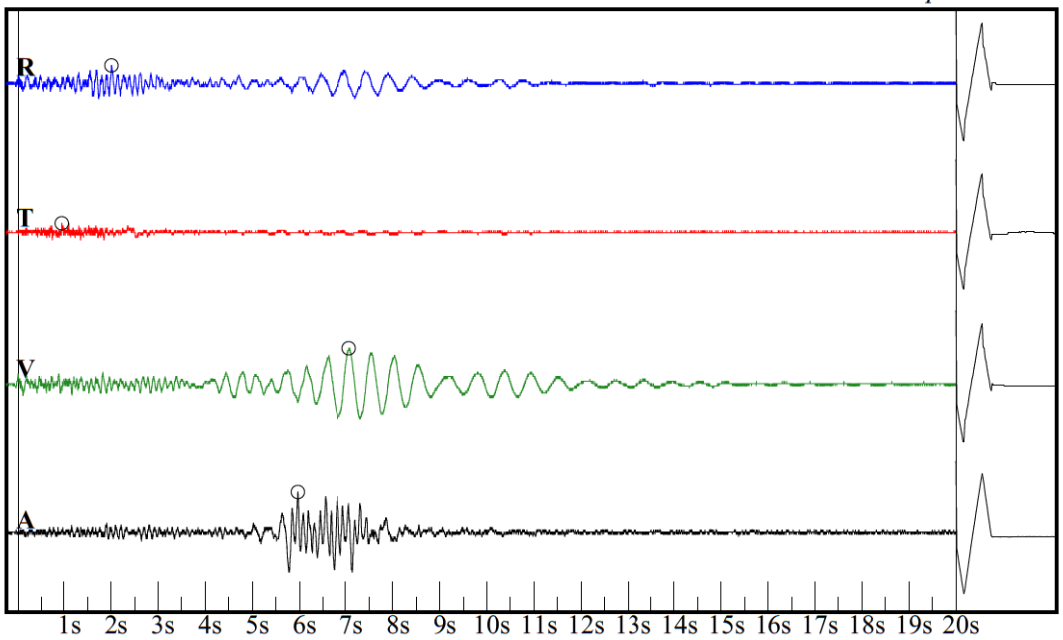
Air

Gain: 1 Trigger: 120 dBL

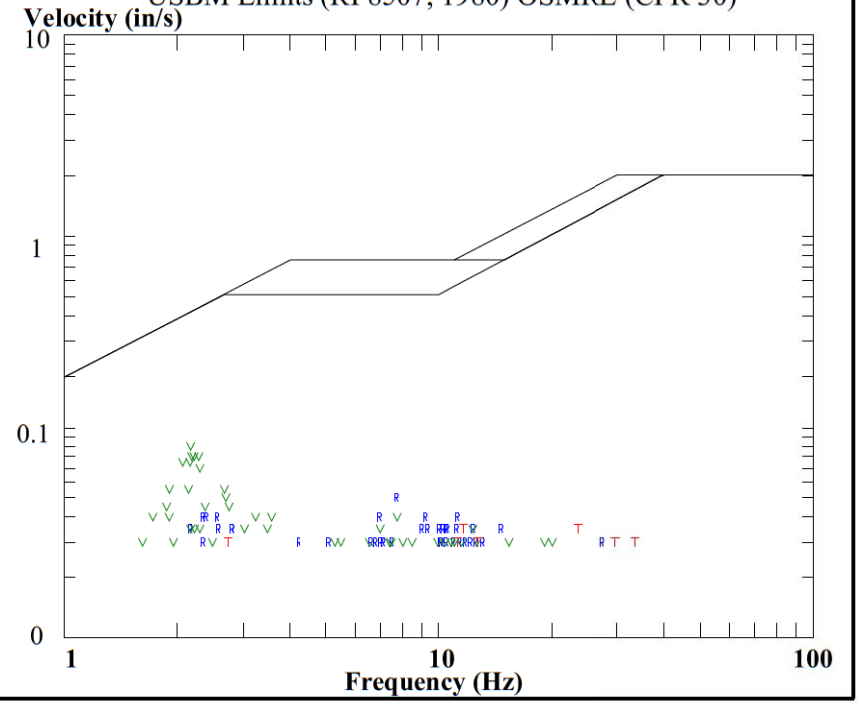
Measurement	Value	Trigger >>> Peak	
psi	.00069	5962.6	
dBL	**108**		
Hz	6.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

16-May-18 at 10:46:30 AM Event # 158

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.030**
Frequency (Hz)	**0.00**	**0.00**	**1.70**
Displacement (in)			**0.0028**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0008**
Trigger >>> Peak	0	0	690.4

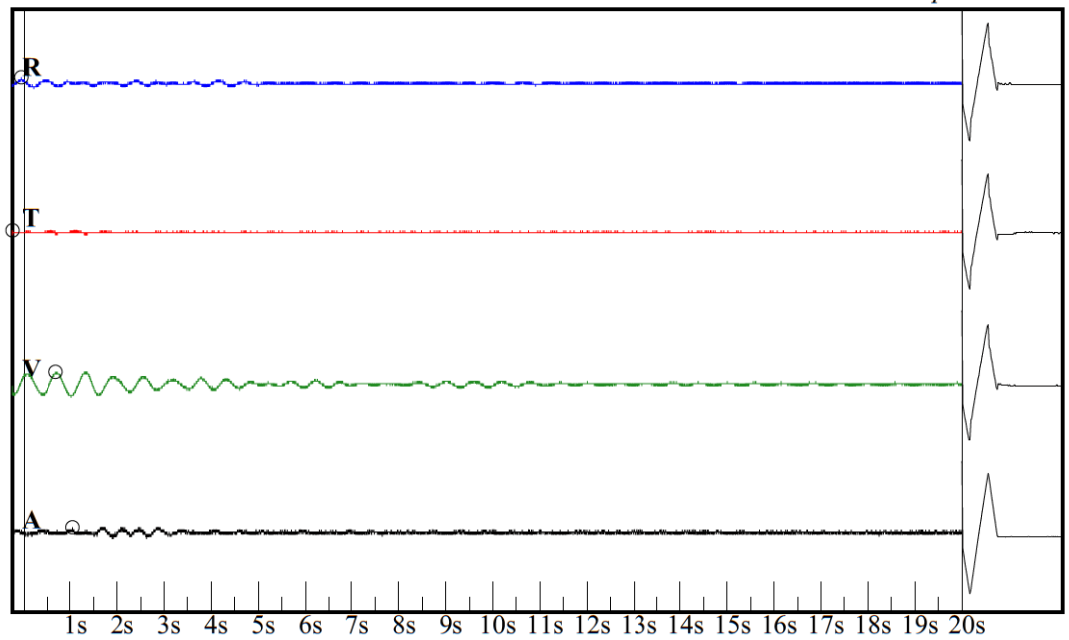
Air

Gain: 1 Trigger: 120 dBL

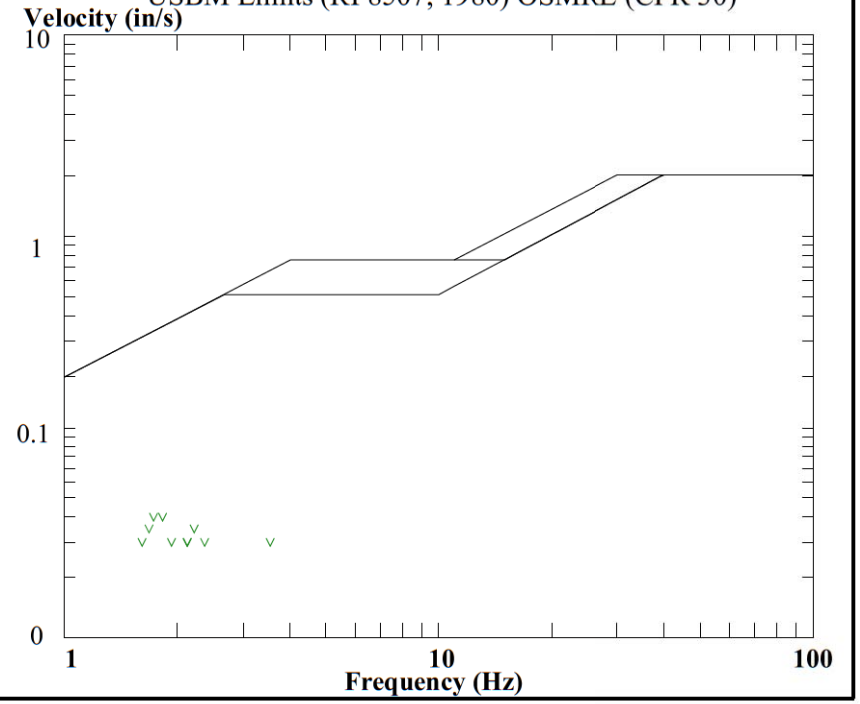
Measurement	Value	Trigger >>> Peak	
psi	.00015	1050	
dBL	**94**		
Hz	0.8		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

18-May-18 at 13:46:47 PM Event # 166

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.030**
Frequency (Hz)	**0.00**	**0.00**	**1.70**
Displacement (in)			**0.0028**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0008**
Trigger >>> Peak	0	0	681.9

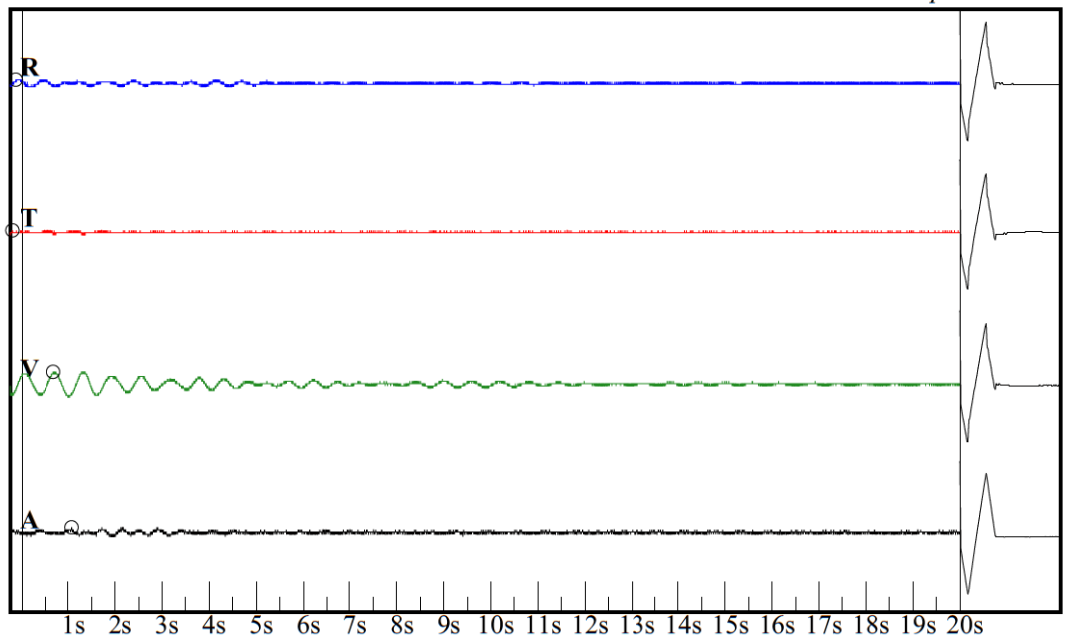
Air

Gain: 1 Trigger: 120 dBL

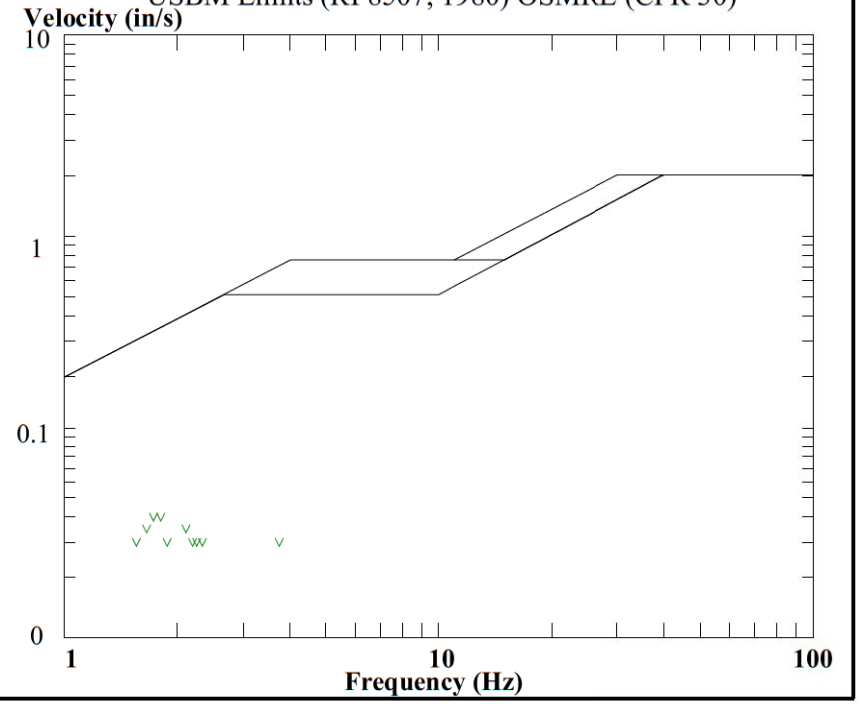
Measurement	Value	Trigger >>> Peak	
psi	.00015	1073.5	
dBL	**94**		
Hz	1.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

21-May-18 at 13:31:08 PM Event # 170

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.015**	**0.020**	**0.035**
Frequency (Hz)	**0.00**	**22.00**	**1.70**
Displacement (in)		**0.0001**	**0.0033**
Acceleration (g's)	**0.0000**	**0.0072**	**0.0010**
Trigger >>> Peak	0	0	10299.6

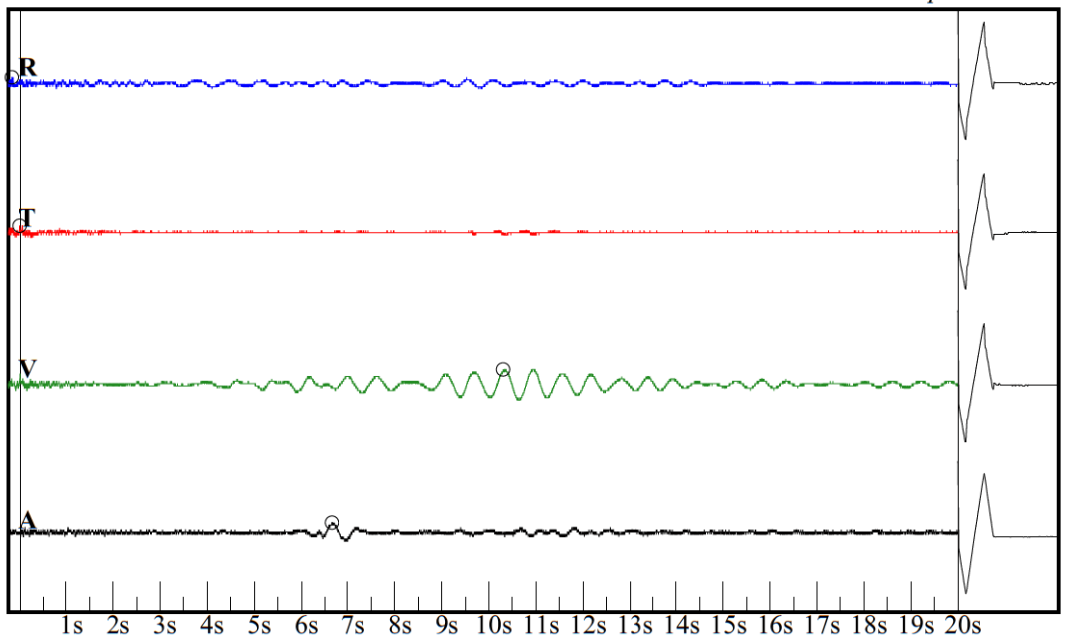
Air

Gain: 1 Trigger: 120 dBL

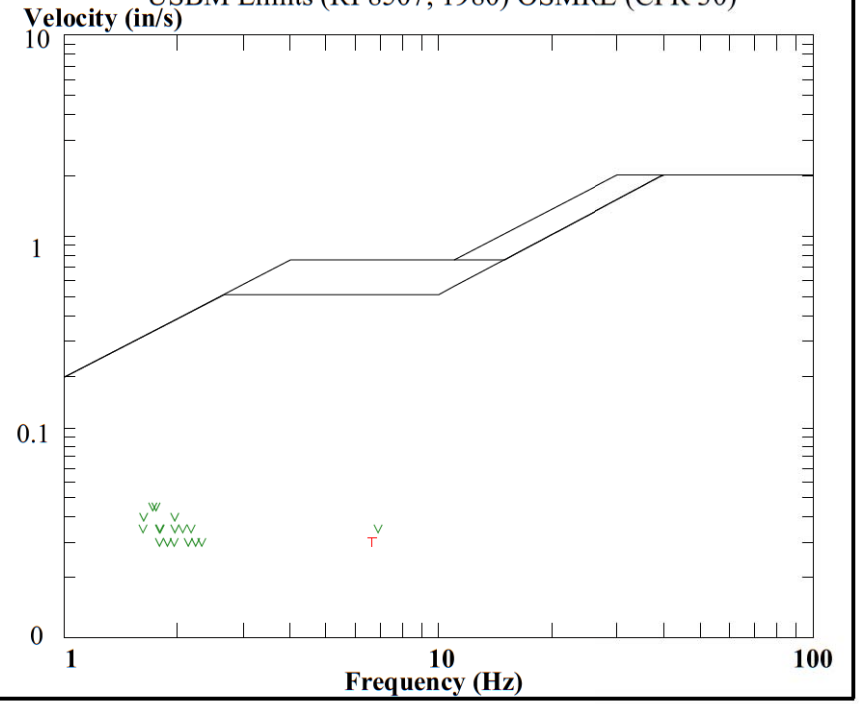
Measurement	Value	Trigger >>> Peak	
psi	.00022	6644.8	
dBL	**98**		
Hz	1.5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

22-May-18 at 13:15:24 PM Event # 172

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.055**	**0.025**	**0.045**
Frequency (Hz)	**9.70**	**13.50**	**10.20**
Displacement (in)	**0.0009**	**0.0003**	**0.0007**
Acceleration (g's)	**0.0087**	**0.0055**	**0.0075**
Trigger >>> Peak	1434.1	1233.6	304.2

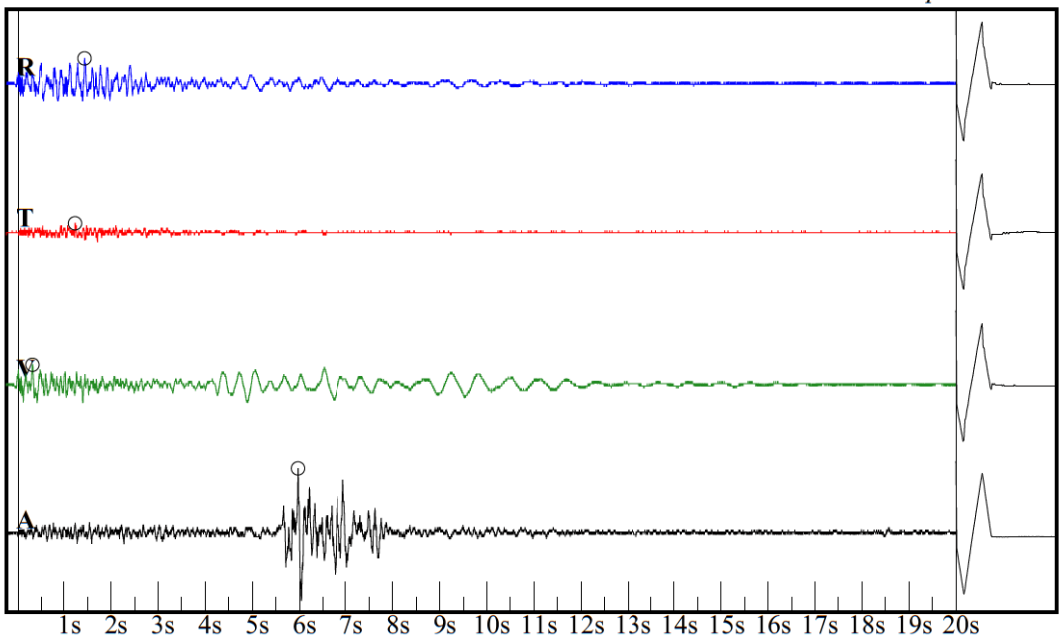
Air

Gain: 1 Trigger: 120 dBL

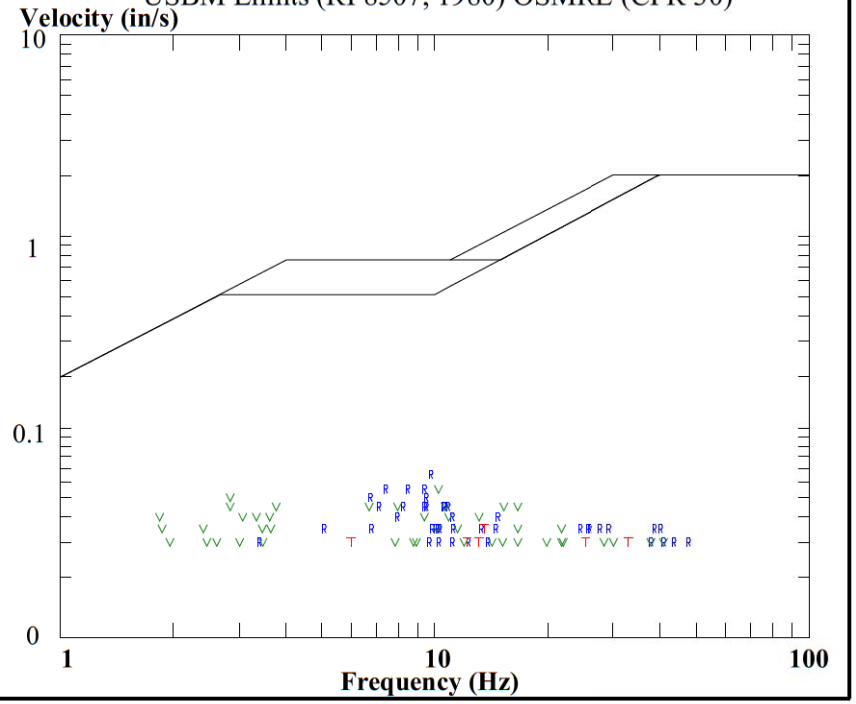
Measurement	Value	Trigger >>> Peak	
psi	.00105	5967	
dBL	**111**		
Hz	5.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

23-May-18 at 13:17:43 PM Event # 174

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.010**	**0.025**
Frequency (Hz)	**0.00**	**0.00**	**2.10**
Displacement (in)			**0.0019**
Acceleration (g's)	**0.0000**	**0.0000**	**0.0009**
Trigger >>> Peak	0	0	0

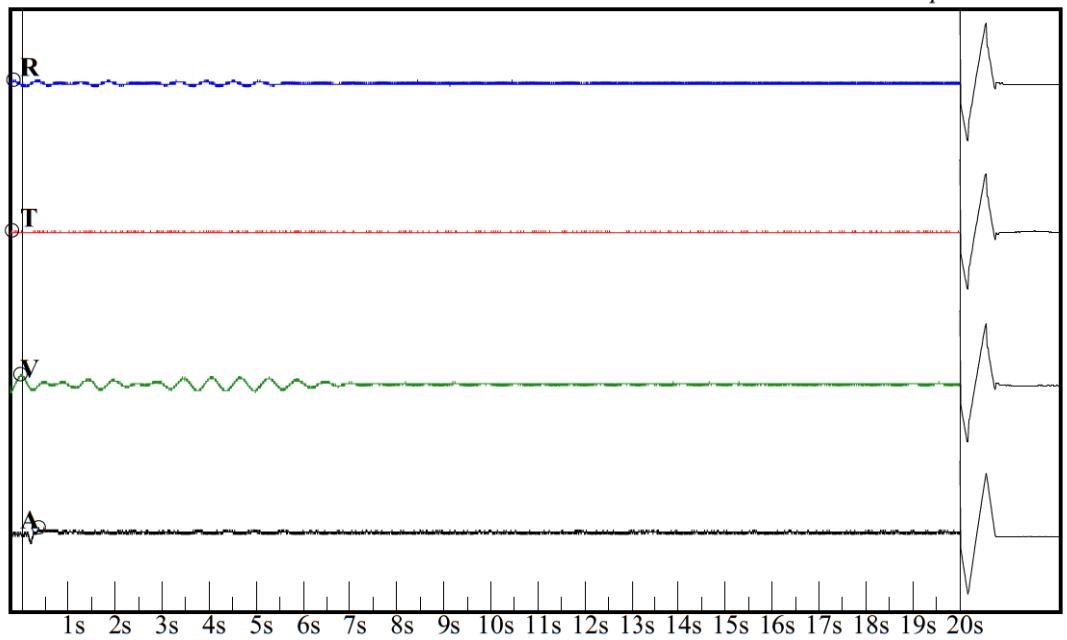
Air

Gain: 1 Trigger: 120 dBL

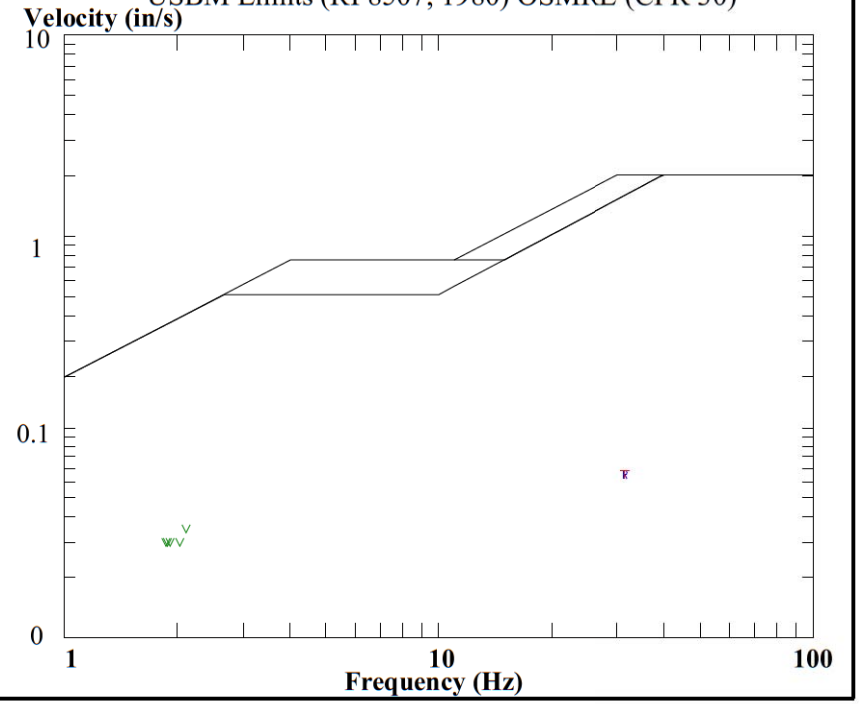
Measurement	Value	Trigger >>> Peak	
psi	.00015	352.5	
dBL	**94**		
Hz	0		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 13007

24-May-18 at 14:31:14 PM Event # 177

Location: White Rock Quarries North Seismograph

Operator: RESPEC

Notes: 25.96698871 -80.36575500

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 13Dec17

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 1 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.035**	**0.020**	**0.060**
Frequency (Hz)	**16.30**	**15.70**	**2.60**
Displacement (in)	**0.0003**	**0.0002**	**0.0037**
Acceleration (g's)	**0.0093**	**0.0051**	**0.0025**
Trigger >>> Peak	2089.1	1424.8	6515.1

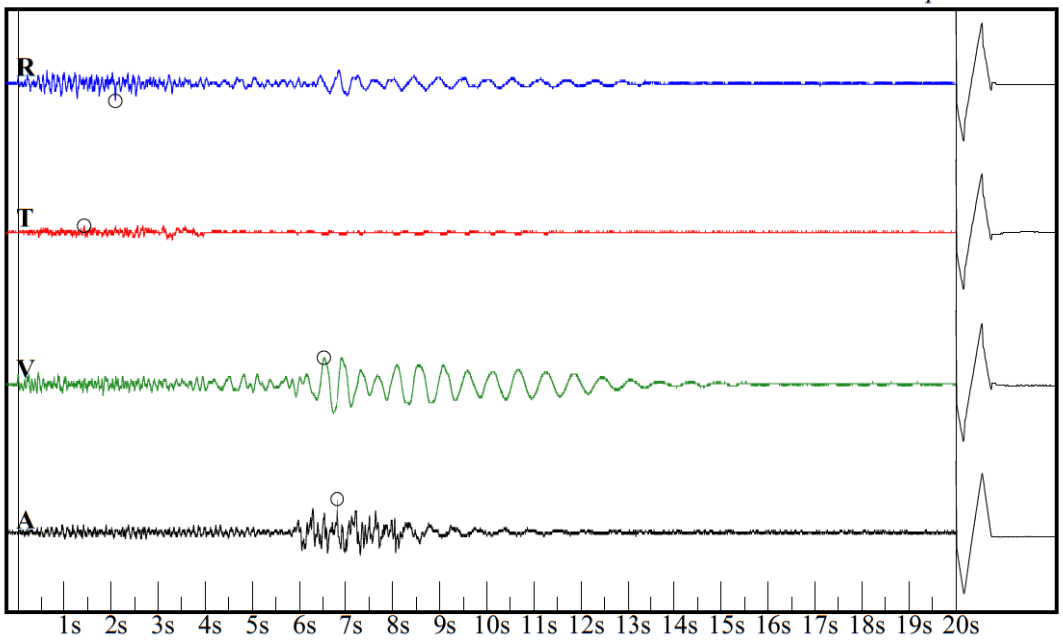
Air

Gain: 1 Trigger: 120 dBL

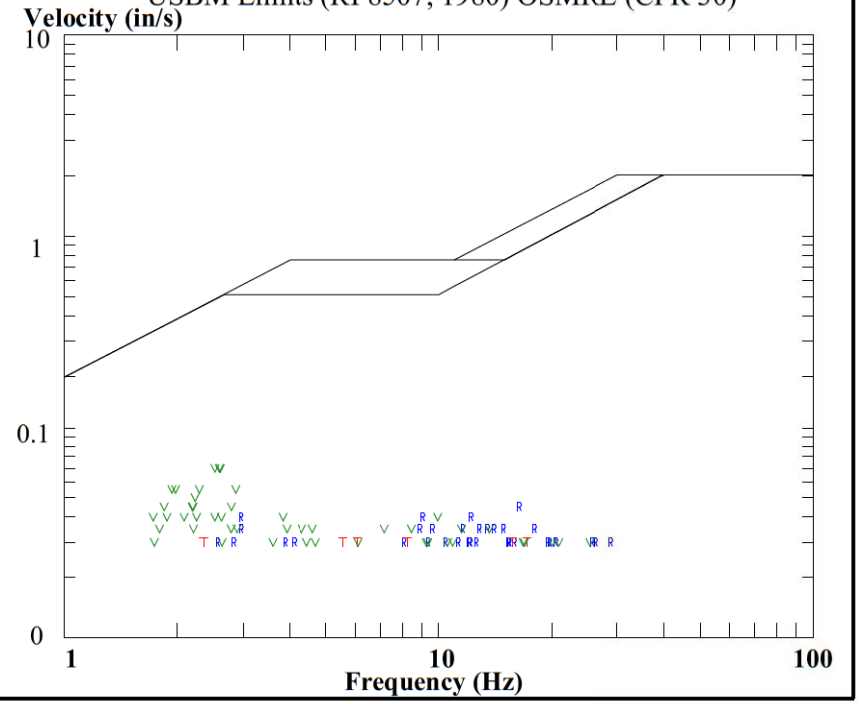
Measurement	Value	Trigger >>> Peak	
psi	.00058	6808.8	
dBL	**106**		
Hz	5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

09-May-18 at 11:40:20 AM Event # 46

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.031**	**0.026**	**0.076**
Frequency (Hz)	**7.50**	**1.40**	**1.60**
Displacement (in)	**0.0007**	**0.0030**	**0.0076**
Acceleration (g's)	**0.0037**	**0.0006**	**0.0020**
Trigger >>> Peak	94.7	2574.5	9584.5

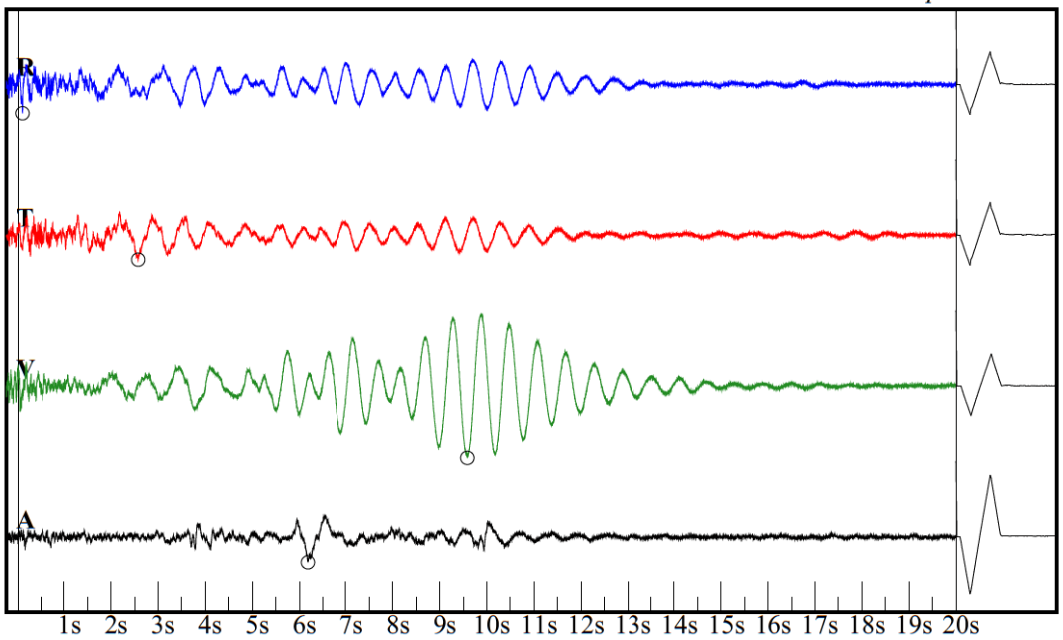
Air

Gain: 1 Trigger: 120 dBL

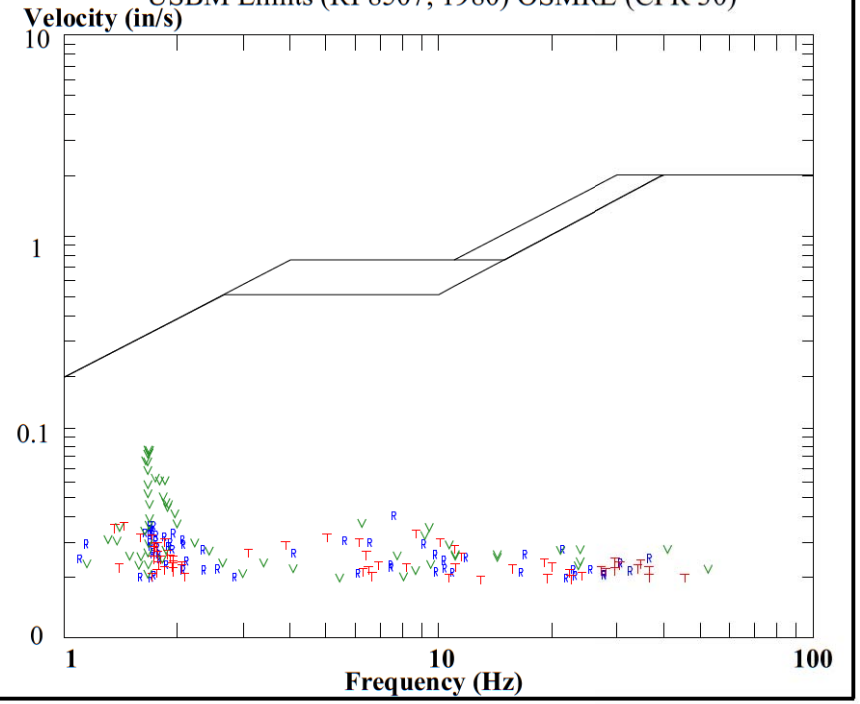
Measurement	Value	Trigger >>> Peak	
psi	.00039	6179.7	
dBL	**103**		
Hz	1.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

10-May-18 at 15:00:07 PM Event # 48

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.075**	**0.060**	**0.111**
Frequency (Hz)	**19.30**	**7.40**	**2.50**
Displacement (in)	**0.0006**	**0.0013**	**0.0071**
Acceleration (g's)	**0.0235**	**0.0072**	**0.0045**
Trigger >>> Peak	1205.1	1637.9	3276.6

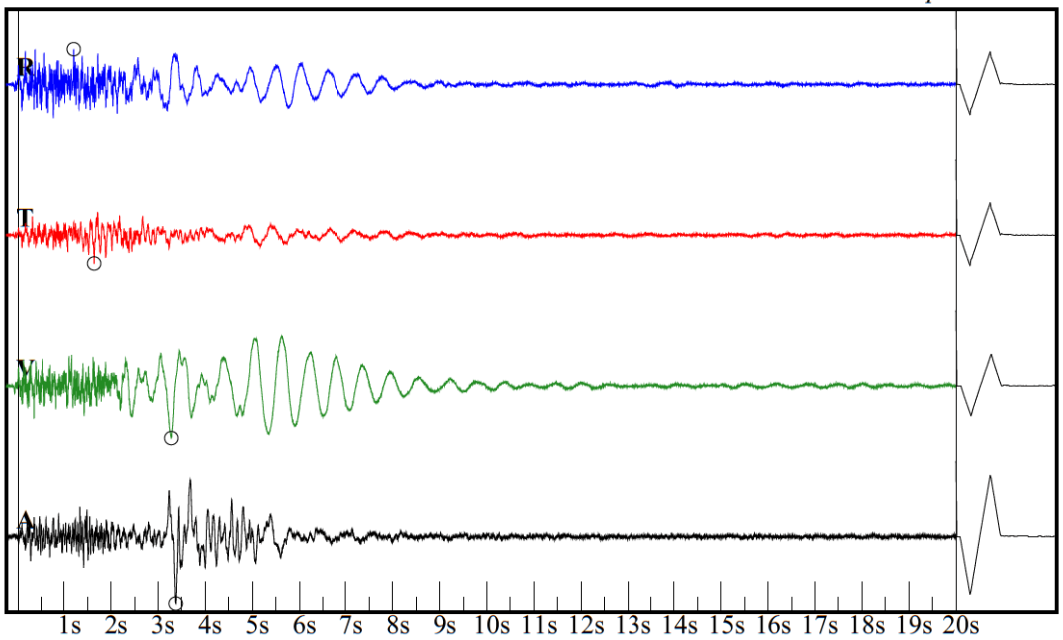
Air

Gain: 1 Trigger: 120 dBL

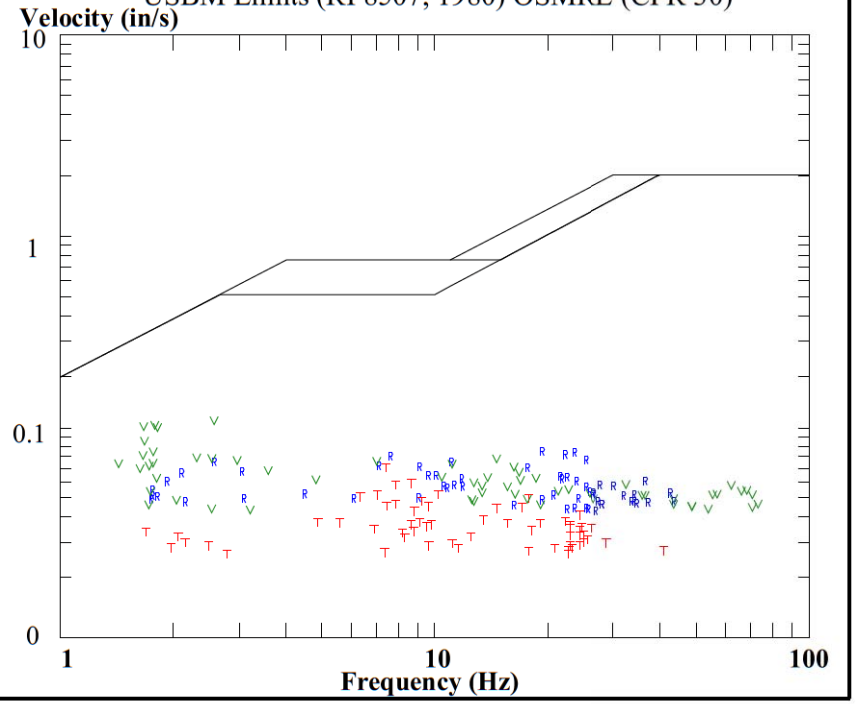
Measurement	Value	Trigger >>> Peak	
psi	.00103	3370.9	
dBL	**111**		
Hz	5		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

11-May-18 at 10:30:21 AM Event # 51

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.027**	**0.047**
Frequency (Hz)	**2.00**	**11.10**	**1.60**
Displacement (in)	**0.0008**	**0.0004**	**0.0047**
Acceleration (g's)	**0.0003**	**0.0048**	**0.0012**
Trigger >>> Peak	7988	3.4	8976.3

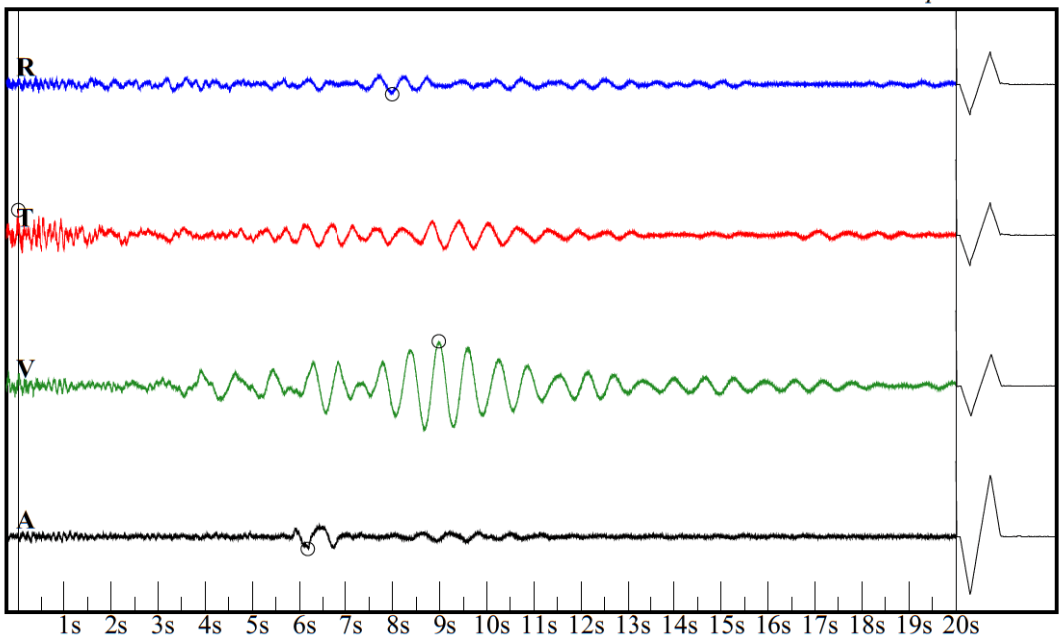
Air

Gain: 1 Trigger: 120 dBL

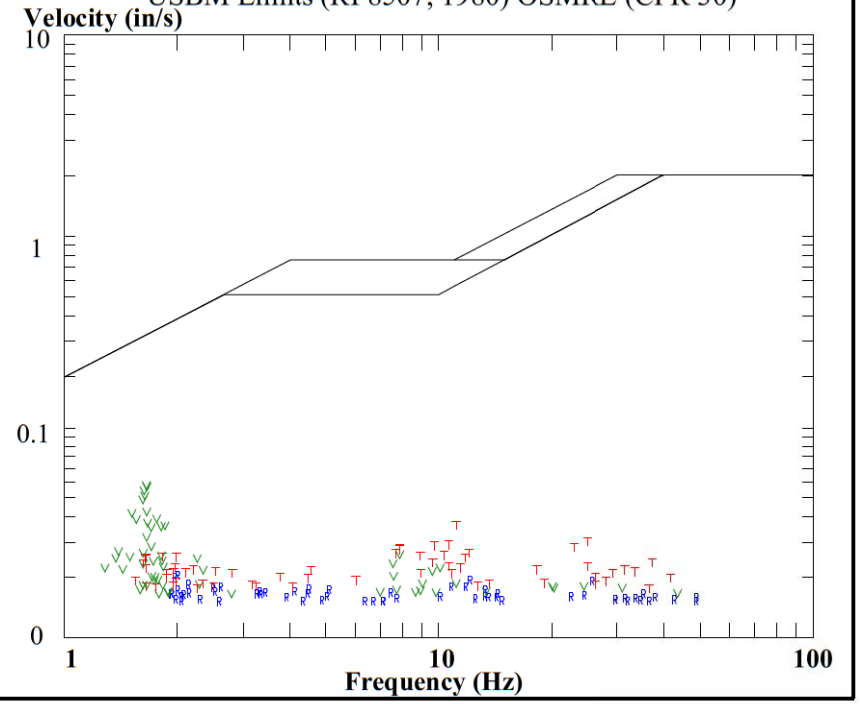
Measurement	Value	Trigger >>> Peak	
psi	.00019	6174.3	
dBL	**96**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

15-May-18 at 14:00:31 PM Event # 71

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.062**	**0.047**	**0.104**
Frequency (Hz)	**2.40**	**10.20**	**1.90**
Displacement (in)	**0.0041**	**0.0007**	**0.0087**
Acceleration (g's)	**0.0024**	**0.0077**	**0.0032**
Trigger >>> Peak	4876.5	1275.9	5199.2

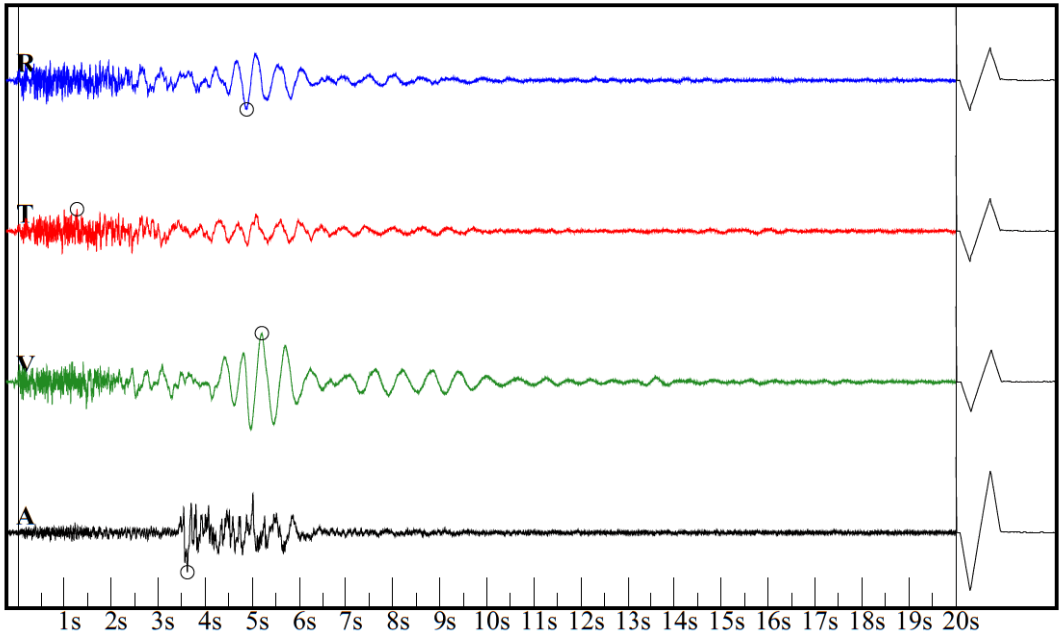
Air

Gain: 1 Trigger: 120 dBL

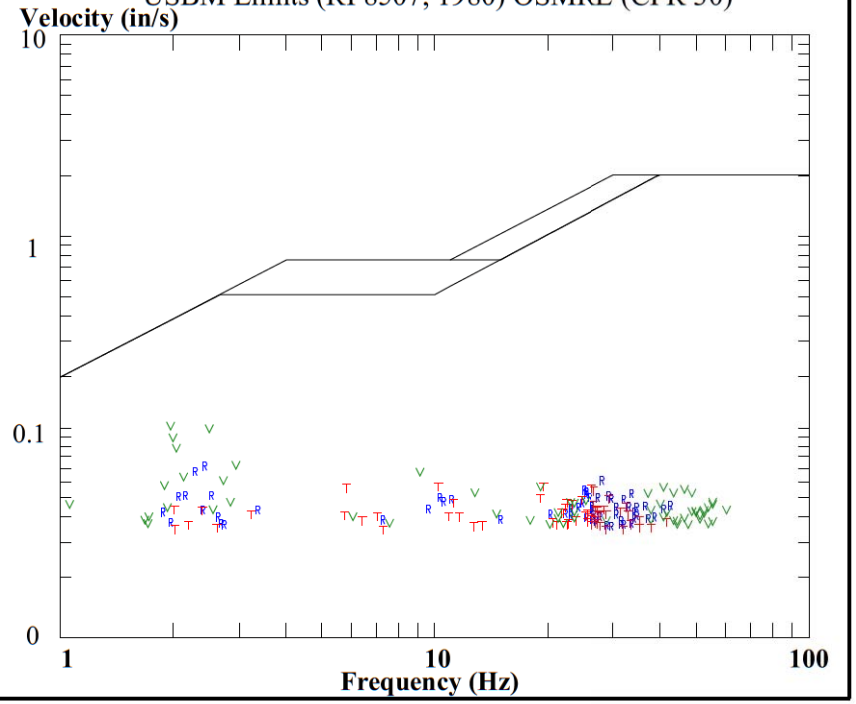
Measurement	Value	Trigger >>> Peak	
psi	.00122	3617.2	
dBL	**112**		
Hz	4.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .0023 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

16-May-18 at 10:45:38 AM Event # 76

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.028**	**0.052**
Frequency (Hz)	**2.00**	**27.30**	**1.60**
Displacement (in)	**0.0008**	**0.0002**	**0.0052**
Acceleration (g's)	**0.0003**	**0.0125**	**0.0014**
Trigger >>> Peak	8141.4	27.3	9146

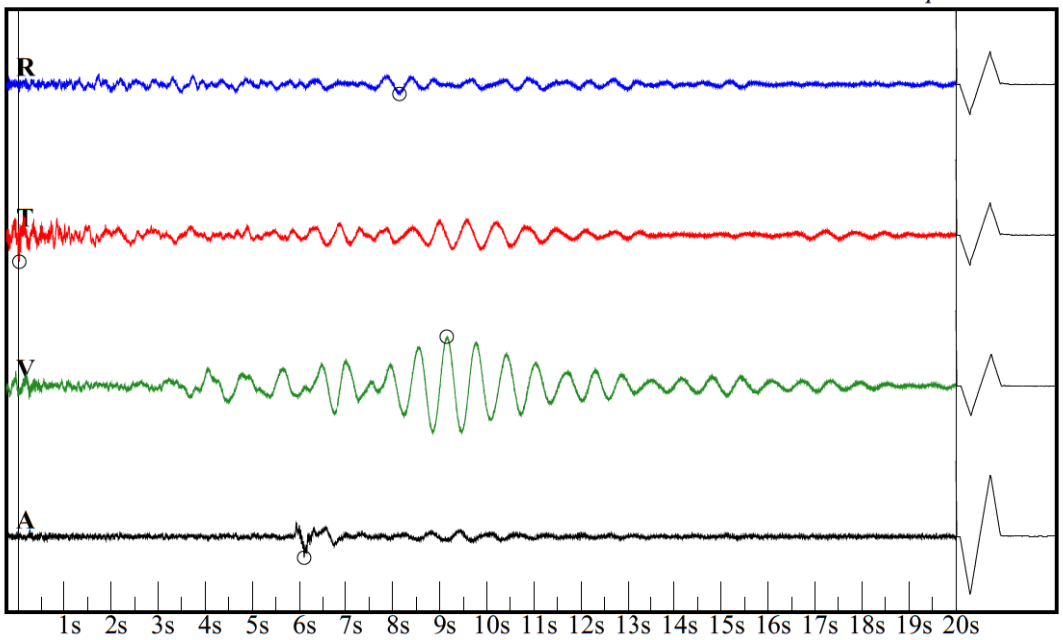
Air

Gain: 1 Trigger: 120 dBL

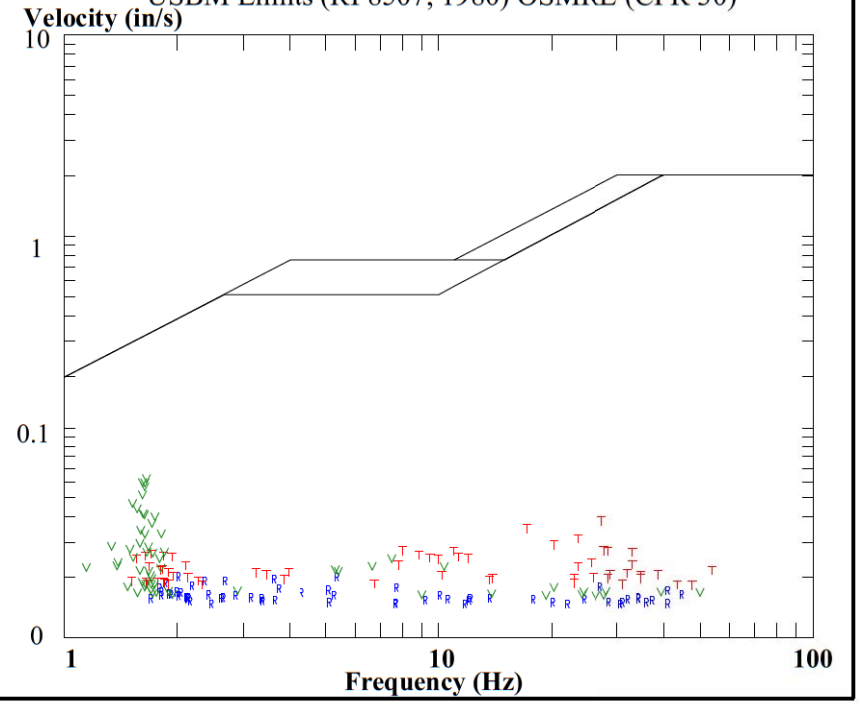
Measurement	Value	Trigger >>> Peak	
psi	.00032	6098.1	
dBL	**101**		
Hz	4.3		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

18-May-18 at 13:45:51 PM Event # 81

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.010**	**0.029**	**0.054**
Frequency (Hz)	**4.40**	**22.50**	**1.60**
Displacement (in)	**0.0004**	**0.0002**	**0.0054**
Acceleration (g's)	**0.0007**	**0.0106**	**0.0014**
Trigger >>> Peak	1786.1	76.2	9234.6

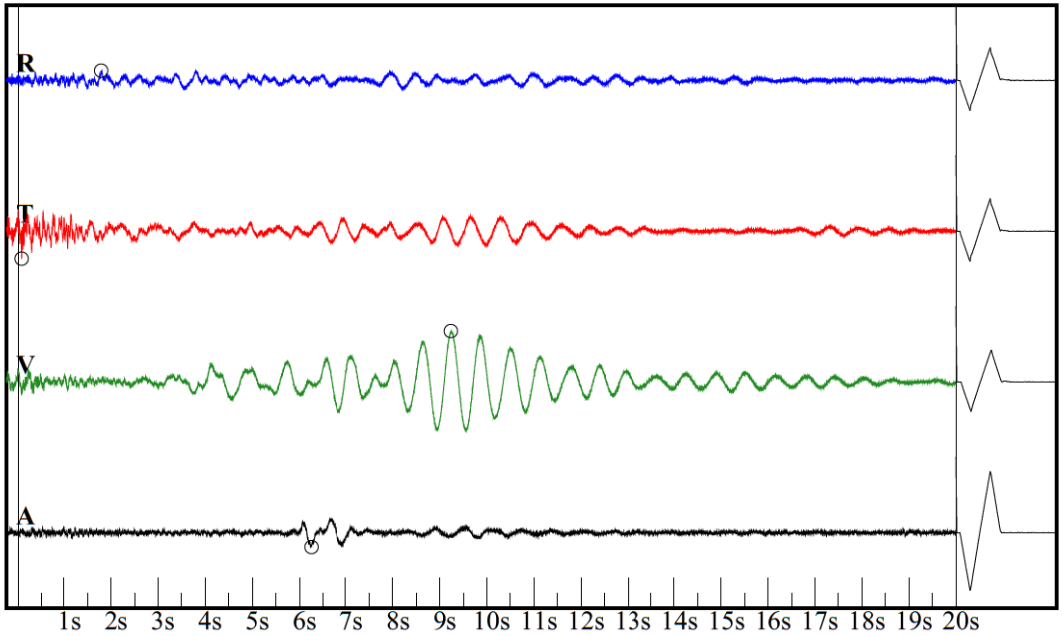
Air

Gain: 1 Trigger: 120 dBL

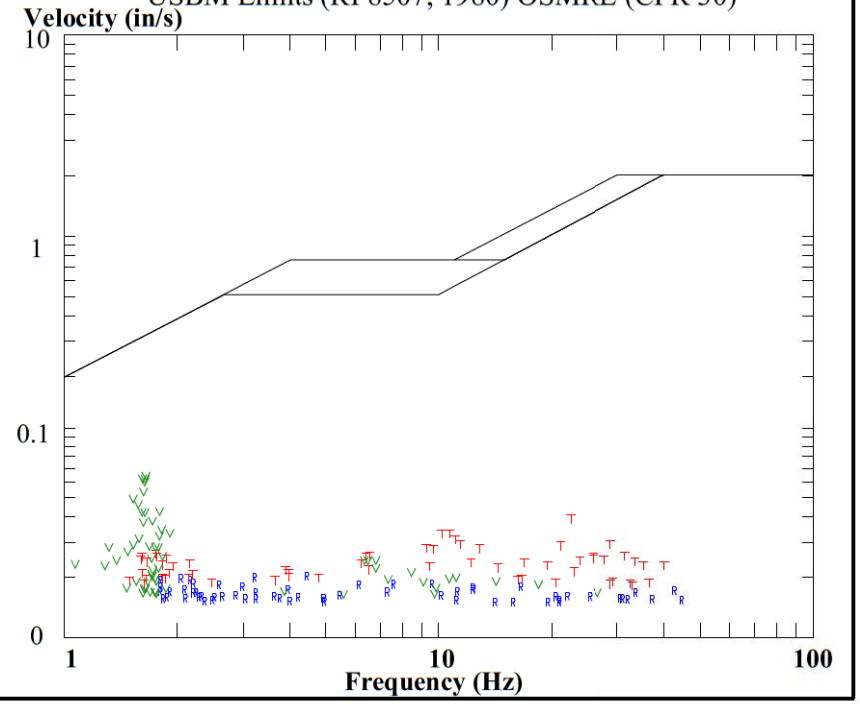
Measurement	Value	Trigger >>> Peak	
psi	.00022	6253.7	
dBL	**98**		
Hz	2.7		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

21-May-18 at 11:05:38 AM Event # 85

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.028**	**0.014**	**0.013**
Frequency (Hz)	**2.30**	**1.40**	**1.10**
Displacement (in)	**0.0019**	**0.0016**	**0.0019**
Acceleration (g's)	**0.0010**	**0.0003**	**0.0002**
Trigger >>> Peak	49.8	0	3743.4

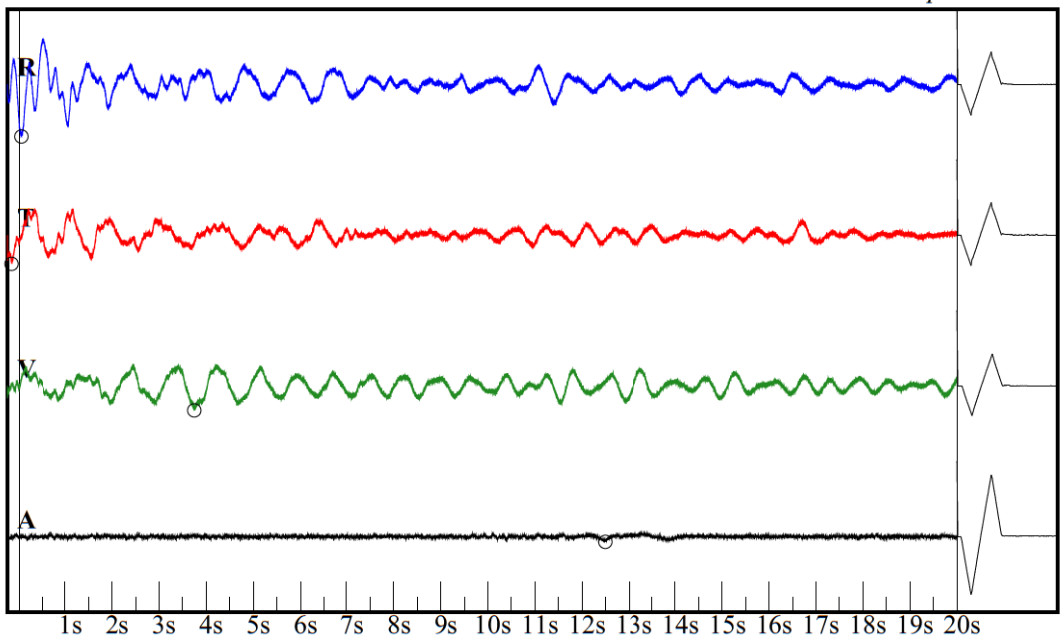
Air

Gain: 1 Trigger: 120 dBL

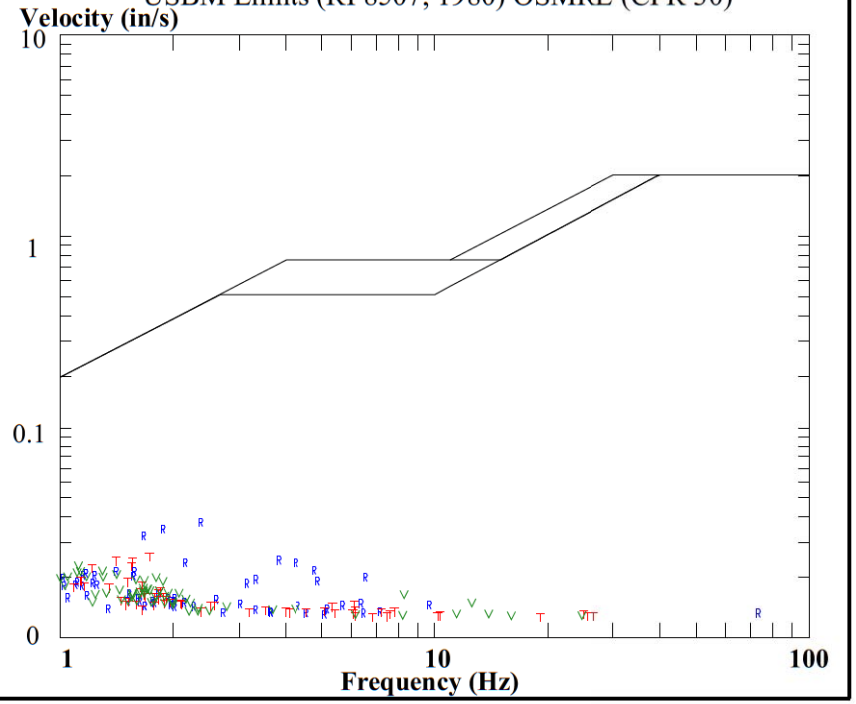
Measurement	Value	Trigger >>> Peak	
psi	.00008	12490.5	
dBL	**89**		
Hz	2.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.04 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

21-May-18 at 13:30:19 PM Event # 86

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.009**	**0.021**	**0.064**
Frequency (Hz)	**3.60**	**17.60**	**1.60**
Displacement (in)	**0.0004**	**0.0002**	**0.0064**
Acceleration (g's)	**0.0005**	**0.0059**	**0.0017**
Trigger >>> Peak	1509.8	72	9268.1

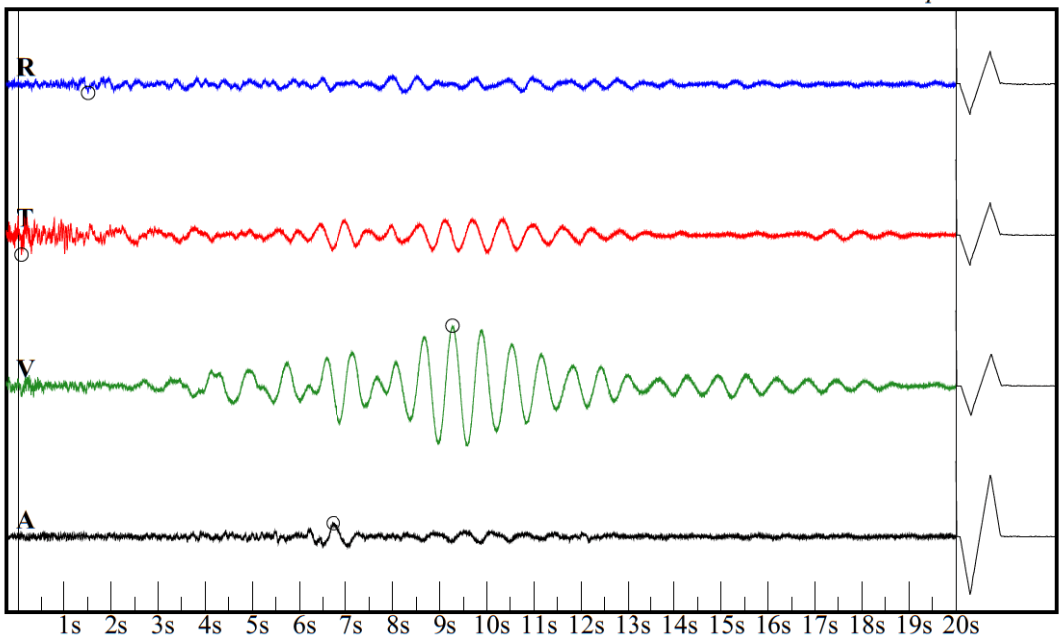
Air

Gain: 1 Trigger: 120 dBL

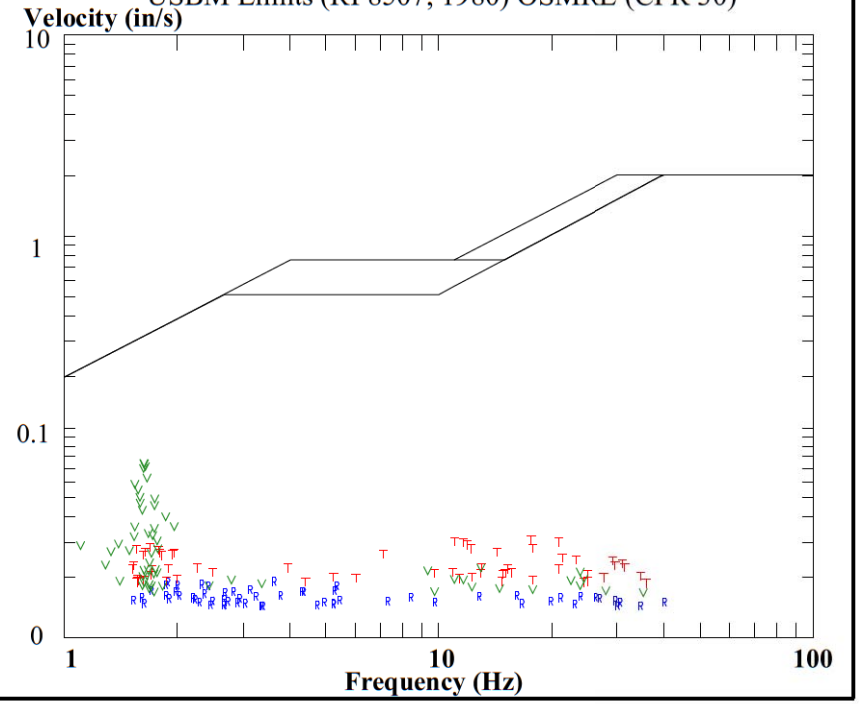
Measurement	Value	Trigger >>> Peak	
psi	.00021	6724.6	
dBL	**97**		
Hz	1.9		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

22-May-18 at 13:14:34 PM Event # 88

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.119**	**0.060**	**0.114**
Frequency (Hz)	**16.00**	**19.80**	**3.90**
Displacement (in)	**0.0012**	**0.0005**	**0.0046**
Acceleration (g's)	**0.0310**	**0.0192**	**0.0072**
Trigger >>> Peak	1272.5	1706.8	3221.2

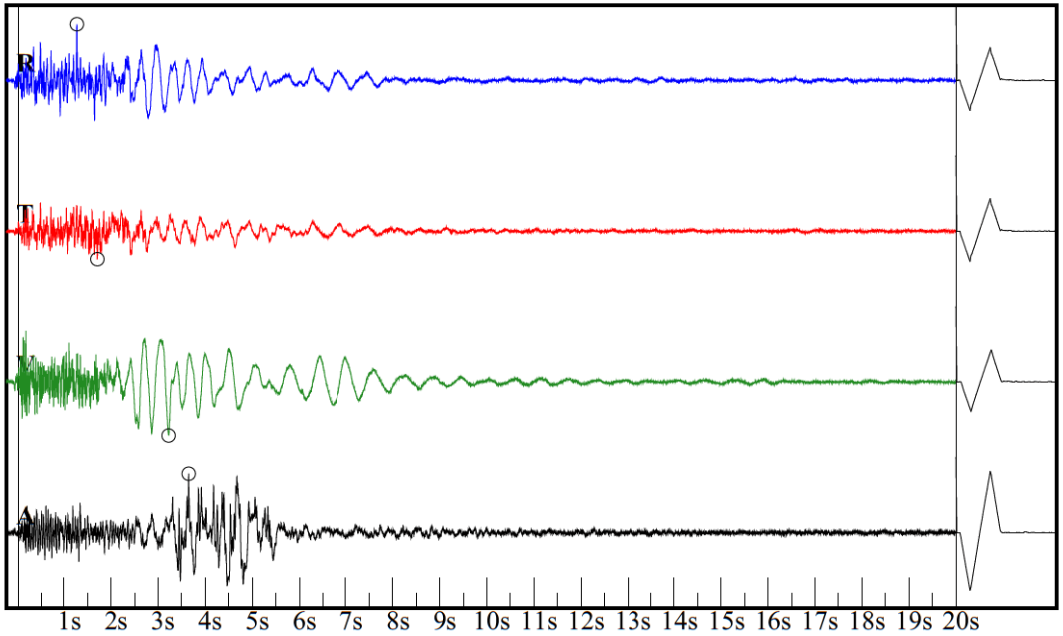
Air

Gain: 1 Trigger: 120 dBL

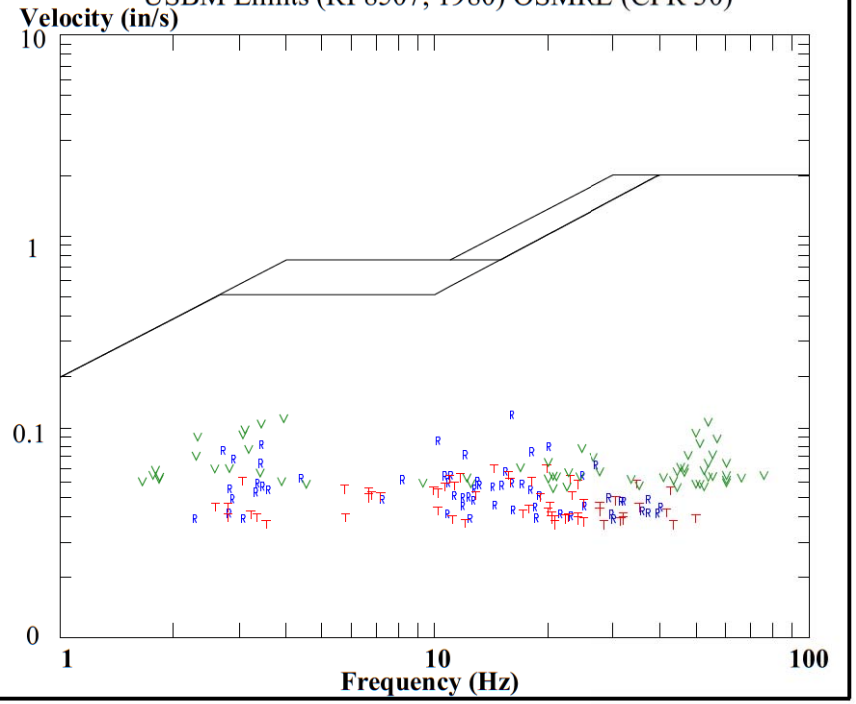
Measurement	Value	Trigger >>> Peak	
psi	.00091	3647	
dBL	**110**		
Hz	4.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

23-May-18 at 13:16:42 PM Event # 90

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.023**	**0.021**	**0.063**
Frequency (Hz)	**44.50**	**1.60**	**1.70**
Displacement (in)	**0.0001**	**0.0021**	**0.0059**
Acceleration (g's)	**0.0168**	**0.0006**	**0.0017**
Trigger >>> Peak	0.7	3172.4	9232.4

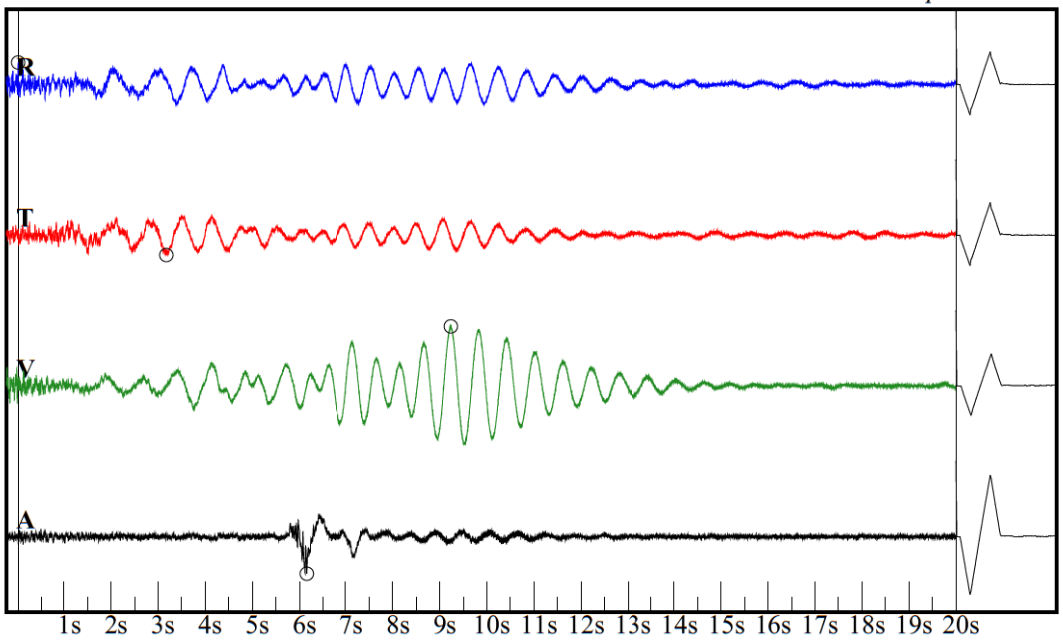
Air

Gain: 1 Trigger: 120 dBL

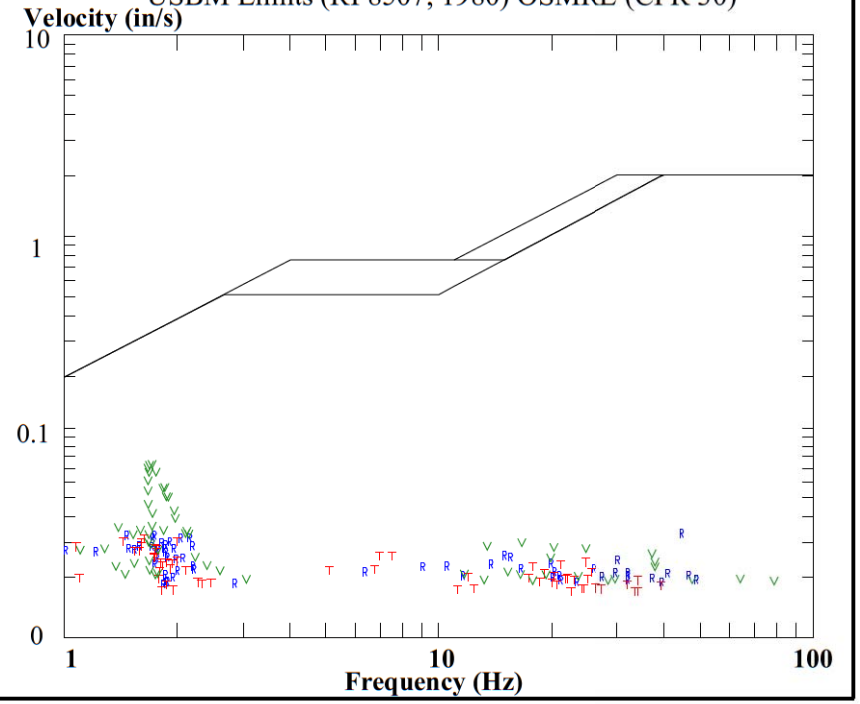
Measurement	Value	Trigger >>> Peak	
psi	.00057	6154.8	
dBL	**106**		
Hz	2.4		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.08 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

24-May-18 at 14:30:21 PM Event # 92

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.075**	**0.051**	**0.144**
Frequency (Hz)	**2.40**	**11.10**	**3.10**
Displacement (in)	**0.0050**	**0.0007**	**0.0074**
Acceleration (g's)	**0.0029**	**0.0091**	**0.0073**
Trigger >>> Peak	4431.4	1392.8	4525.1

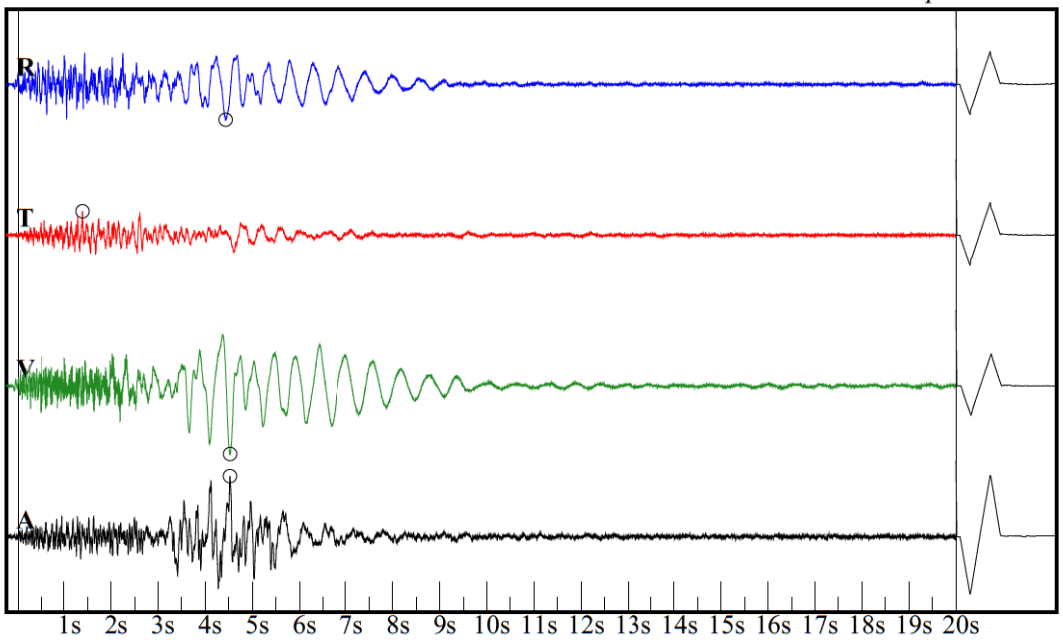
Air

Gain: 1 Trigger: 120 dBL

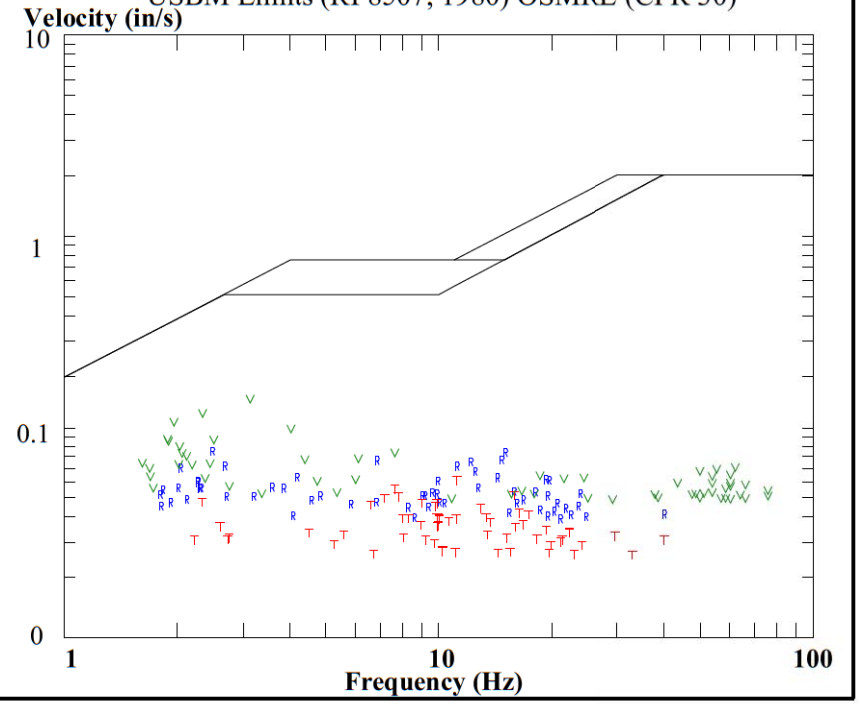
Measurement	Value	Trigger >>> Peak	
psi	.00093	4523.4	
dBL	**110**		
Hz	3.6		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



Sauls Seismic, LLC - Report

Company: RESPEC

Unit #: 20268

31-May-18 at 13:14:08 PM Event # 144

Location: White Rock Quarries North Seismograph 2

Operator: RESPEC

Notes: 25.95772513, -80.36147151

Record Duration: 20.0 sec
Sample Rate: 4096/sec
Last Calibration: 23Feb18

Distance: N *Wgt. Per Delay: N* *Scaled Distance: 0.0*

Seismic

Gain: 2 Trigger: .02 in/s

Channel	Radial	Transverse	Vertical
Velocity (in/s)	**0.079**	**0.047**	**0.156**
Frequency (Hz)	**2.30**	**11.50**	**2.90**
Displacement (in)	**0.0055**	**0.0006**	**0.0085**
Acceleration (g's)	**0.0030**	**0.0087**	**0.0073**
Trigger >>> Peak	3248.3	1764.4	3305.4

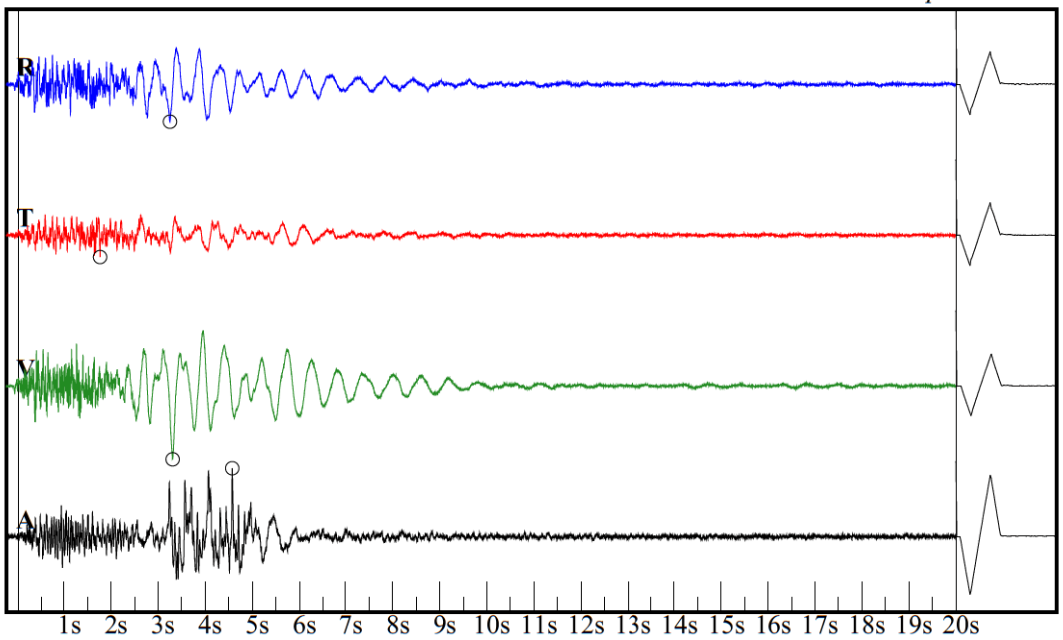
Air

Gain: 1 Trigger: 120 dBL

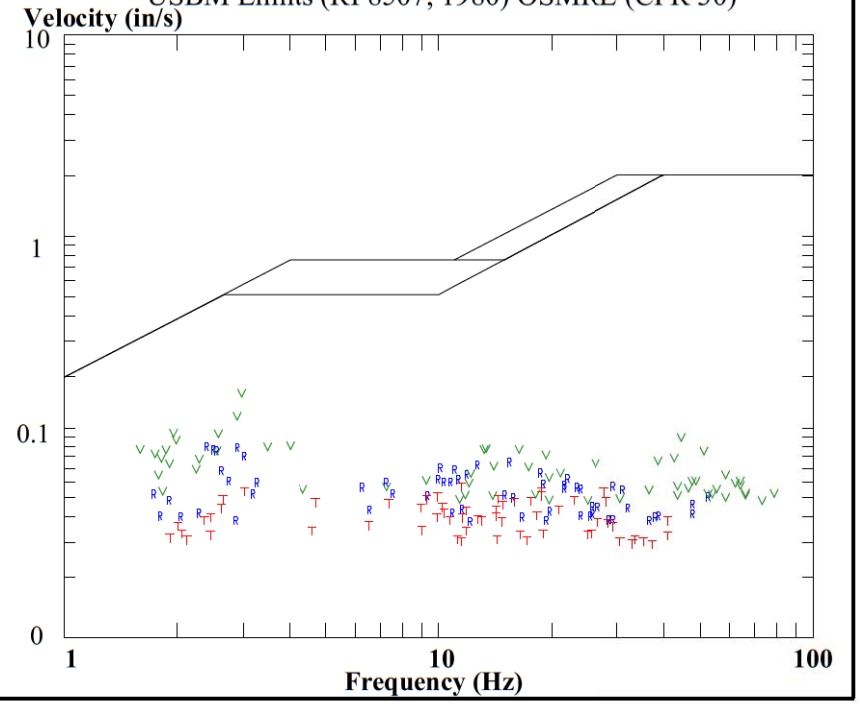
Measurement	Value	Trigger >>> Peak	
psi	.00105	4570.3	
dBL	**111**		
Hz	11.1		

Amplitudes / Frequencies / Frequency Plot

Seismic Scale: 0.16 in/s/div. *Air Scale: .00116 psi/div.*



USBM Limits (RI 8507, 1980) OSMRE (CFR 30)



APPENDIX G

SEISMOGRAPH PLACEMENT ANALYSIS

APPENDIX G: SEISMOGRAPH PLACEMENT ANALYSIS

The data provided by the Florida State Fire Marshal (FSFM) were used to create a blast-to-structure-proximity analysis. The blast-to-structure-proximity-analysis was used to determine whether seismographs are always placed at the nearest residential structure to each blast. Four of the six representative construction materials mines provided enough data to the FSFM for this exercise. The sites include Marianna Mine, Branford Quarry, West Lakes Mine, and Brooksville Quarry. RESPEC found that three of the four sites appeared to be partially out of compliance. Specifically, the potential noncompliant sites occurred where seismographs were placed at residential structures that were not the closet residential structure to a blast location.

White Rock Quarries and Krome Quarry did not report data sufficiently for RESPEC to conduct this analysis. The quarries should be required to report this information so that the FSFM can confirm that the operations are monitoring at the nearest residential structure.

G.1 PROCEDURES

The blast-to-structure-proximity analysis was completed by using QGIS software and spatial analytic techniques. This section provides the steps used to complete the blast-to-structure-proximity-analysis.

G.1.1 PLOT BLAST AND SEISMOGRAPH LOCATIONS

The coordinates from the blasts and seismographs in the study were taken from blasting activities reports, blast reports, and seismograph reports provided by the FSFM. These coordinates were assumed to be accurate; however, RESPEC cannot confirm the methods that were used to collect coordinates by each mine site.

The blast location coordinates and seismograph location coordinates were plotted in QGIS and spatially overlaid onto publicly available aerial photographs. Figure G-1 provides an example of blast and seismograph locations plotted in GIS.

G.1.2 HUB-AND-SPOKE ANALYSIS

Once the blasts and seismographs were spatially located, each seismograph record event was linked to the individual blast event that caused that seismograph recording. A hub-and-spoke analysis was used to create a connecting line between each blast event and the seismograph locations where each blast event caused the seismograph to record, which is shown in Figure G-2. The hub and spoke spatial analytics method is described by QGIS as [QGIS Testing, 2014]:

> *Creates hub and spoke diagrams with lines drawn from points on the Spoke Point layer to matching points in the Hub Point layer. Determination of which hub goes with each point is based on a match between the Hub ID field on the hub points and the Spoke ID field on the spoke points.*

Each hub and spoke line was measured to provide the distance from the blast to the seismograph, which is shown in Figure G-3. Figure G-3 also shows the lines that were drawn via the hub and spoke analysis.

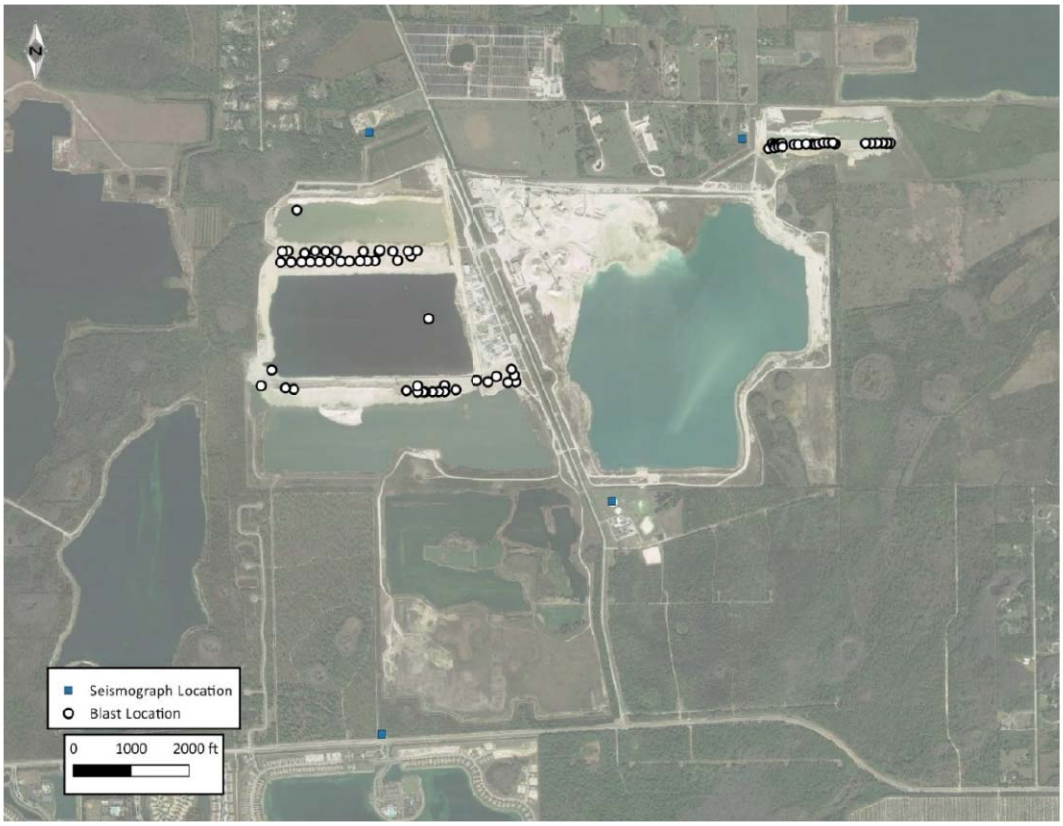


Figure G-1. Example of Blast and Seismograph Locations at the West Lakes Mine (and University Lakes Mine).

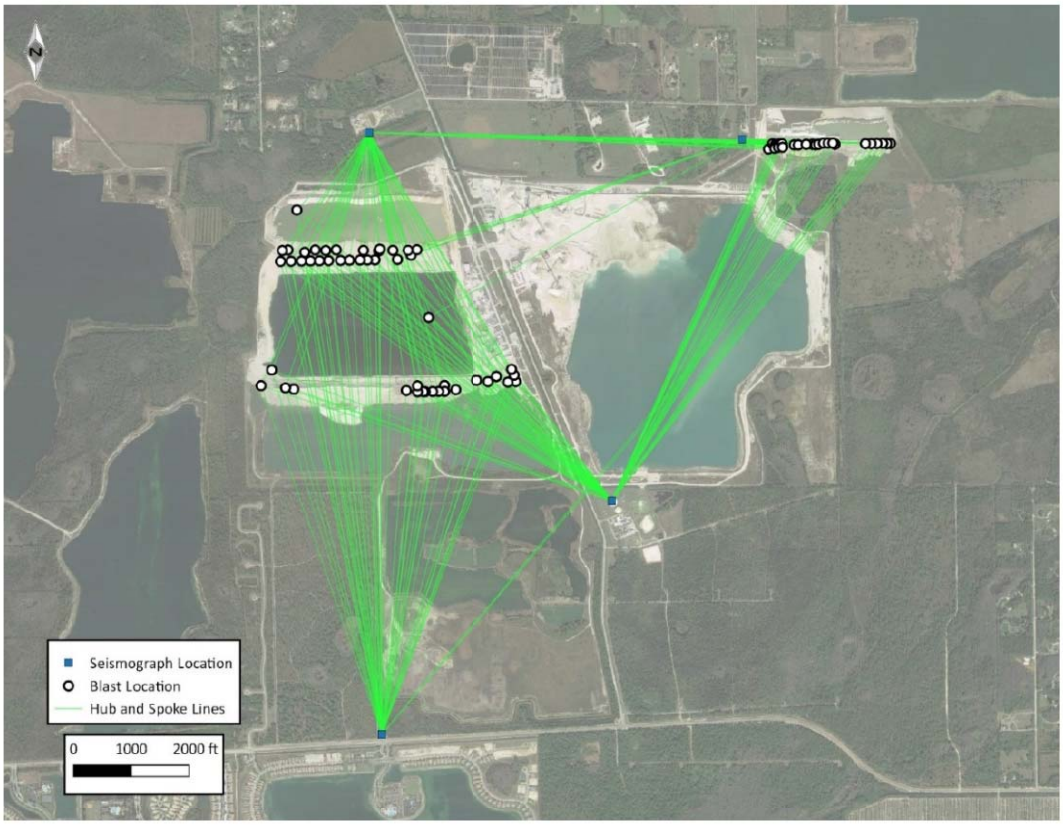


Figure G-2. Hub-and-Spoke Results at the West Lakes Mine (and University Lakes Mine).

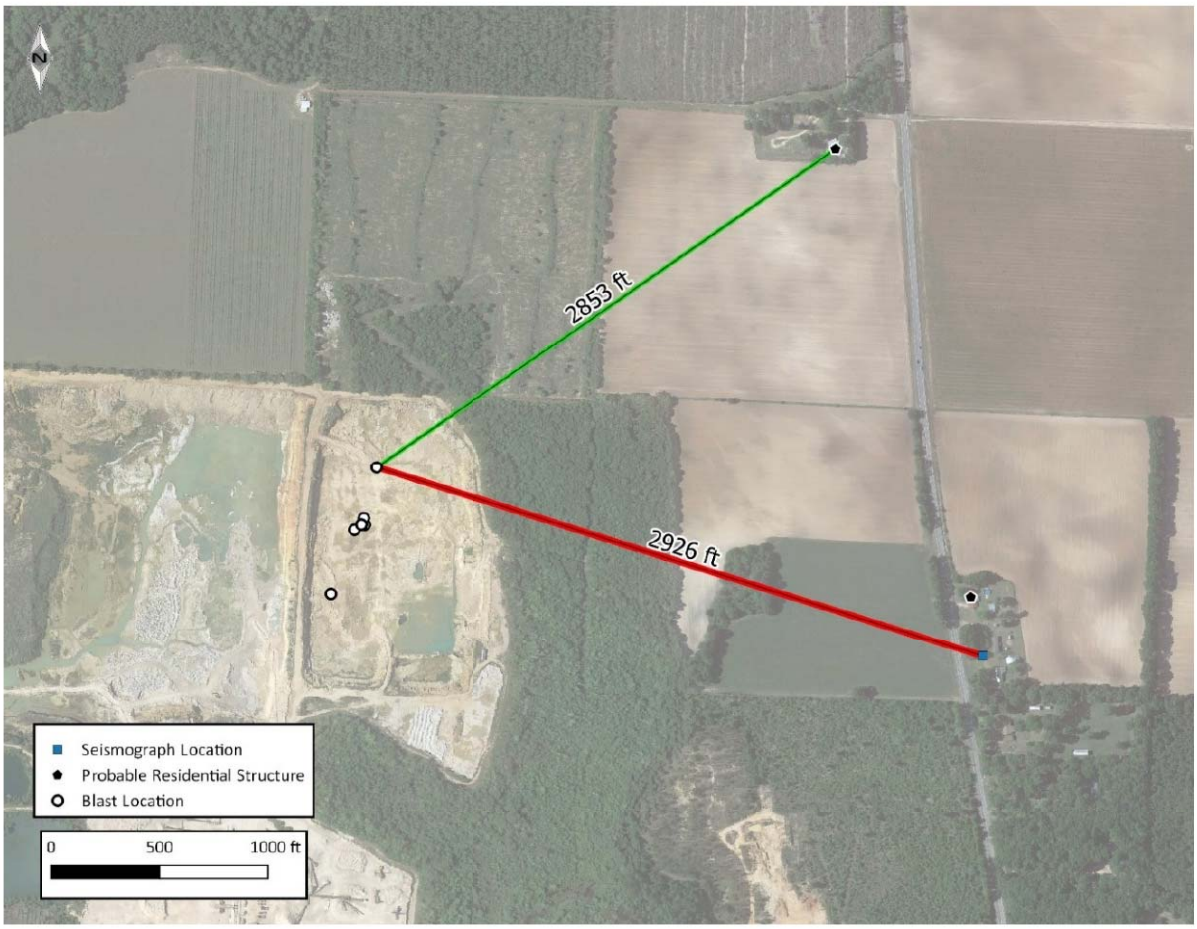


Figure G-3. Example of Distances to Nearest Seismograph and Nearest Residential Structure for One Blast at the Marianna Mine.

G.1.3 PLOT RESIDENTIAL STRUCTURE LOCATIONS

Potential residential structures were identified by using the publicly available aerial images in the QGIS software. Note that RESPEC refers to the structures as potential because they were not confirmed in person. RESPEC may have missed a residential structure or incorrectly identified a commercial building as a residential structure; however, RESPEC has high confidence that the structures were identified correctly for this analysis.

G.1.4 DISTANCE CALCULATIONS

QGIS was used to measure the distances from the nearest residential structures to each blast location. Distances retrieved from the structure-to-blast measurements were compared to the seismograph-to-blast measurements, as illustrated in Figure G-3. RESPEC compared the two sets of distances and identified the blasts that had seismographs placed at the nearest residential structure and those that had shorter distances to residential structures than the distances to the seismographs. Figure G-3 shows an example of this analysis; the blasts that were closer to a structure are identified in red in the figure.

G.2 SITE-SPECIFIC RESULTS

This section provides a summary of each of the four sites that had enough data provided by the FSFM to complete this analysis. Table G-1 summarizes the data.

Table G-1. Data Summary for Each of the Four Sites

Site	Blast Events Analyzed	Probable Out of Compliance Events	Probable In Compliance Events	Percent of Probable Out of Compliance Events
Marianna Mine	9	9	0	100
Branford Quarry	52	0	52	0
Brooksville Quarry	76	31	45	41
West Lakes Mine	73	8	65	11
Total	210	48	162	23

G.2.1 MARIANNA MINE

The following site-specific results and Figure G-4 refer to the Marianna Mine.

Blast Events Analyzed: 9
Probable Out of Compliance Events: 9
Probable In Compliance Events: 0

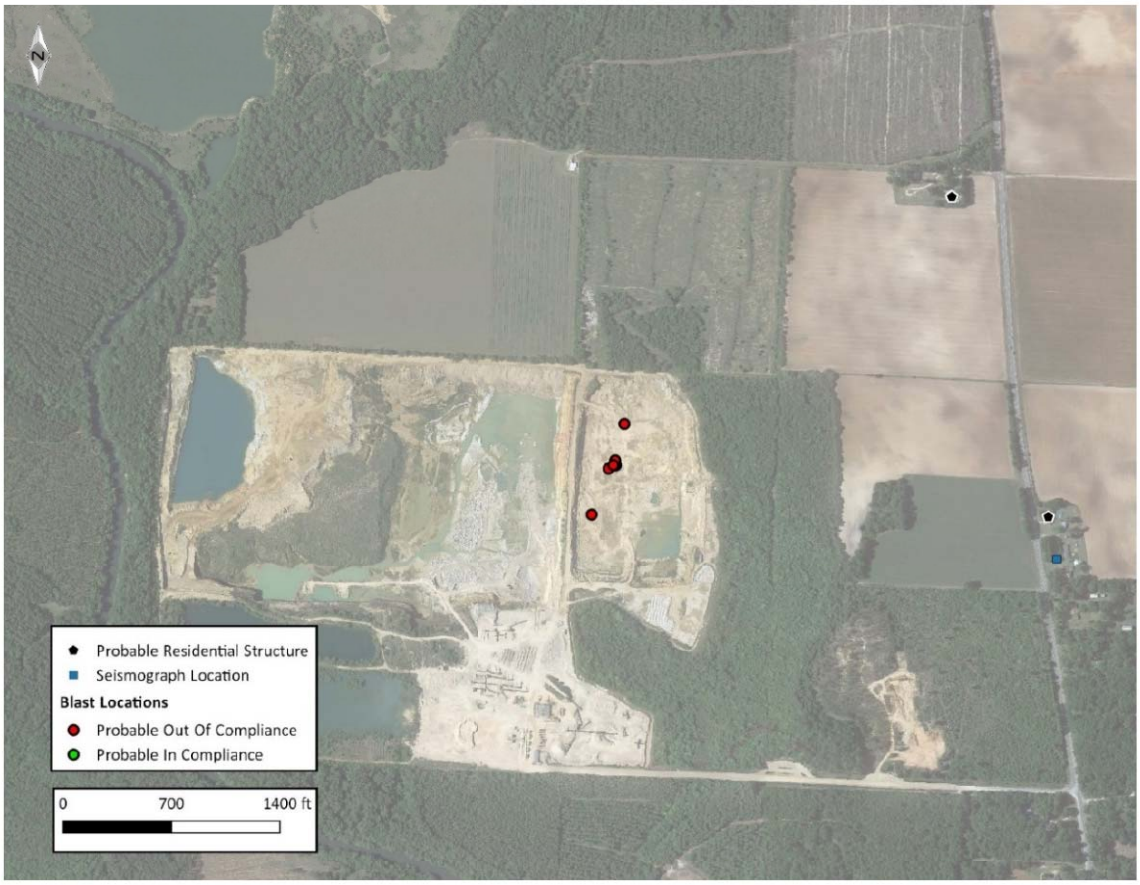


Figure G-4. Marianna Mine Site.

G.2.2 BRANFORD QUARRY

The following site-specific results and Figure G-5 refer to the Branford Quarry.

Blast Events Analyzed: 52
Probable Out of Compliance Events: 0
Probable In Compliance Events: 52

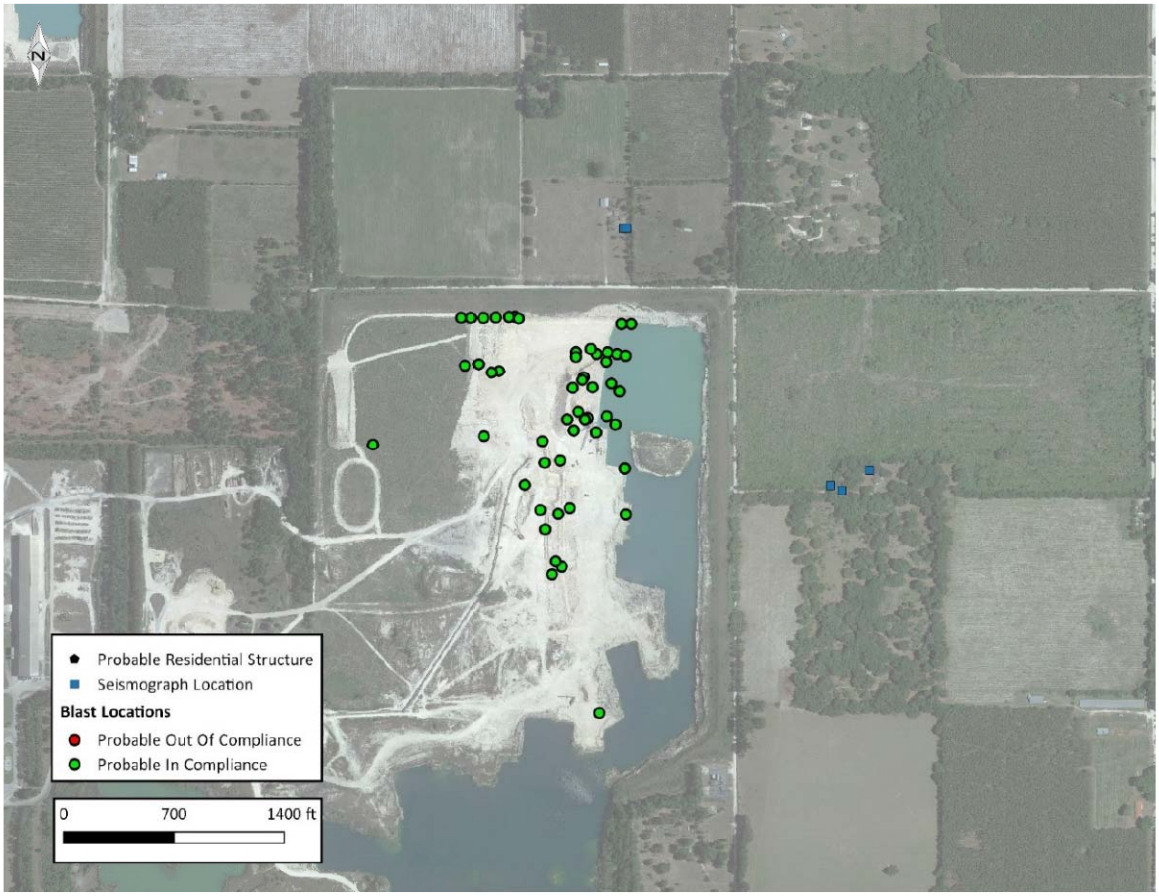


Figure G-5. Branford Quarry Site.

G.2.3 BROOKSVILLE QUARRY

The following site-specific results and Figure G-6 refer to the Brooksville Quarry.

Blast Events Analyzed: 76
Probable Out of Compliance Events: 31
Probable In Compliance Events: 45

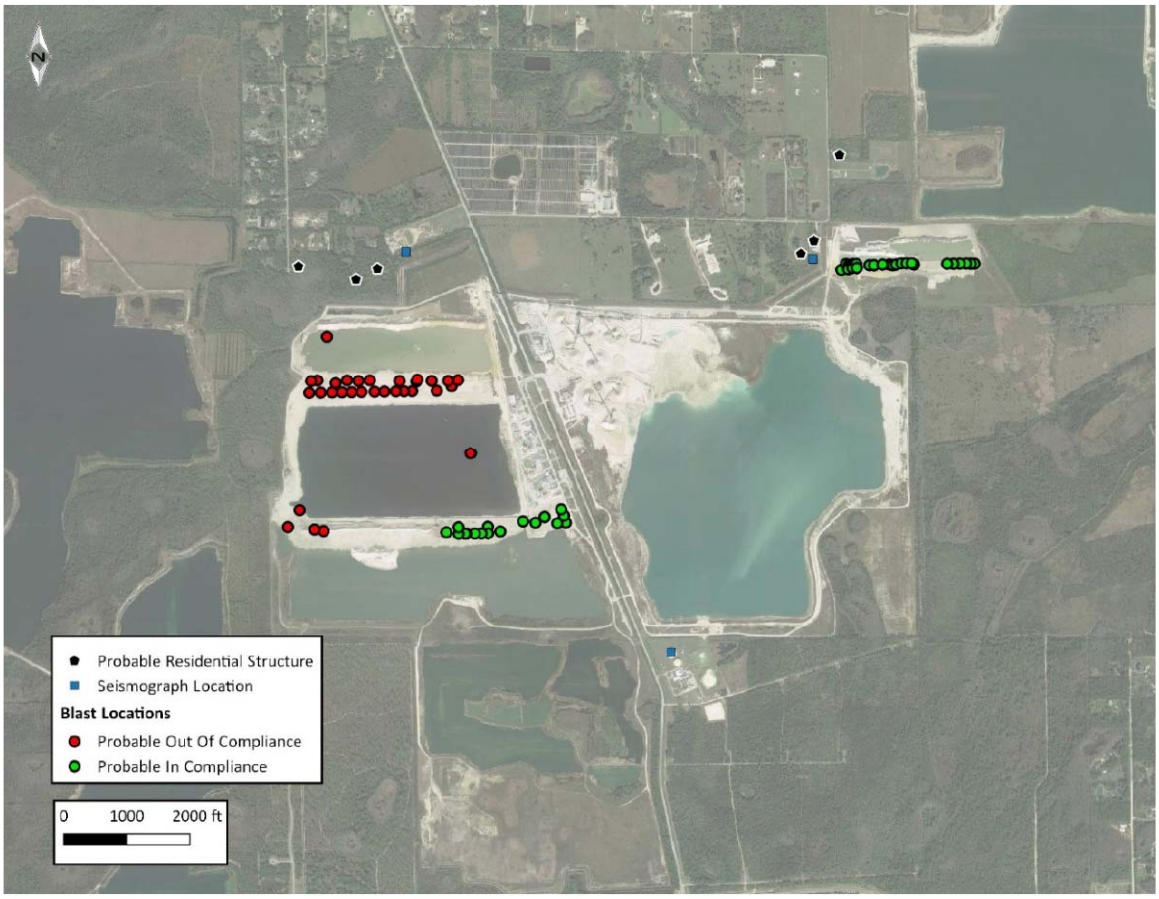


Figure G-6. Brooksville Quarry Site.

G.2.4 WEST LAKES MINE

The following site-specific results and Figure G-7 refer to the West Lakes Mine.

Blast Events Analyzed: 73
Probable Out of Compliance Events: 8
Probable In Compliance Events: 65

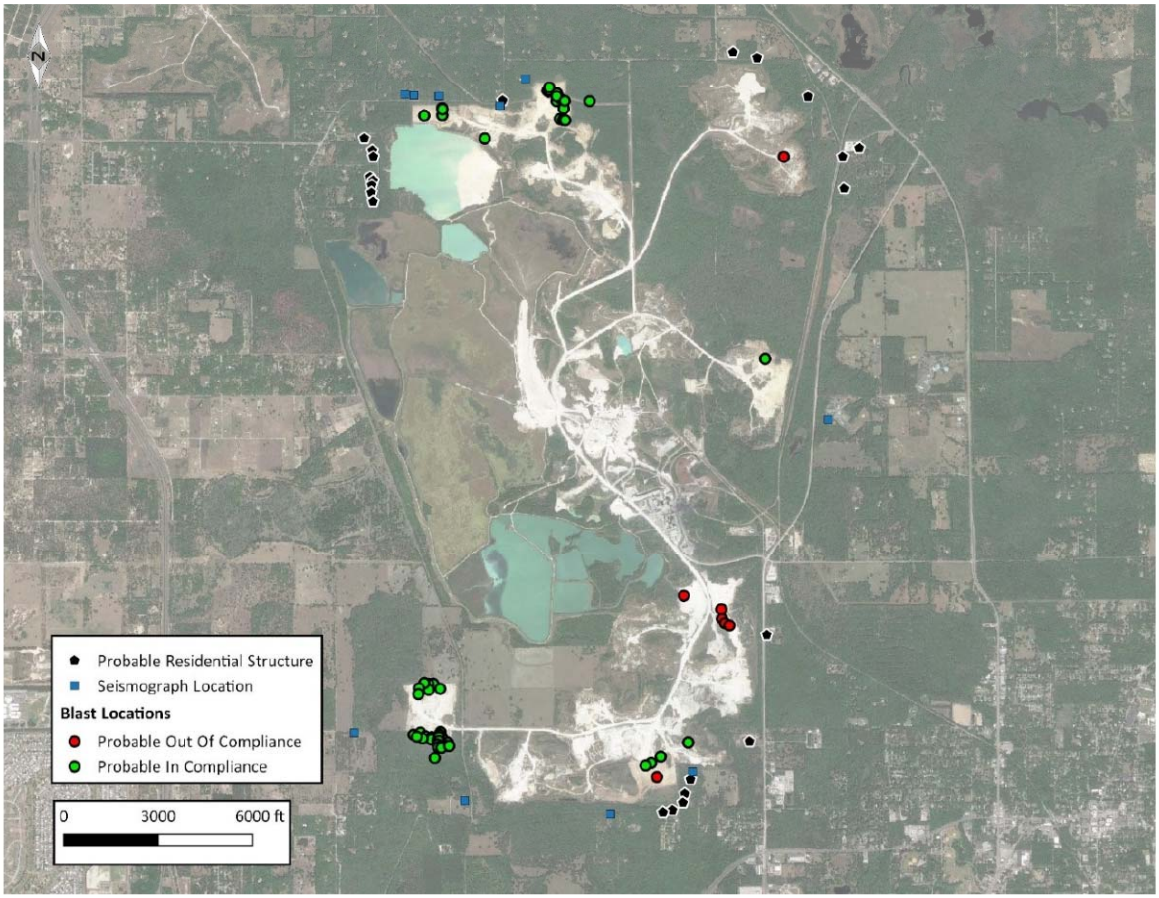


Figure G-7. West Lakes Mine Site.

G.3 REFERENCE

QGIS Testing, 2018. "Hub Lines," *qgis.org,* accessed May 18, 2018, from *https://docs.qgis.org/2.8/en/docs/user_manual/processing_algs/qgis/vector_analysis_tools/hublines.html*

APPENDIX H

GEOLOGY OF FLORIDA REPRESENTATIVE MINES

APPENDIX H: GEOLOGY OF FLORIDA REPRESENTATIVE MINES

RESPEC was selected by the Florida State Fire Marshall (FSFM) to review the existing statewide ground-vibration limits for limestone mine blasting activities and evaluate the claims of the possible damages that were caused by mine blasting. Progressive Water Resources, LLC (PWR) was retained by RESPEC to provide site-specific hydrogeologic and regulatory-related information that is necessary for RESPEC's review of residential complaints regarding the established ground-vibration limits at six representative limestone mines located throughout Florida. PWR reviewed data within the six study areas, which encompassed each of the representative construction materials mining operations.

Florida is one of the largest consumers of crushed limestone products in the US, and its mines produce approximately 120 million tons per year [Lampl Herbert Consultants, 2007]. Crushed limestone, which is found in relatively distinct deposits in Florida, is mined and processed to produce aggregate or rock granules for the construction of roadways, bridges, and buildings. Limestone aggregate that satisfies the testing standards of the Florida Department of Transportation (FDOT) is of the highest value, and the FDOT is the largest consumer of crushed limestone in Florida [Lampl Herbert Consultants, 2007]. Of the total volume of crushed limestone produced in Florida, approximately 50 percent is reportedly obtained from the Lake Belt region of Dade County [Morrell, 2006].

Deposits of construction-grade limestone (aggregate or cement grade) are located in Jackson, Suwanee, Hernando, Lee, and Dade Counties but are not exclusive to these locations. The geologic age and hydrogeological characteristics of limestone deposits, including post-depositional alterations, vary throughout the state. A statewide overview of all six selected mining study areas is shown in Figure H-1.

Two basic categories generally describe limestone mining techniques in Florida: wet mining and dry mining. Wet mining occurs when water table elevations are near the land surface and dewatering the ore body is not technically or economically feasible. Under these conditions, limestone deposits are typically excavated by using a dragline or heavy machinery to lift the rock from beneath the water's surface and place it in elongated piles near the water-filled pits to gravity-drain. Dry mining occurs above the water table and, depending on hydrogeological conditions, may involve dewatering to expose the ore body to excavation equipment. Depending on groundwater levels, the transmissivity of the mining unit, and ore-body depth, some mining operations combine both wet- and dry-mining techniques. A review of aerial photographs indicates that limestone mines within all of the study areas are currently employing or have employed blasting. Once excavated and gravity draining has completed, the limestone is typically transported to an on-site processing plant where it is washed, crushed, and sorted. The mining pits leftover from wet-mining operations are characterized as water-filled pits or lakes that can reach depths of 50–100 feet (ft) below land surface (bls). The mining depths are generally determined by the ore-body characteristics, Florida Department of Environmental Protection (FDEP) regulations, presence of a low-permeability confining unit, and excavating equipment limitations. All of the mines within the study areas excavate into the unconfined Surficial Aquifer System. Study area limestones vary in age. The Ocala Limestone, which is the oldest deposit, is mined in Suwannee County and originates from the late Eocene Age (55.8 to 33.9 million years ago [mya]). The youngest Miami Limestone is mined in Dade County and is from the Pleistocene Age (approximately 0.13 mya). Postdepositional alteration of the limestone deposits has resulted in increased induration

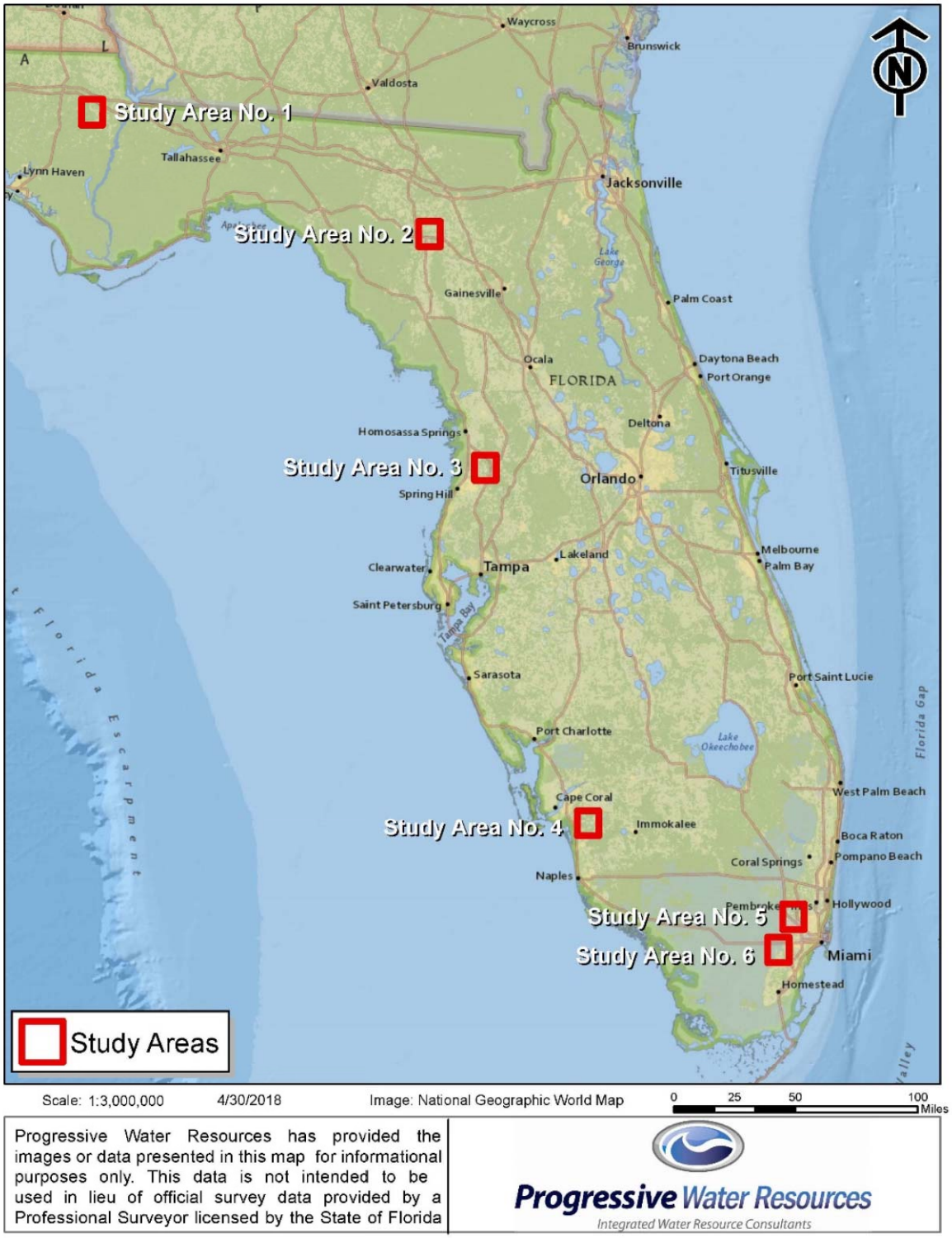


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Figure H-1. Statewide Overview of Study Areas for Limestone Mining Operations.

and recrystallization, which resulted in dense, hardened rock masses that are mined and processed as construction-grade materials.

Surficial soils are generally disturbed because of mining and are typically quartz sand-based, subangular to angular, fine- to medium-grained, silty loams with variable amounts of organics. However, Study Area Nos. 5 and 6 in Dade County exhibit high proportions of organic, rich, fibrous peats and mucks. The three southern study areas exhibit groundwater levels that are within 1–10 ft bls, whereas the mining operations in Hernando and Suwannee Counties have water levels from 20 to 30 ft bls, and dry-mining, or stepped, excavations occur above the water table. Construction-grade aggregate is produced in every study area except for the study area in Suwannee County, where limestone is used for road-base and Portland cement production only. Mining operations in the Jackson County, Suwannee County, Hernando County and Lee County study areas excavate into the Suwannee/Marianna Limestone, Ocala Limestone, Suwannee Limestone, and Tamiami Formation, respectively. Mines in the Dade County study areas excavate limestone that is associated with the Miami Limestone and Fort Thompson Formation.

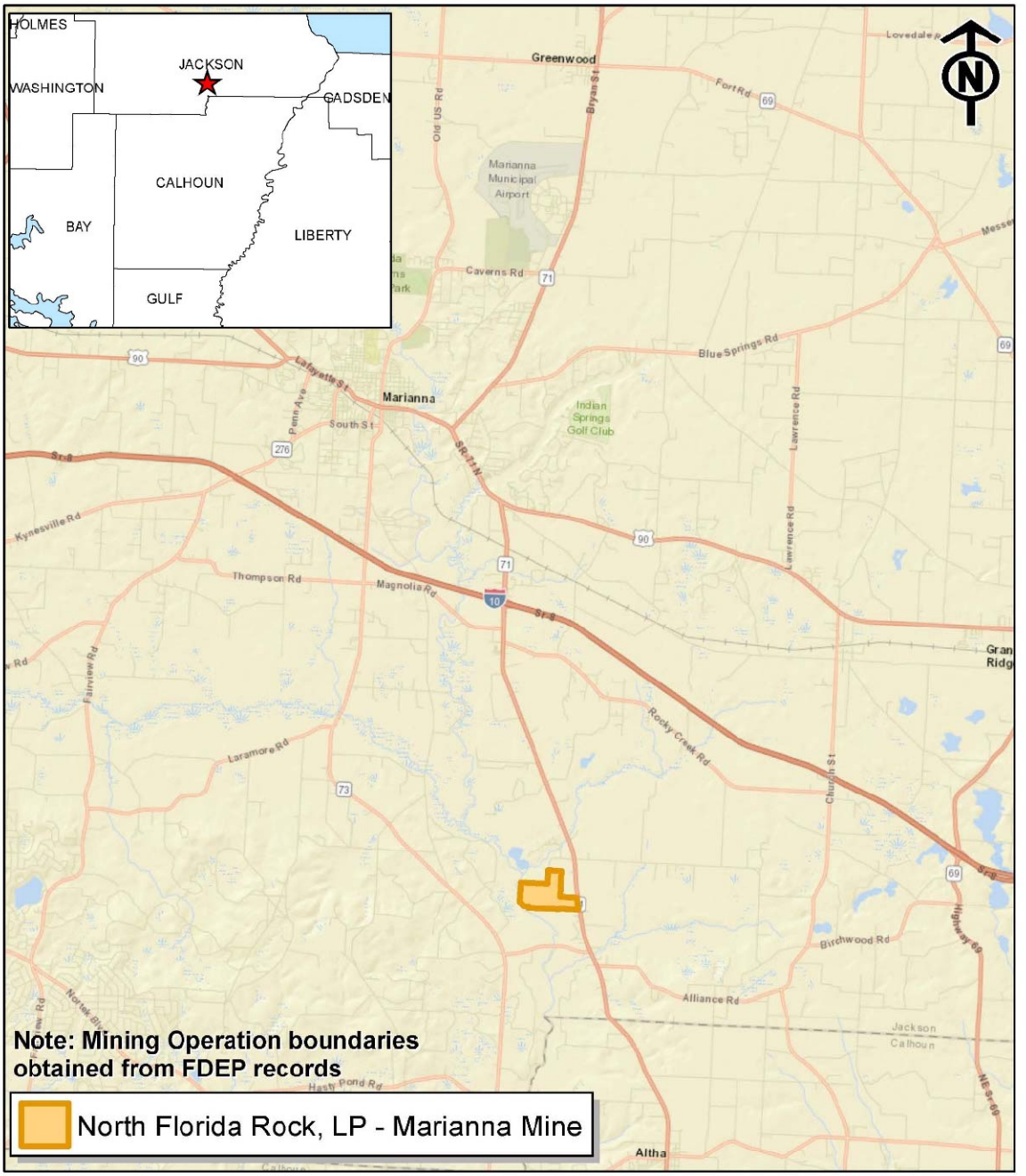
H.1 BACKGROUND

Limestone is defined by the USGS as any rock that consists mostly of calcium carbonate ($CaCO_3$). Limestone is the raw material for various construction, agricultural, environmental, and industrial materials [Bliss et al., 2012]. Limestone deposits can generally be categorized based on hardness; the softer deposits are typically used by the agricultural, industrial, and food-processing industries, and the harder (i.e., more consolidated) limestone is used for building and construction purposes [Lampl Herbert Consultants, 2007]. The chemical composition (i.e., the $CaCO_3$ percentage) of the rock matrix also determines its uses, particularly for manufacturing Portland cement and scrubbing industrial gas emissions. Mining limestone deposits may require explosives to break apart and fracture the rock mass for the ore body to be excavated and processed for use.

Five of the six representative limestone mining operations are currently permitted through the FDEP as part of their Environmental Resource Permit (ERP) program. Note that an FDEP ERP is not currently assigned to the North Florida Rock, LP's Marianna Mine operation because of a previous statute exemption pursuant to Florida Statute 373.4145(6)(a). However, the mining operation has recently proposed to expand their excavation area, and according to the FDEP file of record, an ERP is currently being pursued. ERPs are required for development or construction activities to prevent flooding and protect water quality, wetlands, and other surface waters. In addition to FDEP ERP records, online files of record from the Northwest, Suwannee River, Southwest, and South Florida Water Management Districts were researched to further understand each study area's hydrogeology. Hydrogeological technical reports, documents, coring logs, soils maps, and geologic maps by the US Geological Survey (USGS), the US Department of Agriculture (USDA), the National Resource and Conservation Service (NRCS), and the Florida Geological Society (FGS) were also reviewed.

H.2 STUDY AREA NO. 1 – JACKSON COUNTY, FLORIDA

Study Area No. 1 is located in southern Jackson County, south of the city of Marianna and west of Florida State Road 71 (FL-71), as shown in Figure H-2. Study Area No. 1 is located entirely within the Northwest Florida Water Management District (NWFWMD) and includes a single limestone mining operation: North Florida Rock, LP's Marianna Mine (FDEP Facility ID No. FLR05B608-003). The currently permitted extent of this mining operation is identified in Figure H-3.



Scale: 1:150,000 4/30/2018 Image: ESRI World Street Map 0 1.25 2.5 5 Miles

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Figure H-2. Regional Location of Study Area No. 1 Representative Mining Operation.

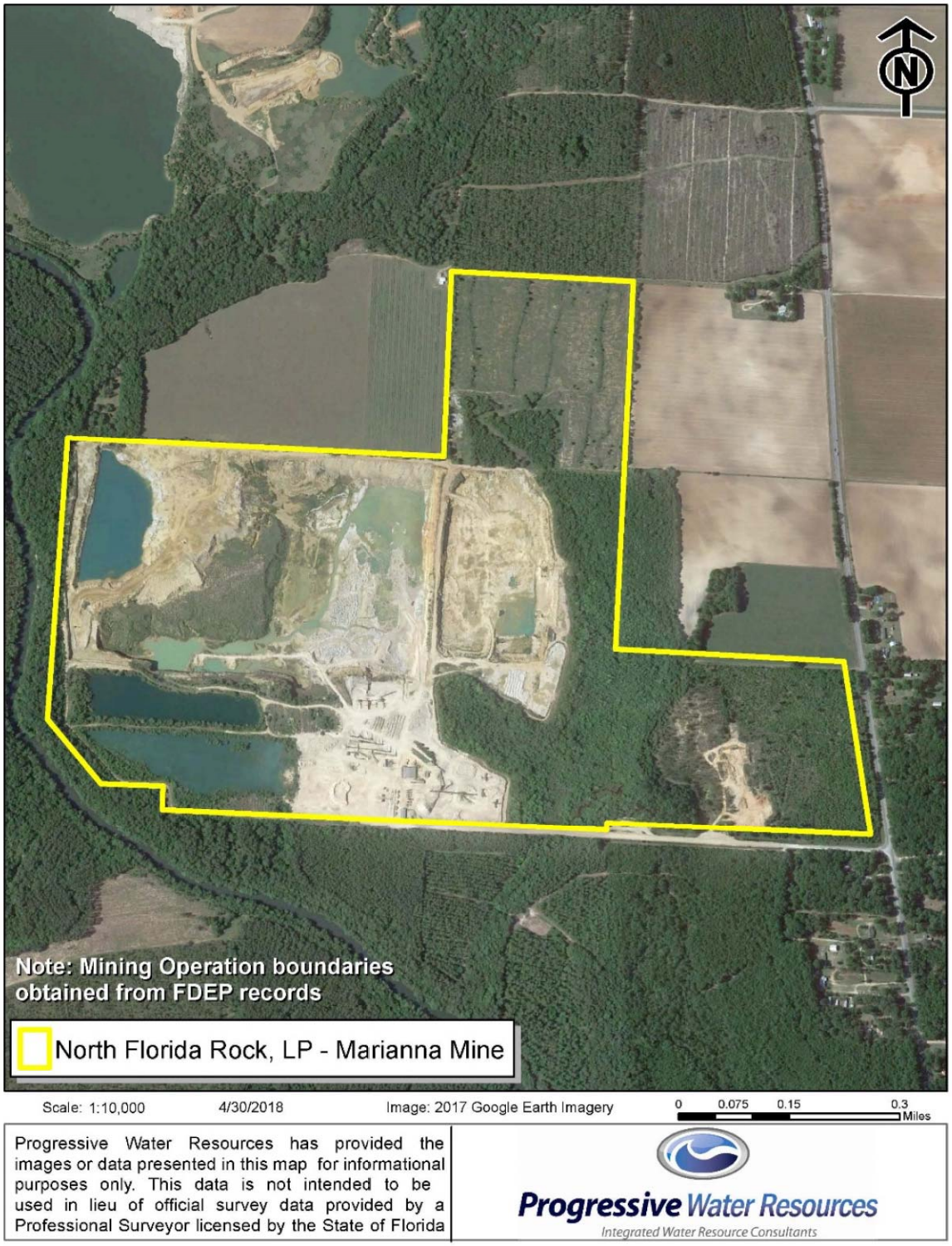

Figure H-3. Study Area No. 1 Permitted Mining Operation Boundary.

H.2.1 GEOMORPHIC SETTING

Study Area No. 1 predominantly lies within the Marianna Karst Plain area of the Marianna Lowlands [Spencer and Loyd, 1999]. This area is highly karstic and has experienced significant erosion from many streams and rivers, which has resulted in reduced land surface elevations when compared to the surrounding areas. Jackson County has several marine terrace plains, which are generally considered depressional features that formed during higher stands of sea level. These terraces trend from south to north with higher elevations to the south and lower elevations to the north [Spencer and Loyd, 1999]. The Chipola River trends north to south, follows joint patterns in the limestone unit, and occasionally flows underground (i.e., captured) because of significant karstic features, particularly near the Marianna Mine.

H.2.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped and published their soil surveys for the limestone mining and surrounding areas in 1979. However, many of the original soils present in the limestone mining areas before the excavation are largely unknown because mining operations in this area have been active for several decades, and the shallow sediments have significantly been disturbed before the 1979 NRCS soil survey was published. Therefore, the most prominent soils that surround the mining operation of interest are described in this section.

The surficial sediments present near the North Florida Rock, LP's Marianna Mine were inferred to primarily consist of Compass loamy sand, Pansey fine sandy loam, and Red Bay fine sandy loam. The Compass series consists of deep, moderately well-drained, slowly permeable, nearly level and gently sloping soils that formed in thick deposits of loamy and clayey marine sediments. The lower part of the subsoil is saturated in winter and early in spring [Soil Conservation Service, 1979]. The Pansey series consists of deep, poorly drained, slowly permeable soils that formed in loamy marine sediments. These nearly level soils are on broad flats, in poorly-defined drainageways, and in scattered depressions. Generally, the water table is within 18 in from the land surface during the wet seasons, and most areas are flooded for 1–3 months annually [Soil Conservation Service, 1979]. The Red Bay series consists of nearly level to sloping, well-drained, moderately permeable upland soils that formed in coarse- and medium-textured marine sediments. The water table for this soil series is below depths of 72 in [Soil Conservation Service, 1979].

Undifferentiated deposits also consist predominantly of quartz sands with localized, minor lenses of sandy clays and clayey sands that occur above the limestone matrix. Surficial soils and undifferentiated deposits extend to depths of approximately 10–20 ft bls and overlie an irregular, highly weathered limestone upper contact. These surficial materials consist of the overburden that is removed before the commencement of mining operations.

H.2.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable unit that occurs directly beneath the overburden in Study Area No. 1 is categorized as Oligocene-age, undifferentiated Suwannee and Marianna Limestone [Spencer and Loyd, 1999]. Based on FDEP records, the mineable deposits of the Suwannee and Marianna Limestone in Study Area No. 1 generally occur at depths of approximately 10–80 ft bls. The undifferentiated Suwannee and Marianna Limestone at this location is used as asphalt aggregate as well as a base coarse material for local

roadways. The extent of the undifferentiated Suwannee and Marianna Limestone within Study Area No. 1 is shown in Figure H-4.

Extraction occurs with heavy machinery (i.e., excavators), and explosives are commonly used to fracture more competent limestone to facilitate its removal. The limestone is typically dried (i.e., gravity-drained) and crushed before shipping for use as asphalt aggregate or roadway base coarse material. This mining operation uses both wet- and dry-excavation techniques depending on overburden thickness and water table depth.

The Marianna Limestone consists of a massive, light-gray to cream limestone, which is less permeable than the Suwannee and ranges in thickness from approximately 25 to 85 ft [Spencer and Loyd, 1999]. The Marianna Limestone is very soft when unweathered and is slightly glauconitic, so when this rock has been subjected to alternative wetting and drying (as in a poorly drained quarry), the rock may exhibit rust-colored specks that are scattered throughout [Moore, 1955]. Large foraminifera are highly common throughout and may be the sole constituents of some beds. The overlying Suwannee Limestone consists of tan to buff-colored, porous, fossiliferous limestones, dolomitic limestones, and dolomite and ranges in thickness from approximately 25 to 110 ft [Spencer and Loyd, 1999]. A generalized hydrogeologic column for Study Area No. 1 is provided as Figure H-5.

H.2.4 AQUIFER SYSTEMS

The undifferentiated surficial deposits (i.e., overburden) constitute a thin-to-absent, minor, water-bearing Surficial Aquifer System (i.e., water table). Average water levels within the mining area are approximately 3–5 ft bls, which is noted in the FDEP file of record. The Surficial Aquifer System is underlain by the generally thin-to-absent Intermediate Aquifer System [Pratt et al., 1996], which consists of clayey sands and sandy clays that overly the undifferentiated Suwannee and Marianna Limestone and constitute a localized semiconfining unit. However, given the limited thickness (±15 ft), limited aerial extent, and leaky nature of the Intermediate Aquifer System in the study area because of karstic features, the underlying Floridan Aquifer System is generally considered unconfined within Study Area No. 1. Within the study area, the Floridan Aquifer System is generally approximately 700 ft thick [Pratt et al., 1996]. Because of the lack of a competent confining unit, a downward hydraulic gradient facilitates recharge to the Upper Floridan Aquifer and contributes to limestone dissolution.

H.2.5 LIMESTONE MINING OPERATIONS – STUDY AREA NO. 1

The North Florida Rock, LP's Marianna Mine uses heavy machinery (i.e., excavators) and explosives to fracture the limestone and excavate the ore body. The limestone is exposed by removing the overburden, which is excavated by heavy machinery and transported by haul trucks for processing. The permitted mining depth is reportedly approximately 80 ft bls.

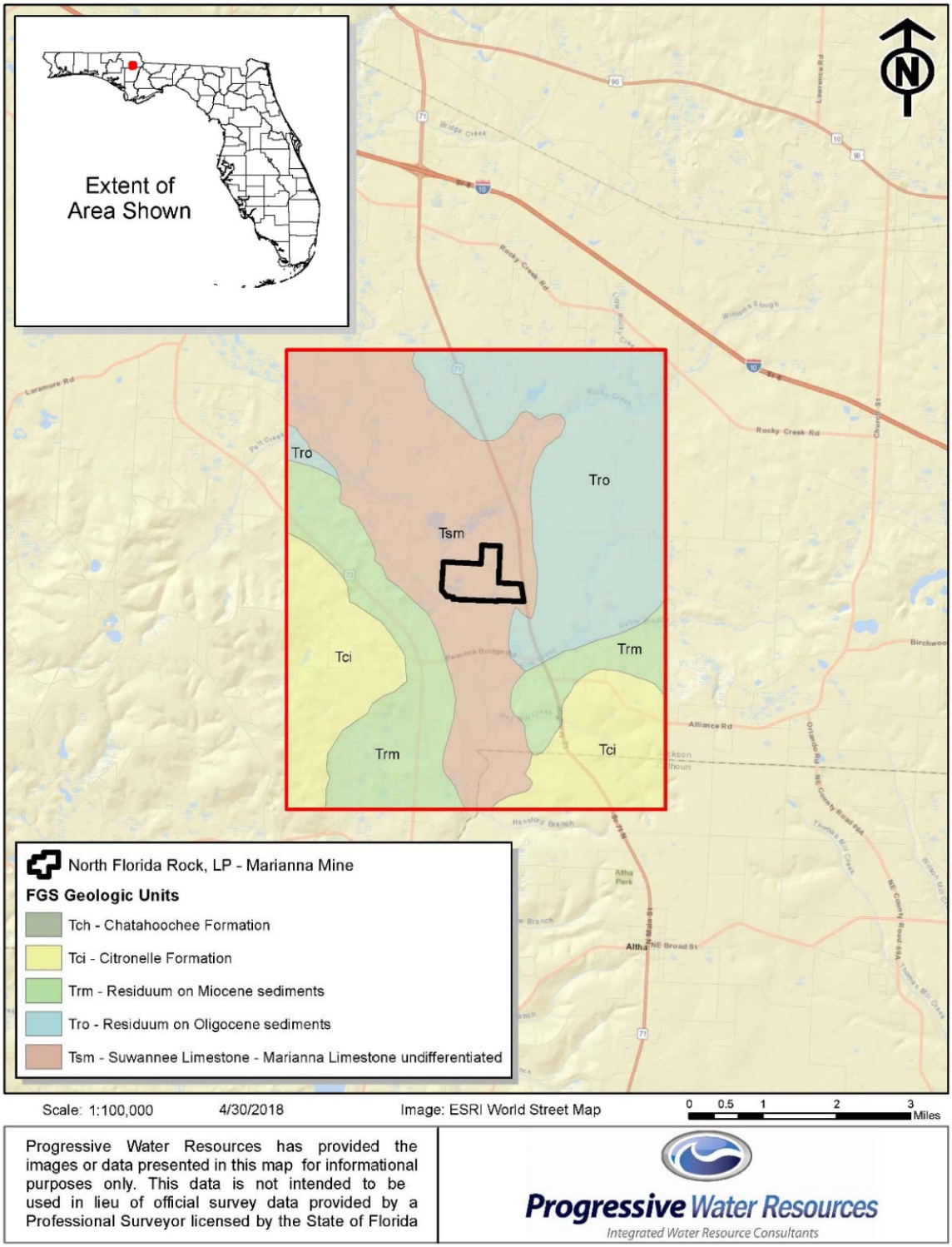

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Figure H-4. Study Area No. 1 Florida Stratigraphic Geology and Mining Operation.

Surficial Sediments

Generally, poorly drained to well drained soils that formed in loamy and clayey marine sediments and coarse and medium textured marine sediments. The water table elevation ranges between 18 inches to below 72 inches during the wet season.

Undifferentiated Suwannee and Marianna Limestone

Generally, Suwannee Limestone consists of tan to buff colored, porous, fossiliferous limestones, dolomitic limestones and ranges in thickness from approximately 25 to 110 feet. Marianna Limestone consists of light gray to cream to white massive limestone which is less permeable than Suwannee Limestone and ranges in thickness from approximately 25 to 85 feet. Marianna Limestone is very soft when fresh and is slightly glauconitic. Mineable deposits of the Suwannee and Marianna Limestone within Study Area No. 1 generally occur at depths of approximately 10 to 80 feet bls.

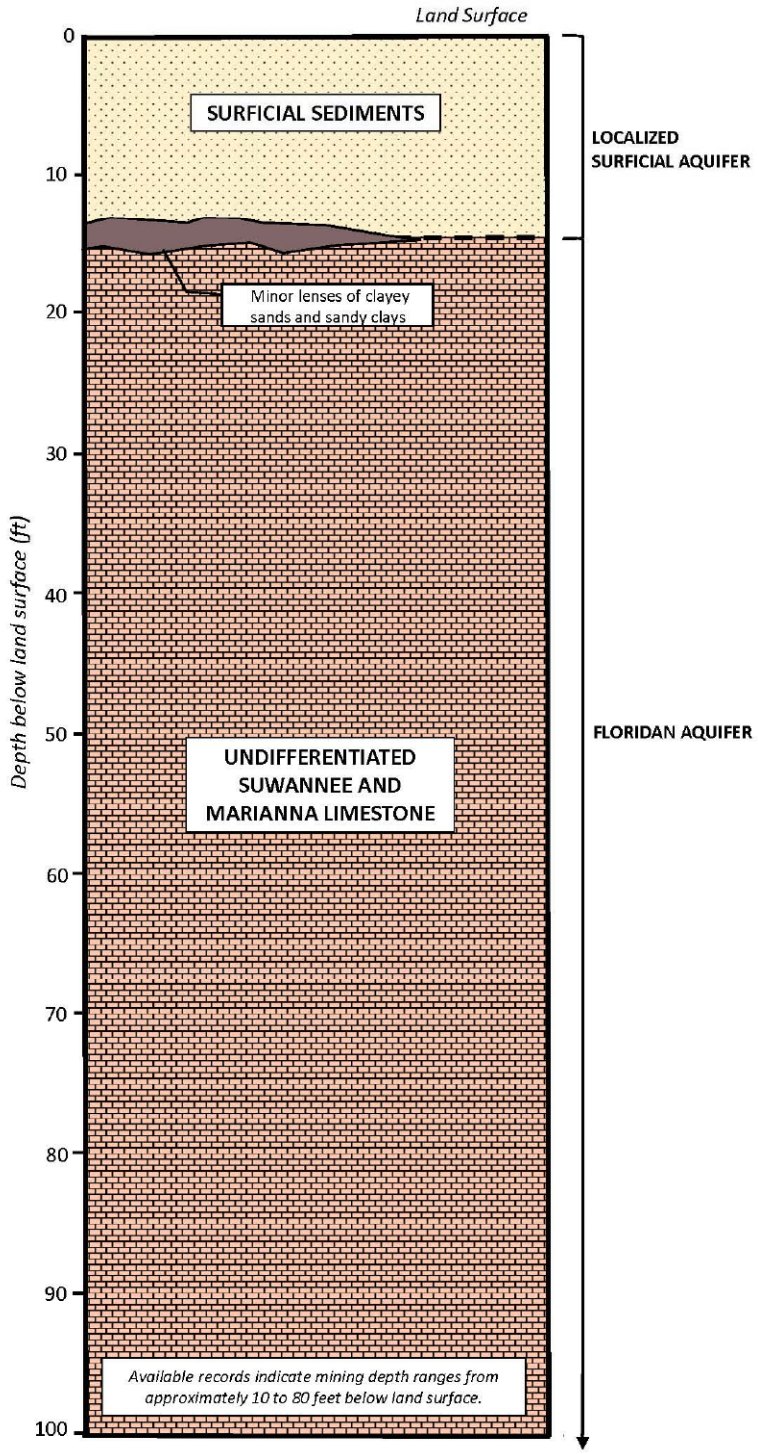

Figure H-5. Study Area No. 1 Generalized Hydrogeologic Column.

H.3 STUDY AREA NO. 2 – SUWANNEE COUNTY, FLORIDA

Study Area No. 2, which is shown in Figure H-6, is located in southern Suwannee County, east of the City of Branford, north of US Highway 27, and predominantly east of County Road 49. Study Area No. 2 is located entirely within the Suwannee River Water Management District (SRWMD) and has one representative operating limestone mine: Suwannee American Cement, LLC's Branford Mine (FDEP ERP Permit No. 175397-003). The currently permitted extent of this mining operation, under its respective ERP, is identified in Figure H-7.

H.3.1 GEOMORPHIC SETTING

Study Area No. 2 predominantly lies within the Gulf Coastal Lowlands physiographic province, which is characterized as a flat, frequently swampy, westward-sloping plain that extends from eastern-central Suwannee County to the Gulf of Mexico. This lowland area was formed by a series of step-like marine terraces that were deposited by the alternately flooding and retreating Plio-Pleistocene seas [Rupert, 2003]. Land-surface elevations within the Gulf Coastal Lowlands generally range between approximately 35 and 100 ft above mean sea level (amsl). To the northeast of the mining areas, higher topographic elevations are encountered because of a relict marine coastline that is identified as the Cody Scarp. The Cody Scarp is a former Pleistocene shoreline, and the erosion and dissolution of the underlying limestone have transformed the escarpment into a series of conjoined sandy hills that produce a rolling topography [Rupert, 2003]. The area is highly karstic, and a review of the FGS Subsidence Incident Reports indicates the reported karst features within the study area, which are shown in Figure H-8.

H.3.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped and published the soil survey of the limestone mining and surrounding areas in 2006. The soils present at Suwannee American Cement, LLC's Branford Quarry are described as Otela-Alpin-Chiefland Complex and Otela-Chiefland-Ichetucknee Complex soils. The Otela component is a moderately well-drained soil, which formed on marine terraces of coastal plains and has a parent material that generally consists of sandy and loamy marine deposits over limestone [NRCS, 2006]. This soil has a seasonal zone of water table saturation at approximately 48–72 in bls. The Alpin component is an excessively drained soil that formed on the karst marine terraces of coastal plains and has a parent material that generally consists of eolian deposits or sandy marine deposits [Sabal Trail Transmission, 2014]. This soil has no seasonal zone of water saturation within a depth of 72 in bls. The Chiefland component is a moderately well-drained soil that formed on ridges or karstic marine terraces and has a parent material that generally consists of sandy and loamy marine deposits over limestone [NRCS, 2006]. This soil does not meet hydric criteria, contains approximately 1 percent organic matter content, and has no seasonal zone of water-table saturation within a depth of 72 in bls. The Ichetucknee component is a somewhat poorly drained soil that formed on knolls on the karst marine terraces and has a parent material that generally consists of sandy and clayey marine deposits over limestone [NRCS, 2006]. This soil has a seasonal high-water table that is approximately 18–36 in bls. The Udorthents component of the Udorthents-Pits Complex is a well-drained, disturbed soil that is formed by cutting or filling; however, this soil does not meet hydric criteria, has no organic matter content, and has a seasonal zone of water saturation that is approximately 35 in or greater [Sabal Trail Transmission, 2014].

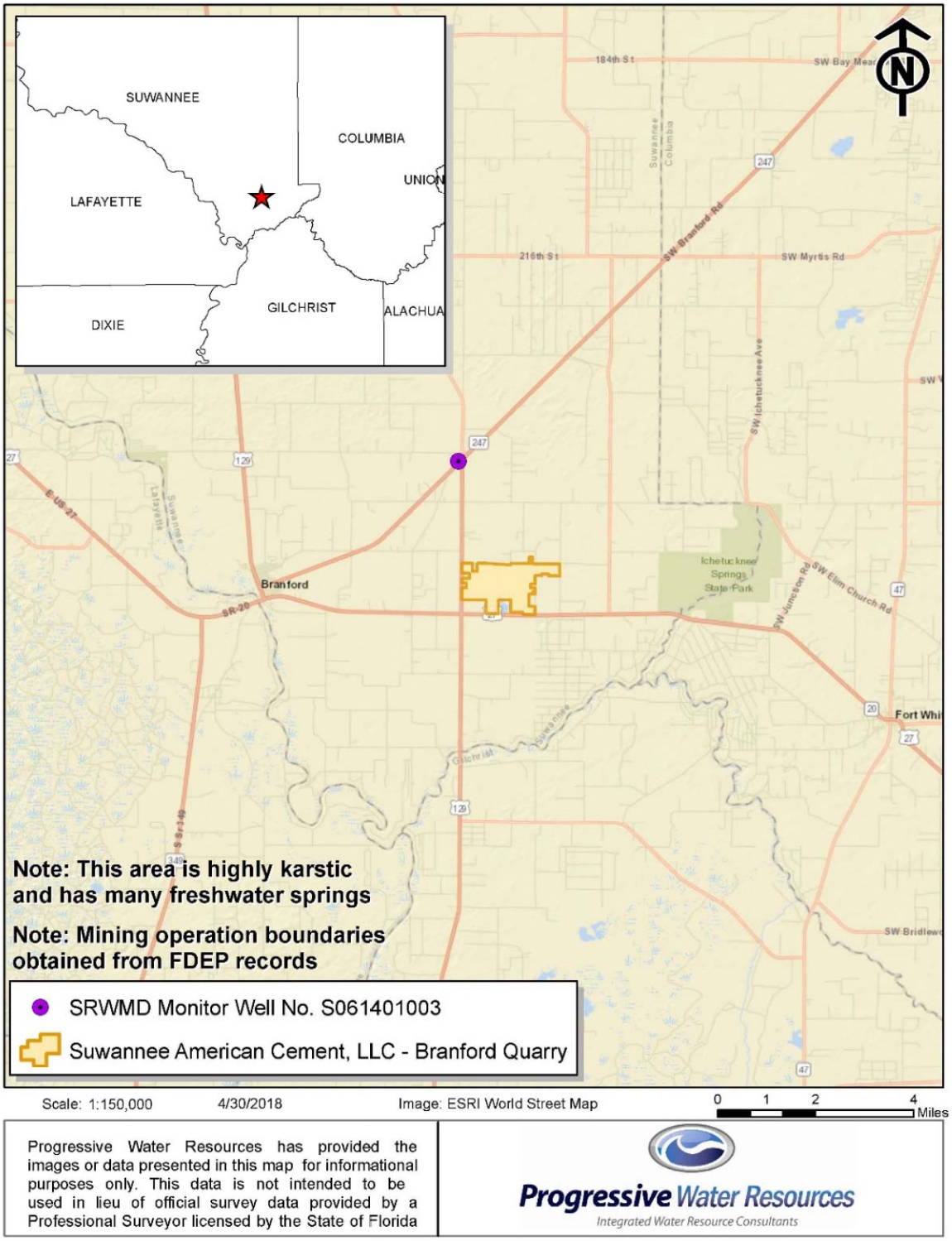

Figure H-6. Regional Location of Study Area No. 2 Representative Mining Operation.

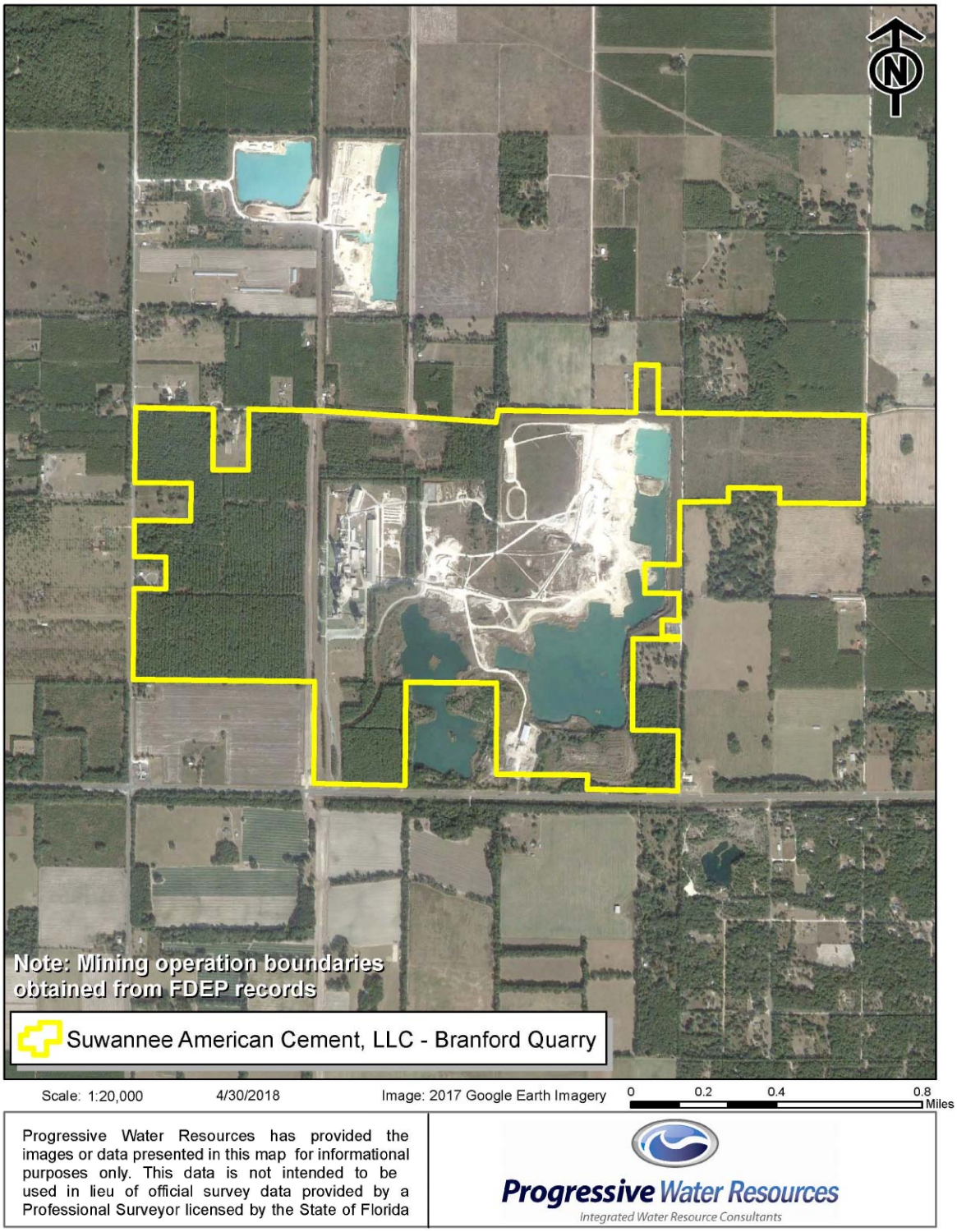

Figure H-7. Study Area No. 2 Permitted Mining Operation Boundary.

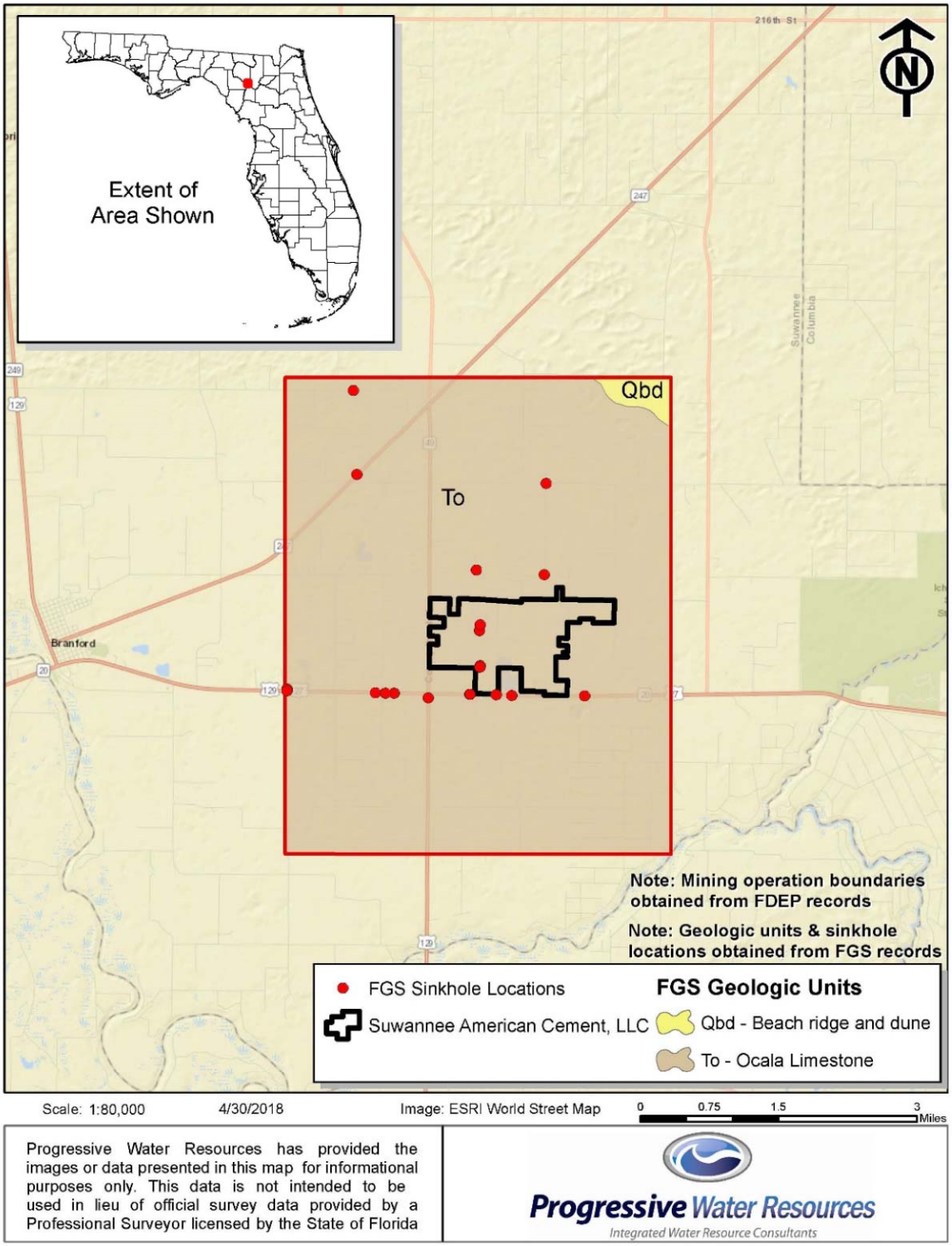

Figure H-8. Study Area No. 2 Florida Stratigraphic Geology and Mining Operation.

In addition to the surficial soils, undifferentiated deposits that consist predominantly of fine- to medium-grained, angular to subangular, quartz sands with localized, minor lenses of sandy clays and clayey sands exist. The undifferentiated deposits extend to depths of approximately 10–20 ft bls and overlie an irregular, highly weathered limestone upper contact. These surficial materials consist of the overburden that is removed before mining limestone.

H.3.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable unit that occurs directly beneath the overburden in Study Area No. 2 is the late Eocene Ocala Limestone. Based on FDEP ERP records, mineable deposits of the Ocala Limestone within Study Area No. 2 generally occur approximately 40–90 ft below the active pit's water surface, with a total mineable thickness that reportedly approaches 110–120 ft. The Ocala Limestone at this location is of high purity, road-base quality rock but is considered too soft and friable for aggregate use [Rupert, 2003]. The broad extent of the Ocala Limestone in Study Area No. 2 is shown in Figure H-8.

Extraction occurs by using a dragline, and explosives are commonly used to fracture the limestone to facilitate its removal. The limestone is typically dried (i.e., gravity-drained) and crushed before being shipped for use in cement production [Rupert, 2003].

The Ocala Limestone lithology is divided into upper and lower units and grades upward from alternating hard to soft, white to tan to grey, fossiliferous calcareous and dolomitic limestone of the lower unit into a white to very light grey to light yellowish orange, abundantly fossiliferous, chalky limestones of the upper unit [Rupert, 2003]. A generalized hydrogeologic column for Study Area No. 2 is provided as Figure H-9.

H.3.4 AQUIFER SYSTEMS

The undifferentiated surficial deposits (i.e., overburden) can locally constitute an unconfined Surficial Aquifer System (i.e., water table) where clayey sands and sandy clays occur above the Ocala Limestone and constitute a localized semiconfining unit. However, given the limited thickness (±10–15 ft), limited areal extent, and leaky nature of the semiconfining sediments, the underlying Floridan Aquifer System is generally considered unconfined within Study Area No. 2, except for areas to the northeast where the Hawthorn Group sediments provide confinement (i.e., the Cody Scarp). The average Upper Floridan Aquifer water level within the mining area is approximately 25 ft bls and seasonally fluctuates between 20 and 30 ft bls, as indicated by the 2013–2018 water levels from the SRWMD Monitor Well No. S061401003. The location of the monitoring well is shown in Figure H-6. The lack of consistent confining sediments and downward hydraulic gradient facilitates recharge to the Upper Floridan Aquifer and contribute to limestone dissolution and continued karstic activity.

H.3.5 LIMESTONE MINING OPERATIONS – STUDY AREA NO. 2

Suwannee American Cement Florida, LLC's Branford Mine uses blasting methods to excavate the ore body. The limestone is exposed by removing overburden, blasted (i.e., broken) into an extractable consistency, excavated by a dragline(s), and transported by haul trucks to a centrally located processing facility and cement plant. The permitted mining depth is reportedly up to 90 ft below the average water level in the pit.

Surficial Sediments

Generally, somewhat poorly to excessively drained loamy and sandy soils which formed on ridges of step-like marine terraces which were deposited by Plio-Pleistocene seas alternately flooding and retreating from this region. Soils are non-hydric and contain little to no organic matter content.

Ocala Limestone

Generally divided into upper and lower facies based on lithology and grades upward from alternating hard and soft, white to tan to grey fossiliferous limestone and dolomitic limestone of the lower unit into white to very light grey to light yellow-ish-orange, abundantly fossiliferous, chalky limestones of the upper unit. The Ocala Limestone has a highly permeable and cavernous nature which makes it an important freshwater bearing unit of the Floridan Aquifer System.

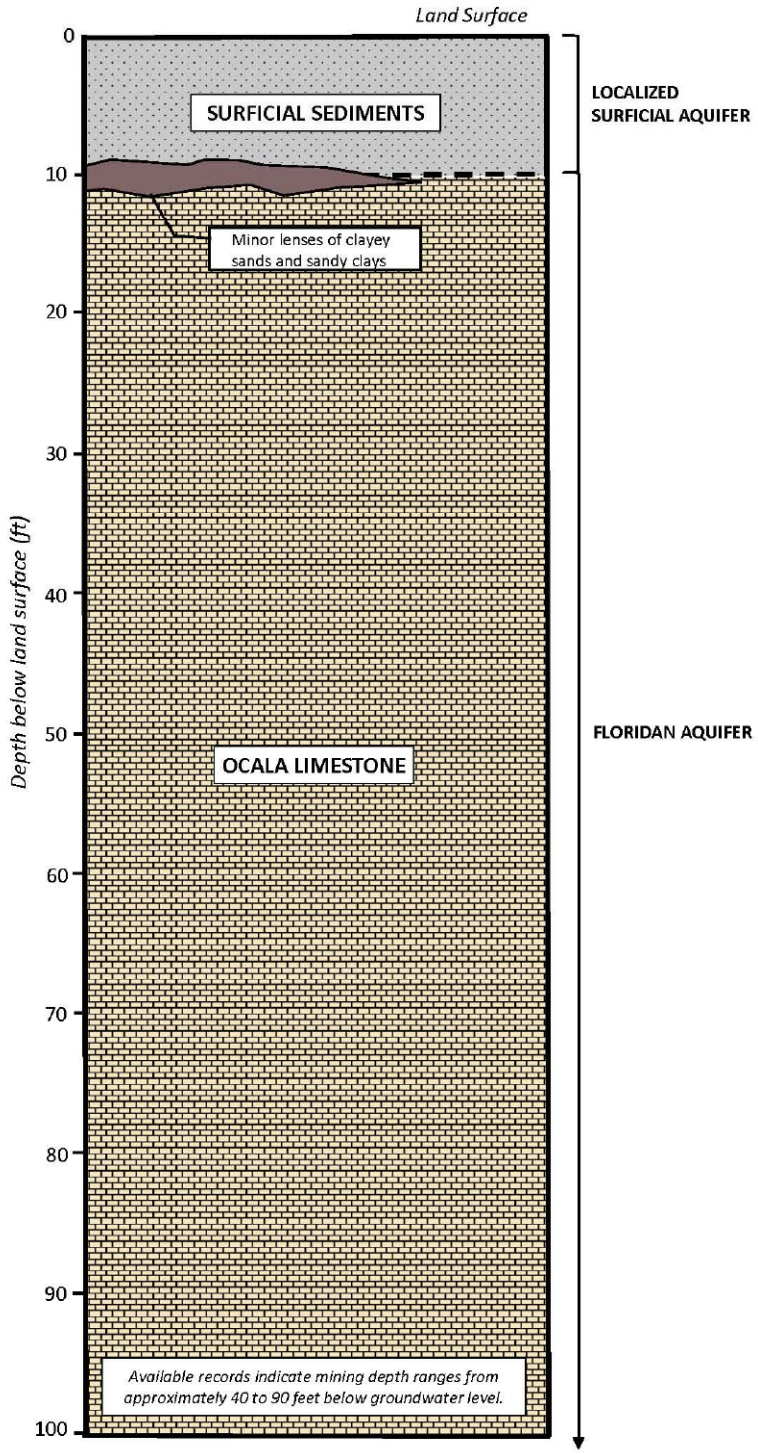

Figure H-9. Study Area No. 2 Generalized Hydrogeologic Column.

H.4 STUDY AREA NO. 3 – HERNANDO COUNTY, FLORIDA

Study Area No. 3, which is shown in Figure H-10, is located northwest of the City of Brooksville, predominantly east of Highway 589 (Suncoast Parkway), and west of State Highway 98 in central Hernando County. Study Area No. 3 is located entirely within the SWFWMD and has one representative operating limestone mine: the CEMEX Construction Materials Florida, LLC Mine, also called the Brooksville Mine (FDEP ERP Permit No. 230357-009). An electrical power plant (Brooksville CEMEX Plant) that is operated by Florida Power and Light and a cement plant (kiln) are also located within the study area. The currently permitted extent of the representative mining operation based on its ERP is identified in Figure H-11.

H.4.1 GEOMORPHIC SETTING

Study Area No. 3 predominantly consists of the Gulf Coastal Lowlands to the west and the Brooksville Ridge to the east [White, 1970]. The Brooksville Ridge is a linear, positive-relief topographic feature with elevations that range from approximately 70 to 250 ft amsl and is characterized by rolling sandy hills with sinkhole lowlands that are mostly occupied by wetlands or lakes [Florea, 2006]. The Oligocene Suwannee Limestone outcrops along the flanks of the Ocala Platform and the limestone-mining operations are oriented near the western flank of the Brooksville Ridge. Paleokarst features infilled with Miocene-age siliciclastics can pierce the Suwannee Limestone throughout the Brooksville Ridge [Yon and Hendry, 1972]. Various reports of karst activity, which are provided by the FGS Subsidence Incident Reports, are indicated to the west of the mining areas within the Gulf Coastal Lowlands physiographic province and are shown in Figure H-12.

H.4.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped and published their soils survey for the limestone mining and surrounding areas in 1977. However, many of the original soils present in the mining area before the excavation are largely unknown because mining operations in this area have been active for several decades and have significantly disturbed the shallow sediments. These mining-related disturbances have continued since the soils survey was published. Therefore, the most prominent soils that surround the mining operation of interest are described herein. Note that the shallow surficial soils may locally support a perched water table in some areas but are generally unsaturated in and around the mining operations [Vulcan Materials Company, 2007].

The surficial sediments that are present near the Brooksville Mine were inferred to originally consist of Flemington fine sandy loam, Micanopy loamy fine sand, and Candler fine sand. The Flemington series is a somewhat poorly drained soil that formed in thick beds of loamy and clayey marine sediments with the water table generally perched during 1–4 months of the wet season [Soil Conservation Service, 1977]. The Micanopy series is a somewhat poorly drained soil that formed in thick beds of loamy and clayey marine sediments. The Candler series is an excessively drained sandy soil that formed in thick beds of unconsolidated sandy marine, eolian, or fluvial sediments [Soil Conservation Service, 1977]. These soils are typically located in upland, sandhill areas, and the water table remains at or below a depth of approximately 80 in throughout the year.

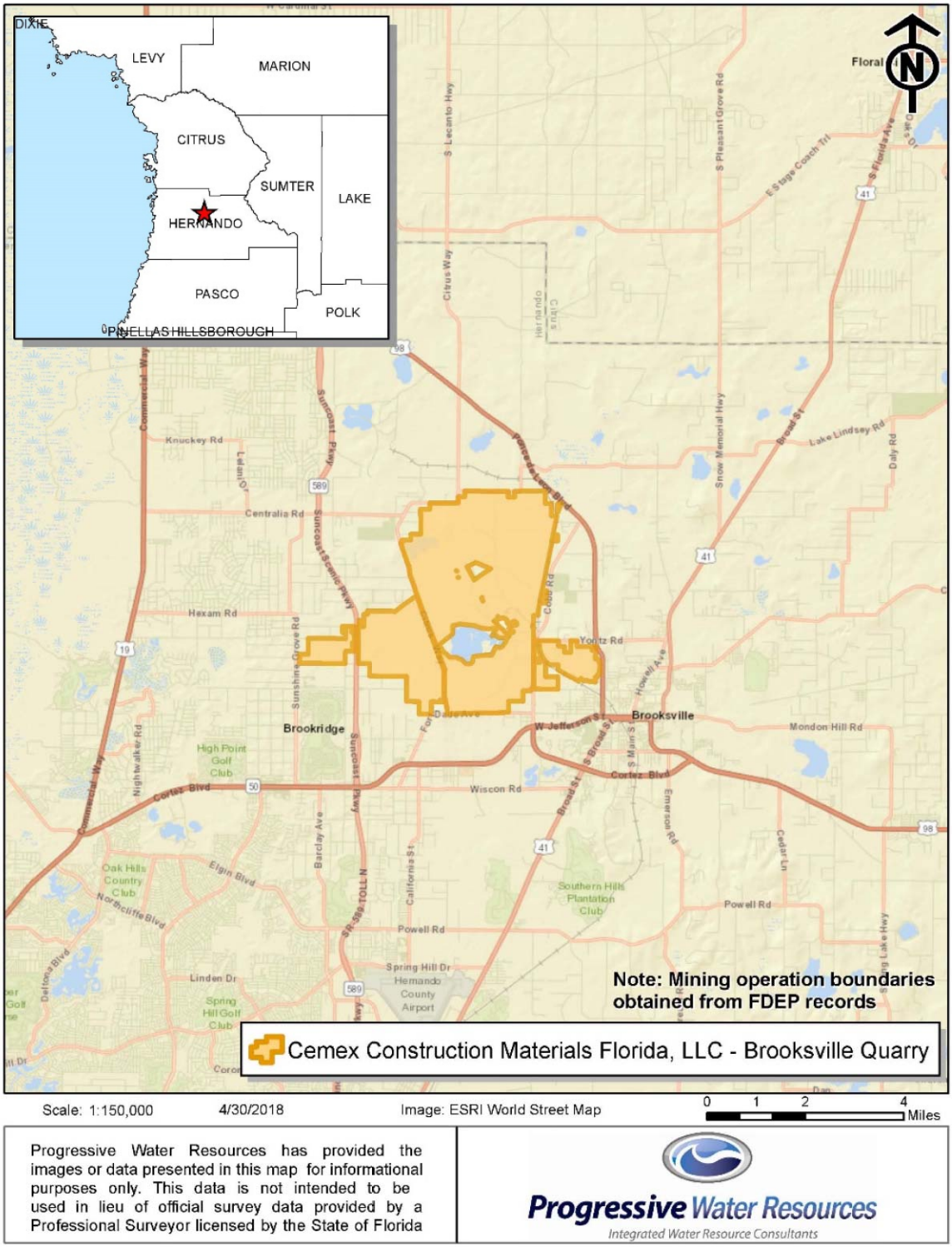

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Figure H-10. Regional Location of Study Area No. 3 Representative Mining Operation.

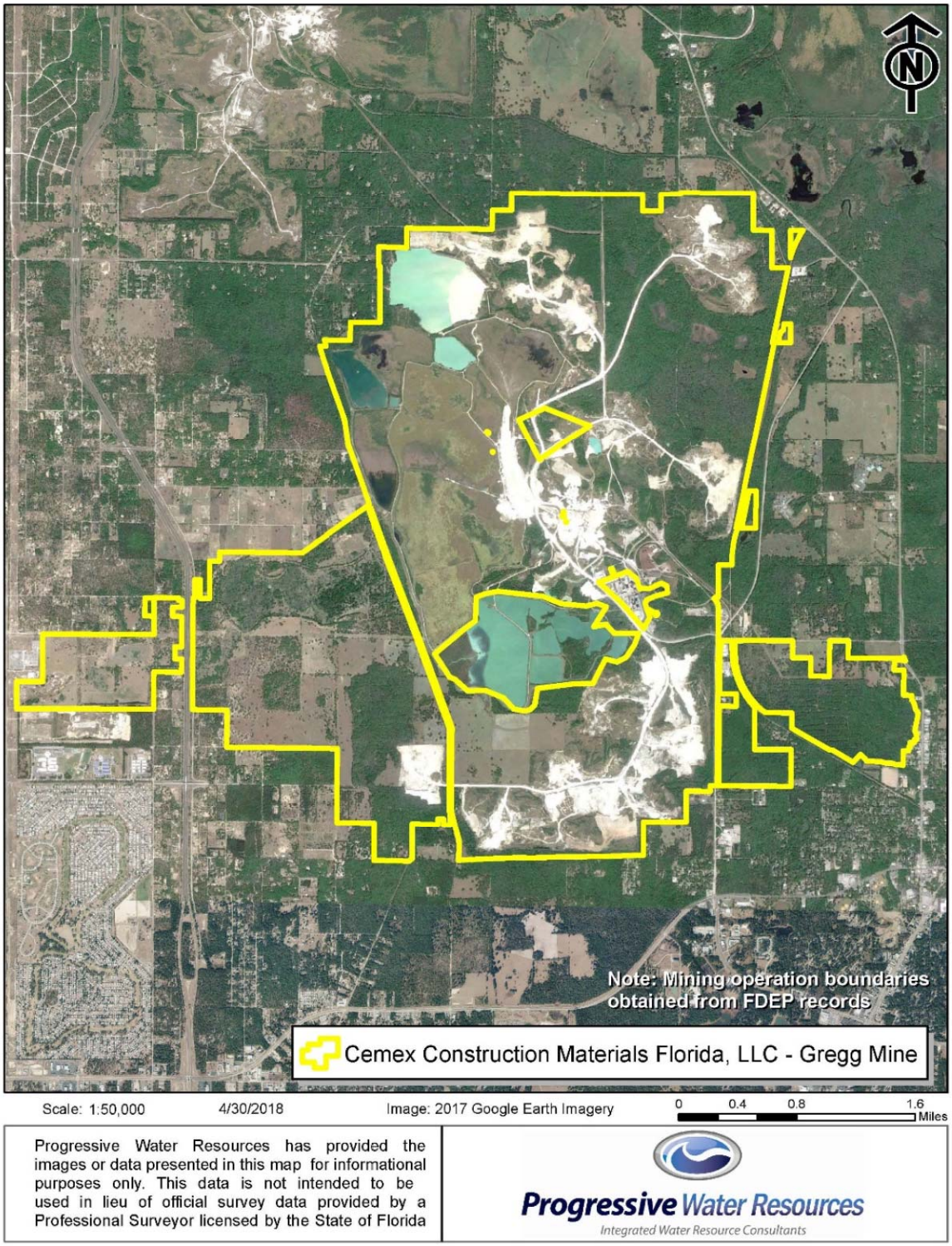

Figure H-11. Study Area No. 3 Permitted Mining Operation Boundary.

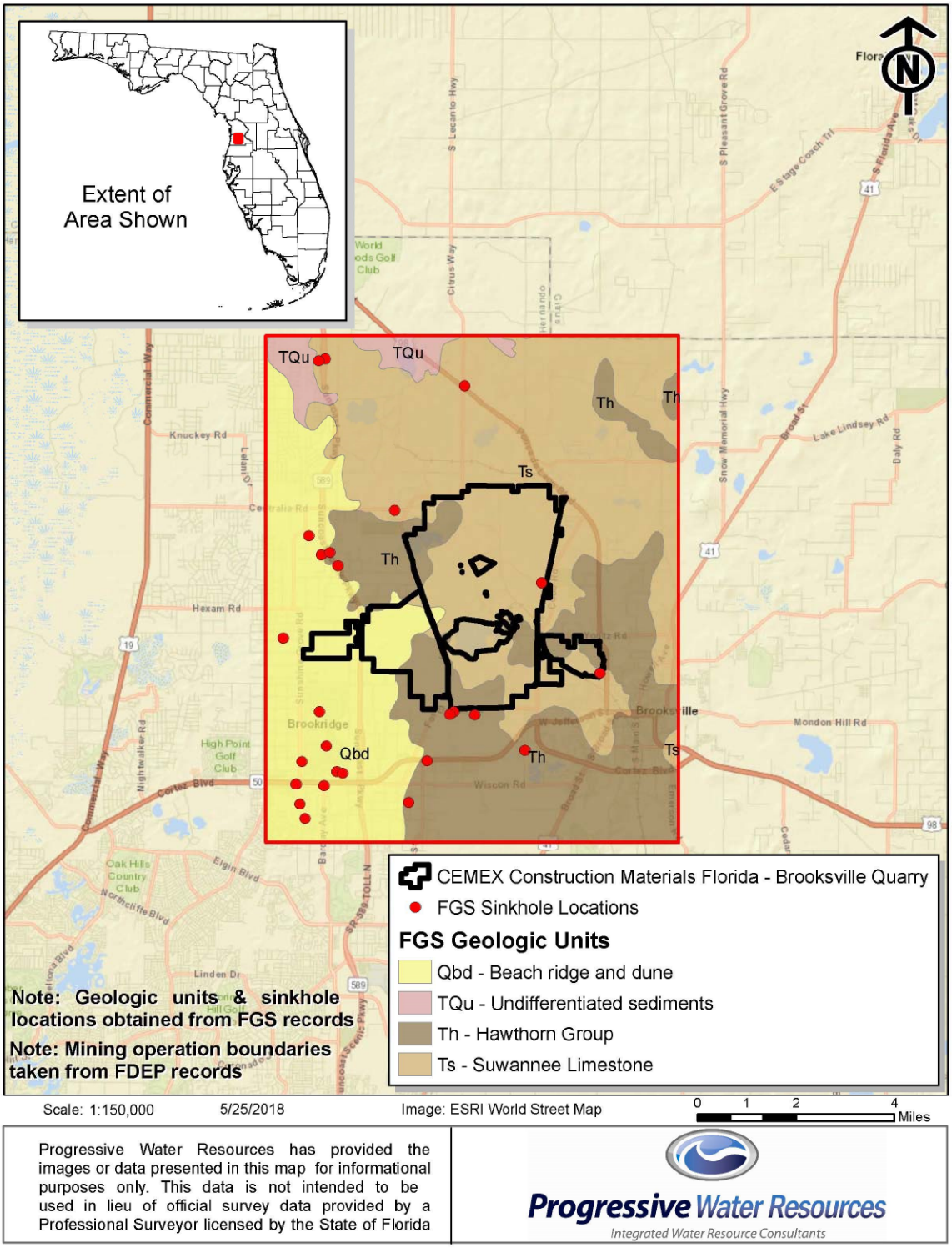

Figure H-12. Study Area No. 3 Florida Stratigraphic Geology and Mining Operation.

Underlying the surficial soils described above are undifferentiated surficial deposits, which consist predominantly of fine- to medium-grained, angular to subangular, quartz sands with minor amounts of sandy clays and clayey sands. The thickness of the surficial deposits can vary widely depending on postdepositional karstic activity and the deposits' proximity to thicker sections of the Brooksville Ridge, but the thickness generally averages approximately 10–20 ft near the active mining operations. Differences in the thickness of surficial deposits may account for the somewhat dispersed nature of the active mining areas. Where the deposits are less thick, the undifferentiated surficial deposits are stripped off before mining to expose the underlying Suwannee Limestone. These surficial materials consist of the overburden that is removed before mining and occurs unconformably above the mineable limestone materials.

H.4.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable limestone unit in Study Area No. 3 that occurs directly below the overburden is the Suwannee Limestone. The Suwannee Limestone is marine, bioclastic, Early Oligocene limestone (33.9 to 23.03 mya) [Yon and Hendry Jr., 1972]. Based on FDEP ERP records, mineable deposits of Suwannee Limestone generally occur to depths of approximately 70–90 ft bls. The lithology of the Suwannee Limestone varies from a partially recrystallized limestone (i.e., calcarenite), which is very pale, finely crystalline, firmly to weakly cemented with fine to very fine, silty sand and clay to a very pale orange, very finely crystalline, firmly cemented calcarenite (i.e., hard) with very-fine- to fine-grained sand and clay [Yon and Hendry Jr., 1972]. Postdepositional recrystallization has resulted in alternating hard and soft lenses or zones of varying thickness, with thin discontinuous beds of clay and chert sometimes occurring within the limestone matrix [Yon and Hendry Jr., 1972]. The Suwannee Limestone can also be highly fossiliferous. The approximate extent of the Suwannee Limestone within Study Area No. 3 is presented in Figure H-12. As shown, lower permeability Hawthorn Group sediments can also occur in isolated extents above the Suwannee Limestone, which thereby increases the overburden thickness and potentially limits its extraction.

The recrystallized areas of the Suwannee Limestone at Study Area No. 3 exhibit sufficient hardness from postdepositional alteration and are useable for concrete (i.e., aggregate) or other construction purposes. Both the interbedded hard and soft layers are mined, but only the harder, recrystallized limestone is reportedly of high value. The harder material is extracted by a dragline and explosives to facilitate removal. Softer material and clays are removed with heavy machinery only (i.e., trackhoes) and are typically washed away and stored in specified tailings ponds [Yon and Hendry Jr., 1972]. A generalized hydrogeologic column for Study Area No. 3 is provided in Figure H-13.

H.4.4 AQUIFER SYSTEMS

The undifferentiated surficial deposits (i.e., overburden) can locally support an unconfined Surficial Aquifer System (i.e., perched water table) where clayey sands and sandy clays occur above the Suwannee Limestone upper contact. However, given their limited areal extent, the underlying Floridan Aquifer System is considered generally unconfined within Study Area No. 3.

The Suwannee Limestone, which is relatively permeable and can exhibit cavernous voids, is an important freshwater-bearing unit of the Floridan Aquifer System and is used as a water-supply source by the mining industry, industrial facilities, and domestic self-suppliers. The underlying Ocala Limestone

Undifferentiated Sediments

Generally, undifferentiated sand, silt and clay which is poorly to excessively drained across the study area. These surficial deposits may support a perched water table in some areas but are generally unsaturated in the mining operation facilities.

Suwannee Limestone

Generally, white to pale orange, occasionally sandy, partially recrystallized to crystalline marine bioclastic limestone which has alternating hard and soft beds of varying thickness. May also include thin seams and beds of clay and chert.

Ocala Limestone

Generally divided into upper and lower facies based on lithology: Lower facies is white to cream-colored, fine to medium grained, poorly to moderately indurated, very fossiliferous limestone. Upper facies is white, poorly to well indurated, poorly sorted, very fossiliferous limestone.

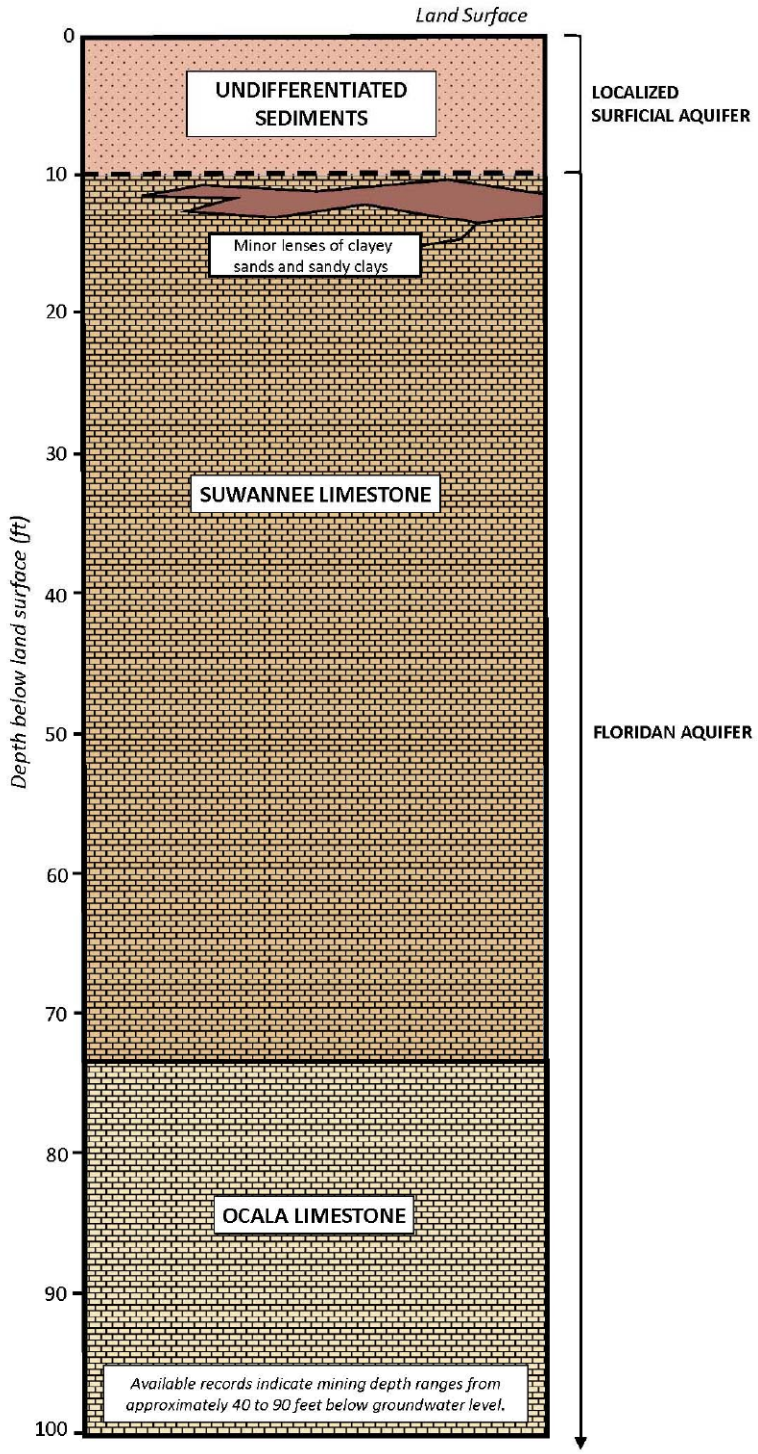

Figure H-13. Study Area No. 3 Generalized Hydrogeologic Column.

is included in the Upper Floridan Aquifer, is a major water-supply source in the region, and is one of the most permeable rock units in the Floridan Aquifer System. Average Upper Floridan Aquifer water levels can range from 30 to 50 ft bls, which allows strip mining to occur without dewatering or using draglines. The lack of consistent confining sediments and downward hydraulic gradient facilitates recharge to the Upper Floridan Aquifer and contributes to limestone dissolution.

H.5 STUDY AREA NO. 4 – LEE COUNTY, FLORIDA

Study Area No. 4, which is shown in Figure H-14, is located east of Interstate 75 (I-75) and north of Corkscrew Road in southern Lee County. Study Area No. 4 is located entirely within the SFWMD and has one representative operating limestone mine that consists of two ERPs: the Youngquist, Harvey and Timothy – University Lakes Mine (FDEP ERP No. 176063) and the Youngquist Brothers Rock, Inc. – West Lakes Mine (FDEP ERP No. 194206). Note that, although permitted separately, these mines generally appear to function as one large mining operation that is controlled by the same entity according to the FSFM. The currently permitted extent of this mining operation that is based upon the two respective ERPs is identified in Figure H-15.

H.5.1 GEOMORPHIC SETTING

Study Area No. 4 occurs near the western boundary of the Immokalee Rise and is within the Southwestern Slope physiographic province. The Immokalee Rise to the east is an emergent submarine shoal that was reportedly formed by low-energy conditions [White, 1970]. The Southwestern Slope is a gentle, westerly sloping plain between the Immokalee Rise and the Gulf Coastal Lagoons to the west. Land-surface elevations within Study Area No. 4 generally range from 19 to 26 ft North American Vertical Datum of 1988 (NAVD88), with an average of 22.5 feet NAVD88 [Lee County, 2018]. Lee County has also been described as occurring within the South Florida Province, which lies within the Gulf of Mexico Sedimentary Basin, and generally consists of carbonate sedimentary rocks [Wedderburn et al., 1982].

H.5.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped the soils that surround the mining and nearby areas in 1984. The soils within Study Area No. 4 are highly variable, and large areas have been disturbed by mining activities, but predominant soils are reported by the NRCS as Pineda fine sand, Malabar fine sand, and Valkaria fine sand. Pineda fine sand typically formed in thick beds of sandy and loamy marine sediments that are nearly level, poorly drained with slopes that range from 0 to 2 percent. The water table can range from 10 in bls in the wetter seasons to 10–40 in during the rest of the year. During extended dry periods, the water table can exceed more than 40 in bls [Soil Conservation Service, 1984]. Malabar *fine* sand is a poorly drained to very poorly drained soil with slopes that range from 0 to 2 percent. Under normal conditions, the water table can range from less than 10 in to more than 40 in bls during extended dry periods. During heavy rain events, the soil is covered by a shallow layer of water for periods of approximately 7 to 30 days [Soil Conservation Service, 1984]. Another soil described within Study Area No. 4 is Valkaria fine sand, which is a rapidly permeable soil that formed in thick beds of marine sands with slopes that range from 0 to 2 percent. These soils occur in broad, poorly defined, low-gradient drainage ways, depressions, and low nearly level areas. Under natural conditions, these soils are saturated at depths between 0 and 12 in with depressional areas that are covered by shallow water during the summer rainy season [Henderson, Jr., 1984].

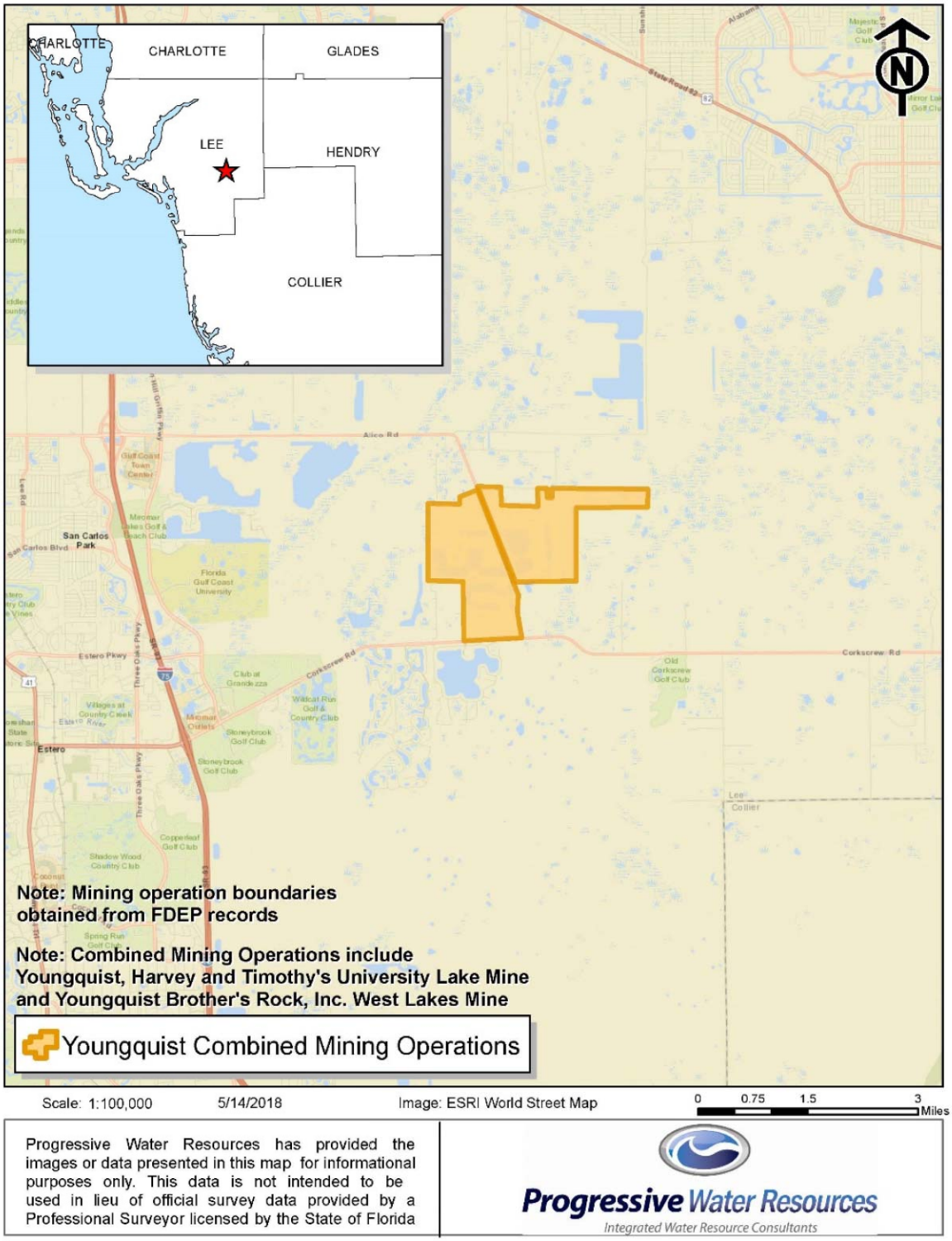

Figure H-14. Regional Location of Study Area No. 4 Representative Mining Operation.

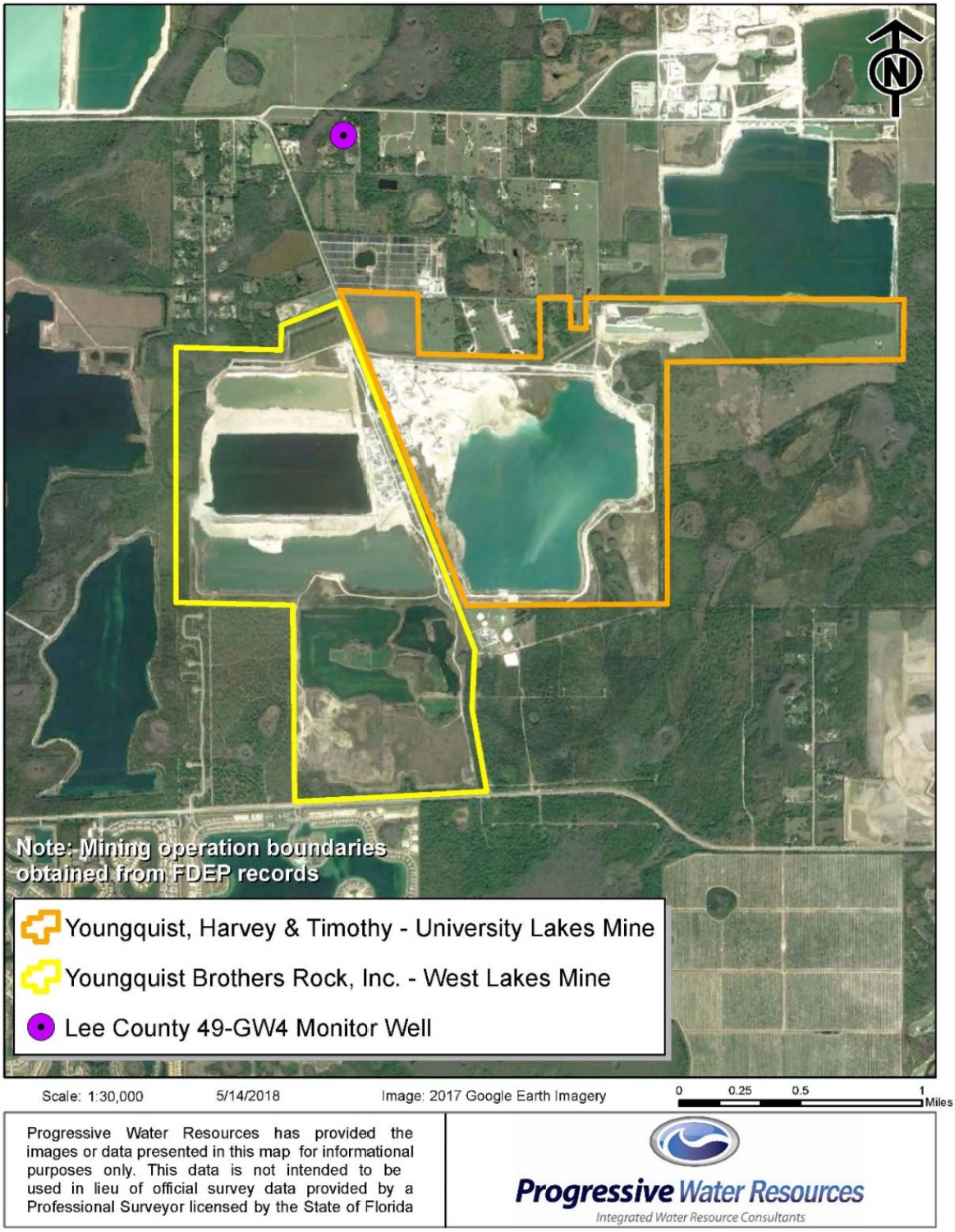

Figure H-15. Study Area No. 4 Permitted Mining Operation Boundaries.

Beneath these surficial soils are undifferentiated deposits that consist predominantly of fine-grained, silty quartz sand with variable amounts of shell. Lithologically, these sediments are complex and can contain some of the most abundant and diverse mollusk fossil faunas in the world [USGS, 2018a]. Below the surficial sands, thin discontinuous deposits of clayey sands can sometimes overlay an uneven, upper contact of limestone associated with the underlying Tamiami Formation. These surficial materials extend approximately 10–20 ft bls and consist of the overburden that is removed before mining the underlying limestone. The broad extent of surficial materials that overlie the Tamiami Formation in Study Area No. 4 is shown in Figure H-16.

H.5.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable unit, which occurs directly beneath the overburden within Study Area No. 4, is the Tamiami Formation; although, the shelly deposits above the Tamiami Formation can also be mined. Based on FDEP ERP records, mineable deposits of the Tamiami Formation within Study Area No. 4 occur to depths of approximately 45–108 ft bls. Based on the Lee County Utilities (LCU) Well Completion Reports within Study Area No. 4, the limestones, sands, and marls of the Tamiami Formation extend to approximately 130 to 150 ft bls. The Tamiami Formation consists primarily of yellowish gray, shelly, quartz, sandy, slightly phosphatic limestone with a calcilutite or recrystallized calcite matrix and includes the Ochopee and Buckingham Limestone Members as well as the Pinecrest Sand Member [Green et al., 1990]. Minor phosphate is present as sand- to gravel-sized particles. Fossils can occur as molds, casts, and original material and include barnacles, mollusks, corals, and echinoids [Green et al., 1990].

In some areas of Lee County, the sediments of the Tamiami Formation can be subdivided into upper and lower units that are separated by low permeability (i.e., clayey sediments). A review of the well completion reports for Lee County's public supply wells and nearby citrus irrigation wells does not indicate the presence of a consistent confining unit that separates the upper and lower sediments of the Tamiami Formation; however, where present, the confining unit may play a role in the permitted mining depths. Underlying the Tamiami Formation is the Hawthorn Group, which consists of variably phosphatic clayey sands, sandy clays, and dolostones. A generalized hydrogeologic column for Study Area No. 4 is provided as Figure H-17.

H.5.4 AQUIFER SYSTEMS

The Tamiami Formation has highly permeable to impermeable lithology that forms a complex aquifer. Locally, the Tamiami Formation is part of the Surficial Aquifer System that underlies all of Study Area No. 4 and is a major regional source of groundwater because of the unit's shallow depth (near the land surface) and high transmissivity. The unconfined Surficial Aquifer System extends to depths of approximately 130–150 ft bls. Agricultural operations and other water users have extensively used the high-yielding Tamiami Formation as a water-supply source for decades. A relatively thick, confining unit of clayey sediments associated with the Hawthorn Group marks the base of the unconfined Surficial Aquifer System [Boggess and Watkins, 1986]. Based on the monitor well data that were obtained from Lee County's Hydrological Monitoring Program, groundwater levels for the Tamiami Formation seasonally fluctuate between approximately 0.5 and 4 ft bls.

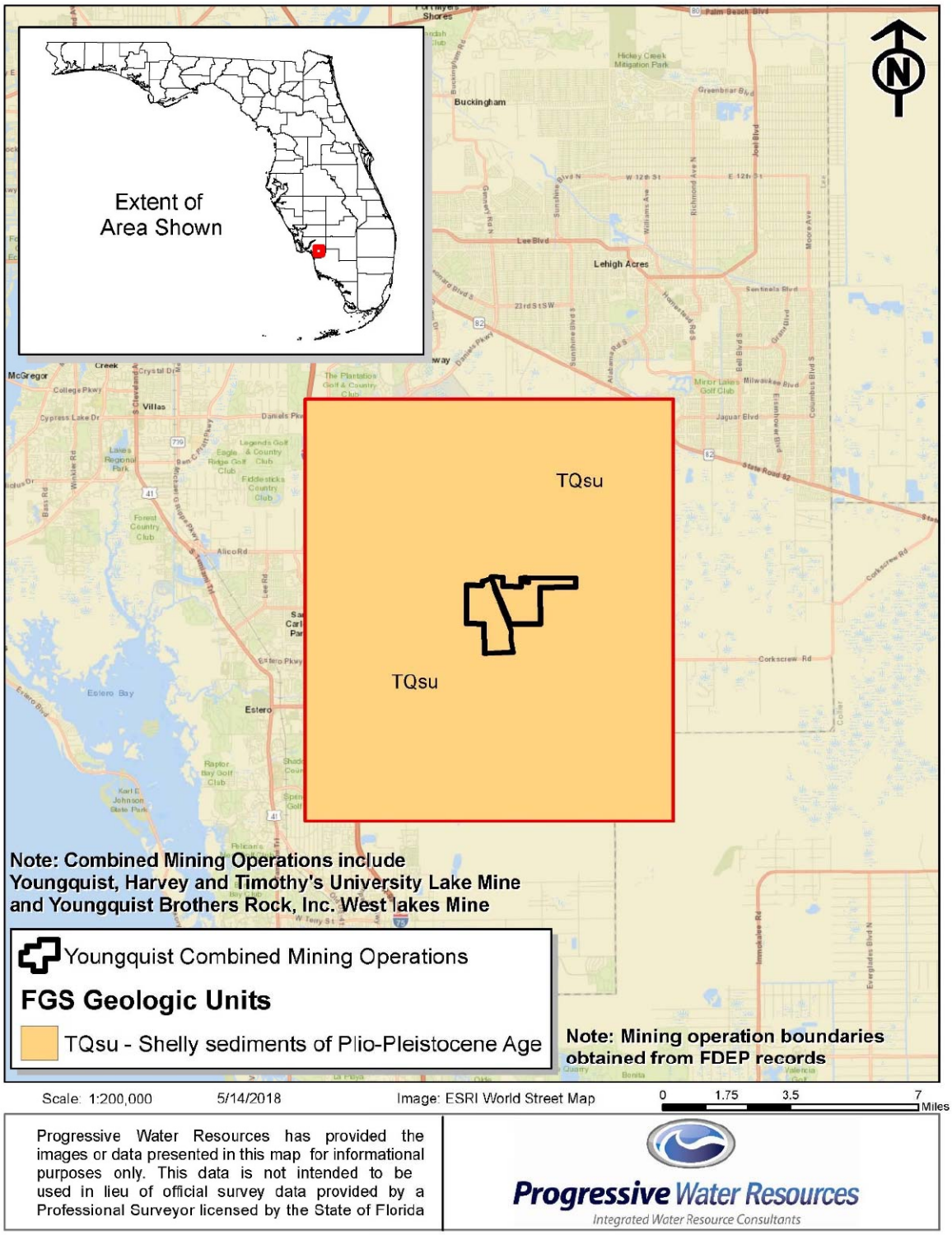

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Figure H-16. Study Area No. 4 Florida Stratigraphic Geology and Combined Mining Operations.

Plio-Pleistocene Shelly Sediments

Generally, white to gray to yellow, unconsolidated to poorly indurated sand that contains interbedded white to light orange, calcareous sandstone that is variably poorly to moderately indurated. Shell and shell fragments are present throughout.

Tamiami Formation

Generally, yellowish gray, shelly, quartz sandy, slightly phosphatic limestone with calcilutite or recrystallized calcite matrix. Includes the Ochopee and Buckingham Limestone Members and the Pinecrest Sand Member.

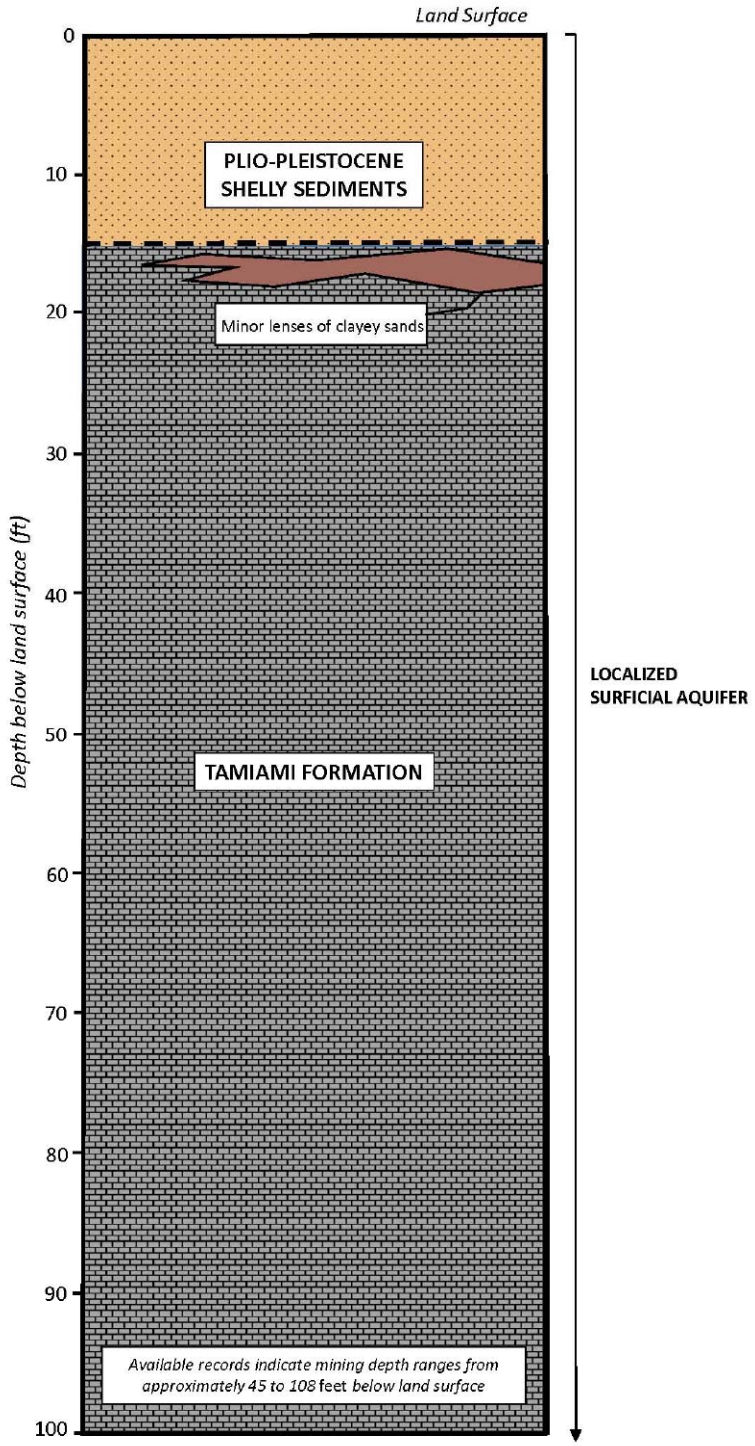


Figure H-17. Study Area No. 4 Generalized Hydrogeologic Column.

H.5.5 LIMESTONE MINING OPERATION – STUDY AREA NO. 4

The FDEP-permitted mining operations within Study Area No. 4 are presented in Figure H-15. Note that although permitted separately, these mines generally appear to function as one large mining operation controlled by the same entity according to the FSFM. According to FDEP ERP records, the maximum depth of mining ranges between approximately 92 and 108 ft bls. This mining operation reportedly uses blasting methods to excavate the limestone. Limestone is excavated via a dragline from water-filled pits and transported by haul trucks to a centrally located processing facility and further refined before shipment.

H.6 STUDY AREA NO. 5 – NORTHERN DADE COUNTY, FLORIDA

Study Area No. 5, which is shown in Figure H-18, is located west of I-75, bisected by US Highway 27, and situated along the Broward-Dade County line. Study Area No. 5 is located entirely within the SFWMD and has one representative limestone mining operation: the Vecellio and Grogan, Inc. White Rock Quarries Mine (FDEP ERP No. 0175273-017). The permitted extent of this mining operation is shown in Figure H-19.

The representative mining operation for Study Area No. 5 is located within the Lake Belt region. The Lake Belt region (the Northwest Dade County Freshwater Lake Plan Area) is wholly located within Dade County and is approximately 89 square miles [Kindinger, 2002]. The Lake Belt region is bounded by the Everglades to the west, the Homestead Extension of the Florida Turnpike to the east, and Kendall Drive (State Highway 94) to the south. The Lake Belt region consists of various manmade lakes because of significant limestone mining activities and is reported to exhibit the hardest and most durable limestone materials in the state [Lampl Herbert Consultants, 2007]. Several of the mining operations within the Lake Belt region are large in areal extent and have a relatively high annual production output compared to other limestone mining operations in Florida.

H.6.1 GEOMORPHIC SETTING

Study Area No. 5 is wholly within the Everglades physiographic province. Land-surface elevations within the study area are generally less than 10 ft amsl. Land surface and the upper contact of the underlying limestone are virtually horizontal, which infers that the area was effectively leveled through dissolution and weathering associated with historic sea levels [White, 1970]. The surface below the upper contact can commonly exhibit a jagged, pockmarked appearance. The subsequent accumulation of peat deposits (which can reach several feet in thickness) above the limestone was reportedly produced by prolonged high-freshwater-level conditions that supported the growth of fibrous wetland vegetation.

H.6.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped the soils that surround the nearby mining and urban areas of the Broward and Dade Counties in 1976. Given the highly disturbed, developed, and altered conditions of Study Area No. 5, only the three predominant soil types described by the NRCS are included herein. Lauderhill Muck is a moderately deep, poorly drained soil of well-decomposed plant remains and overlies limestone substrate in freshwater marshes. The depth to limestone is approximately 20–36 in. Dania Muck is a very poorly drained soil found in freshwater marshes and swamps along the fringes of deeper organic soils.

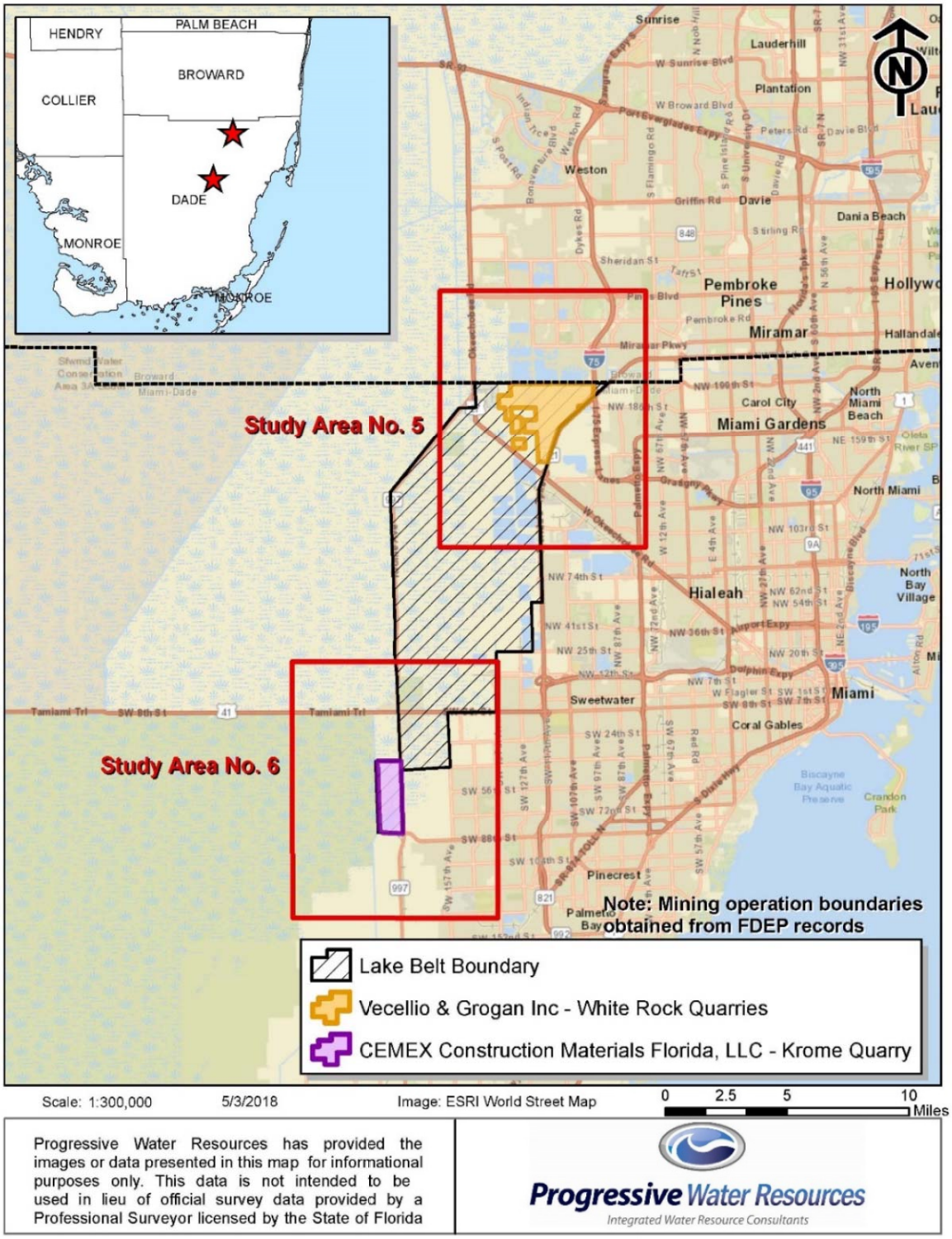
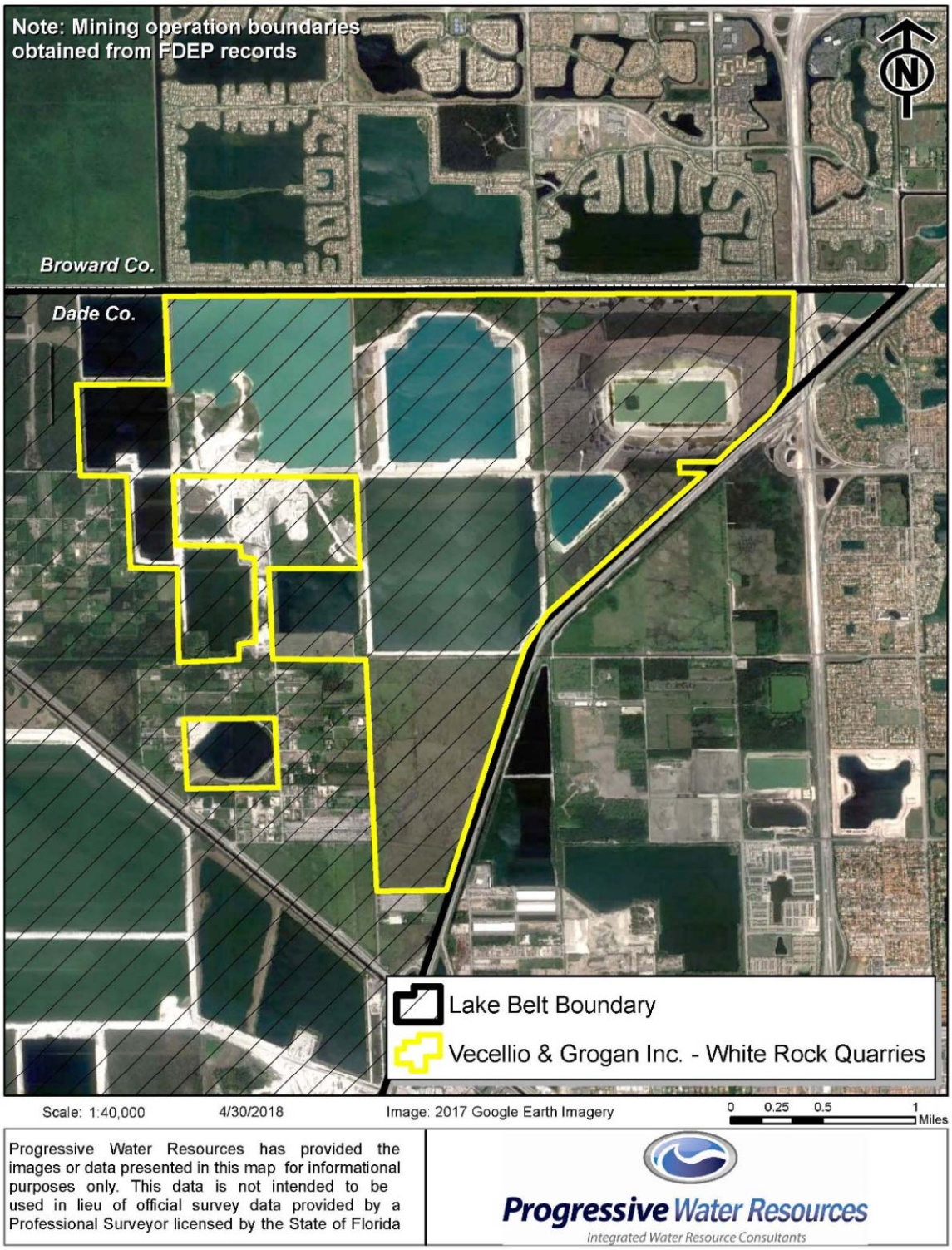


Figure H-18. Regional Locations of Study Area Nos. 5 and 6 Representative Mining Operations.



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Integrated Water Resource Consultants

Figure H-19. Study Area No. 5 Permitted Mining Operation Boundary.

These soils formed in thin deposits of well-decomposed plant remains that overlie sandy marine sediments and limestone. The depth to limestone is approximately 18 in. Udorthents – Water Complex is an excessively drained, unconsolidated, heterogeneous soil material that has been excavated and redeposited. The texture and thickness are highly variable, and the soil can be located in urban areas where soils were deposited to maintain structures above the seasonal highwater table. These surficial materials consist of the overburden that is removed before mining.

H.6.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable unit, which occurs directly underneath the organic rich (i.e., peat) surficial soils, is the Pleistocene Miami Limestone (previously identified as the Miami Oolite). Based on FDEP records, mineable deposits of the Miami Limestone within Study Area No. 5 have a thickness of approximately 15 to 20 ft, all of which is removed during mining. The Miami Limestone is generally white to orangish gray, poorly to moderately indurated, sandy limestone (grainstone) with scattered concentrations of fossils [USGS, 2018b]. Lenses of quartz sand and cemented sands may also be present, and fossil molds and casts are common. The broad extent of the Miami Limestone, which occurs at or very near to the land surface and extends beneath the everglades, is shown in Figure H-20.

Extraction occurs by using a dragline, and explosives are commonly used to fracture the limestone to facilitate its removal. The limestone is typically dried (gravity-drained) and crushed before being shipped for use in producing cement.

The Miami Limestone formed approximately 0.13 mya and reportedly consists of two facies: an oolitic-rich facies and a bryozoan facies [USGS, 2018b]. Oolites are small, round calcareous grains that concentrically form around a quartz sand grain or shell fragment nucleus. The separate facies indicate different depositional environments with the oolitic facies forming under higher energy conditions that are similar to those in the present-day Bahamas, whereas the bryzoan facies appear to have formed in a quieter, lagoon-type environment [Draper et al., 2006]. The higher energy conditions of the oolitic facies are shown by the pronounced cross-bedding commonly observed in exposures.

Underlying the Miami Limestone is the Fort Thompson Formation. The Pleistocene-age Fort Thompson Formation consists of alternating freshwater and marine marls and limestones with sand, shell marl, and sandstones and extends to depths of 80–100 ft bls [Cunningham et al., 2006]. Fluctuations in water-level elevations reportedly resulted in increased cementation with calcite, which caused the rock to harden and made the unit a significant source of aggregate. The Tamiami Formation underlies the Fort Thompson Limestone. A generalized hydrogeologic column for Study Area No. 5 is provided as Figure H-21.

H.6.4 AQUIFER SYSTEMS

The Miami and Fort Thompson Limestones consist of the highly productive Biscayne Aquifer. The Biscayne Aquifer is unconfined and extends down to the upper contact of lower permeability silts and clays of the Tamiami Formation [USGS, 2018b]. The Biscayne Aquifer is the principal source of water for the Dade and Broward Counties and the southeastern part of Palm Beach County. Miami-Dade County has its Northwest Wellfield within the Lake Belt region (immediately south of Study Area No. 5) and is part of the largest integrated, drinking-water wellfield system (386.07 million gallons per day) in Florida [Cunningham et al., 2006].

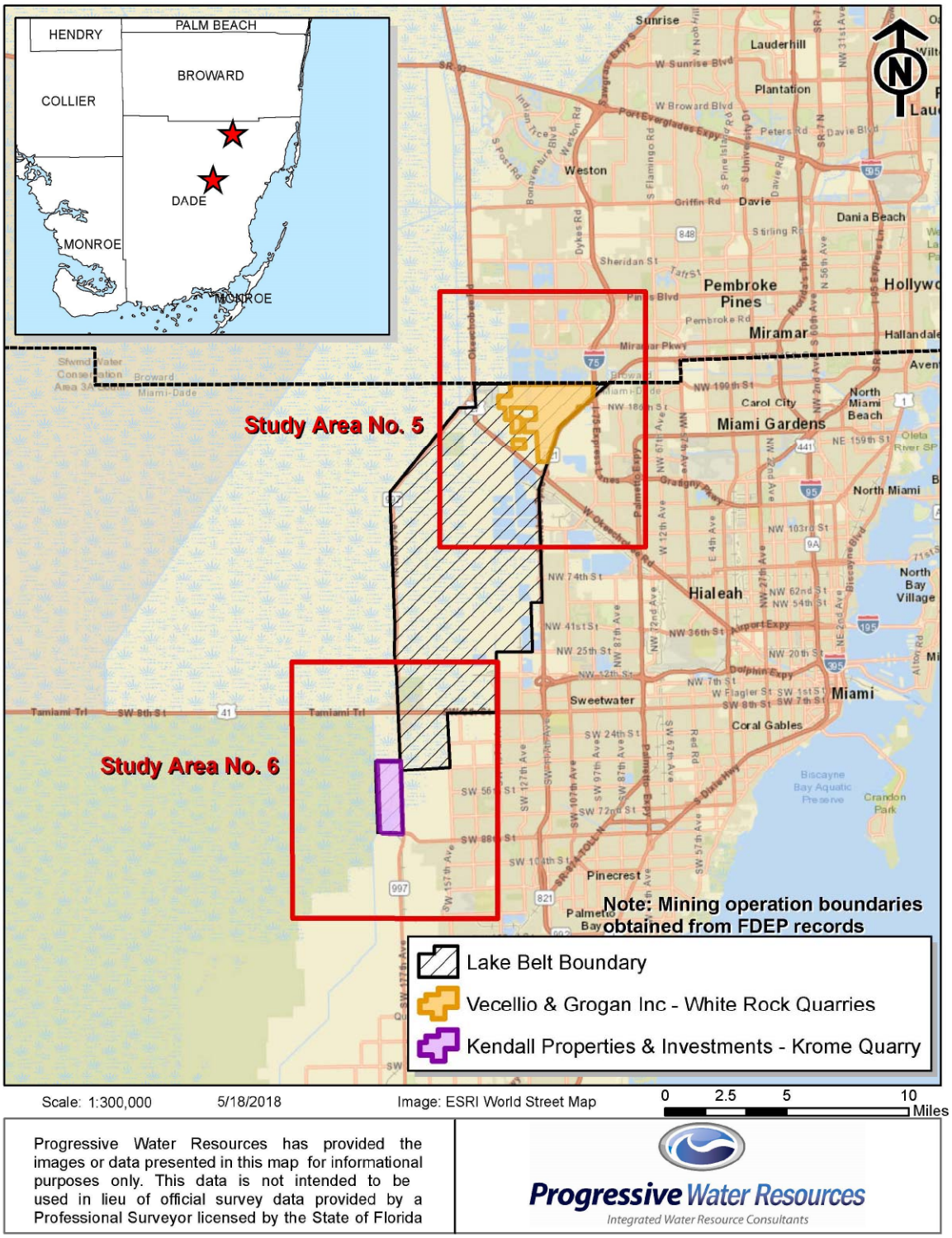

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Figure H-20. Study Area Nos. 5 and 6 Florida Stratigraphic Geology and Mining Operations.

Peat Surficial Soils

Generally, highly disturbed and altered organic rich (peat) soils which vary in thickness due to soil deposition to maintain structures above the seasonal high water table.

Miami Limestone

Generally, occurs at, or very near to, land surface and consists of two facies: an oolitic-rich facies which formed under high energy conditions similar to those in present day Bahamas and a bryozoan facies which formed under lower energy, lagoon-type environment. The higher energy conditions of the oolitic facies is evidenced by pronounced cross-bedding commonly observed in exposures. Generally white to orangish gray, poorly to moderately indurated, sandy, limestone with scattered concentration of fossils.

Fort Thompson Formation

Generally, composed of alternating fresh-water and marine marls and limestones with sand, shell marl, sandstones present. Fluctuations in water level elevations reportedly caused increased cementation with calcite, hardening the rock and making the unit a significant source of aggregate.

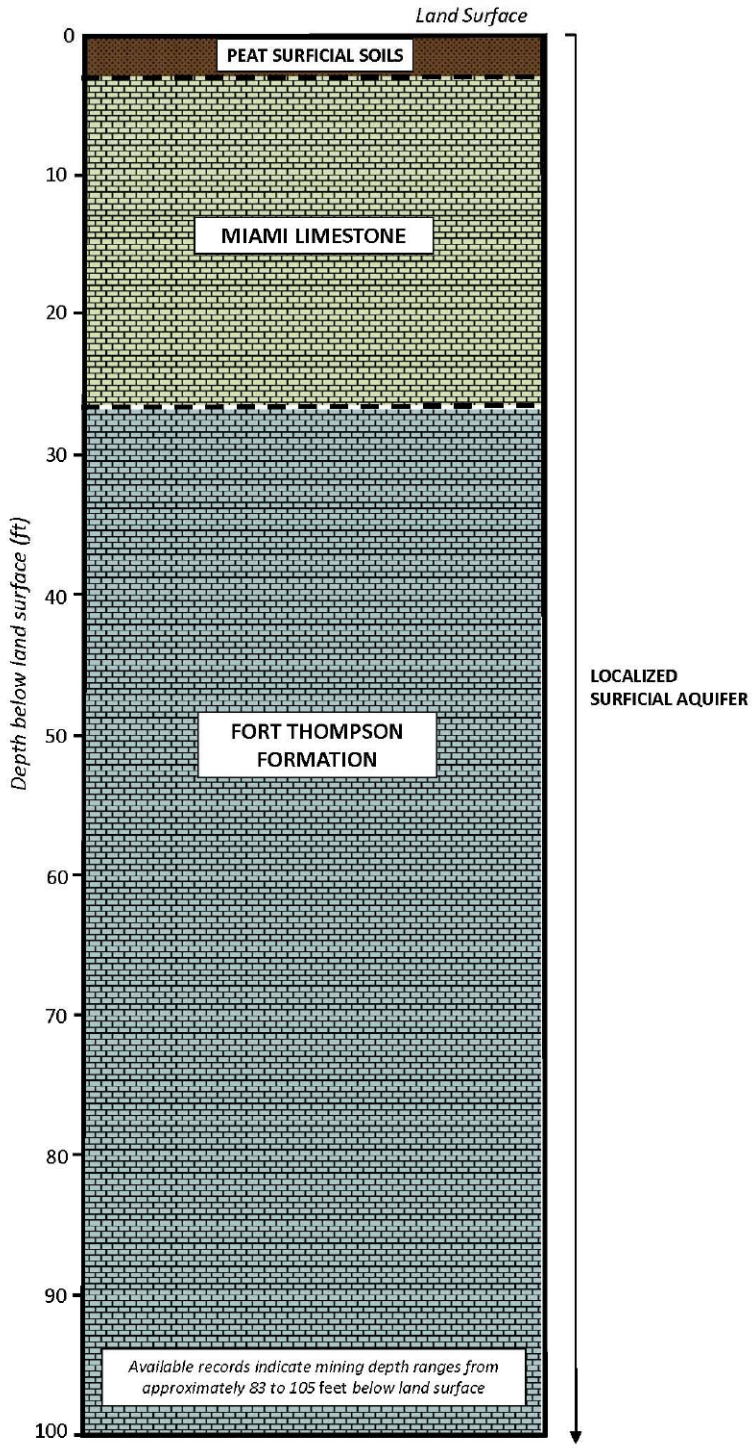

Figure H-21. Study Area No. 5 Generalized Hydrogeologic Column.

H.6.5 LIMESTONE MINING OPERATIONS – STUDY AREA NO. 5

The representative mining operation within Study Area No. 5 employs explosives and draglines to excavate. The FDEP ERP permit indicates that the representative Study Area No. 5 mine is generally permitted to extract limestone through the entire vertical section of the Miami Limestone and Fort Thompson Formation, and the Vecellio and Grogan Inc. White Rock Quarries mine is authorized to excavate to 100 ft deep.

H.7 STUDY AREA NO. 6 – CENTRAL DADE COUNTY, FLORIDA

Study Area No. 6, which is shown in Figure H-20, is immediately south of Study Area No. 5 and more specifically located west of the city of Miami, immediately west of Krome Avenue or SW 177th Avenue (State Road 997), and east of the L-30N Canal and the eastern boundary of the Everglades National Park in central Dade County. Study Area No. 6 is located entirely within the SFWMD and has one representative operating limestone mine: the Kendall Properties & Investments Krome Quarry (FDEP Permit No. 175262-005). The permitted extent of this mining operation is identified in Figure H-22.

H.7.1 GEOMORPHIC SETTING

Similar to Study Area No. 5, Study Area No. 6 is wholly within the Everglades physiographic province. The land surface is flat with surface elevations generally less than 10 ft amsl. The land surface and upper contact of the underlying limestone are virtually horizontal with the upper contact commonly exhibiting a weathered, pockmarked appearance. Study Area No. 6 also has freshwater peat deposits unconformably above the Miami Limestone.

H.7.2 DESCRIPTION OF SURFICIAL SOILS

The NRCS mapped the soils that surround the nearby mining and urban areas. Predominant surficial soils present within Study Area No. 6 are described by the NRCS as Chekika (very gravely loam), Dania Muck, and Udorthents – Water Complex [NRCS, 2018]. The Chekika series consists of very shallow, somewhat poorly drained, moderately permeable soils over the limestone substrate. These soils were formed by the weathering and erosion of limestone outcrops. Slopes range from 0 to 2 percent [NRCS, 2018]. Dania Muck is a very poorly drained soil found in freshwater marshes and swamps along the fringes of deeper organic soils. These soils are formed in thin deposits of well-decomposed freshwater plant remains that overlie sandy marine sediments and limestone. The depth to the limestone is approximately 18 in [NRCS, 2018]. Udorthents – Water Complex is an excessively drained, unconsolidated heterogeneous soil material that has been excavated and redeposited. The texture and thickness are highly variable, and the soil is often found in urban areas, where soils were deposited to maintain structures above the seasonal high-water table [NRCS, 2018]. These surficial materials comprise the overburden that is removed before mining and is above mineable limestone materials.

H.7.3 DESCRIPTION OF GEOLOGIC UNITS

The mineable unit, which occurs directly underneath the surficial soils, is the Pleistocene Miami Limestone. Based on FDEP ERP records, mineable deposits of the Miami Limestone within Study Area No. 6 are approximately 15–20 ft thick. The Miami Limestone is a generally white to orangish gray, poorly to moderately indurated, sandy grainstone with scattered concentrations of fossils [USGS, 2018b].

Figure H-22. Study Area No. 6 Permitted Mining Operation Boundary.

Lenses of quartz sand and fossil molds as well as casts are common. As with Study Area No. 5, the Pleistocene Miami Limestone reportedly has two facies—an oolitic-rich facies and a bryozoan facies [USGS, 2018b]—that represent a higher energy and a quieter, lagoon-type depositional environment, respectively [Draper et al., 2006].

Extraction occurs by using a dragline, and explosives are commonly used to fracture the limestone to facilitate its removal. The limestone is typically dried (i.e., gravity-drained) and crushed before being shipped for use in producing cement.

Underlying the Miami Limestone is the Fort Thompson Formation. The Pleistocene-age Fort Thompson Formation consists of freshwater and marine marls and limestones with sand, shell marl, and sandstones and extends to depths of 80–100 ft bls [Cunningham et al., 2006]. The limestones are hardened through postdepositional alteration, which results in units being a significant source of construction aggregate. The Tamiami Formation underlies the Fort Thompson Limestone. A generalized hydrogeologic column for Study Area No. 6 is provided as Figure H-23.

H.7.4 AQUIFER SYSTEMS

The Miami and Fort Thompson Limestones consist of the highly productive Biscayne Aquifer. The Biscayne Aquifer is unconfined and extends down to the upper contact of the Tamiami Formation [USGS, 2018b]. The Biscayne Aquifer is the principal source of water for the region, and the Miami-Dade County Northwest Wellfield is located immediately to the north.

H.7.5 LIMESTONE MINING OPERATIONS – STUDY AREA NO. 6

The representative mining operation within the Lake Belt region uses explosives and draglines to excavate. As shown on Figure H-20, the Kendall Properties & Investments Krome Quarry Mine is within the Lake Belt region. FDEP records indicate that the Kendall Properties & Investments Krome Quarry Mine is permitted to excavate to approximately 50 to 55 ft bls, respectively.

Peat Surficial Soils

Generally, highly disturbed and altered organic rich (peat) soils which vary in thickness due to soil deposition to maintain structures above the seasonal high water table.

Miami Limestone

Generally, occurs at, or very near to, land surface and consists of two facies: an oolitic-rich facies which formed under high energy conditions similar to those in present day Bahamas and a bryozoan facies which formed under lower energy, lagoon-type environment. The higher energy conditions of the oolitic facies is evidenced by pronounced cross-bedding commonly observed in exposures. Generally white to orangish gray, poorly to moderately indurated, sandy, limestone with scattered concentration of fossils.

Fort Thompson Formation

Generally, composed of alternating fresh-water and marine marls and limestones with sand, shell marl, sandstones present. Fluctuations in water level elevations reportedly caused increased cementation with calcite, hardening the rock and making the unit a significant source of aggregate.

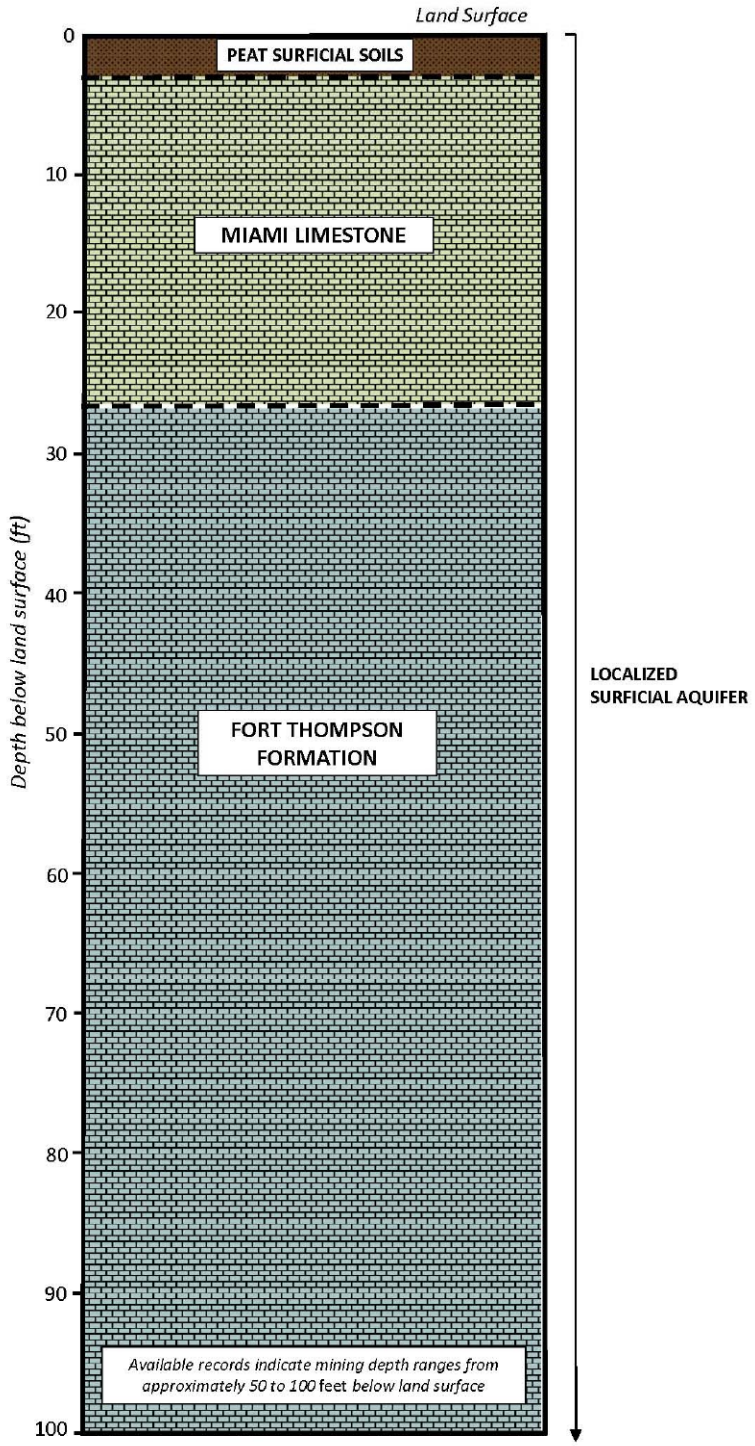

Figure H-23. Study Area No. 6 Generalized Hydrogeologic Column.

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APPENDIX I

COMPLAINT INVESTIGATION REPORT SUMMARY

Site	Complaint Date	Complaint Time	Case Number	Damage Claim (Y/N)	Claim Notes	Over Limits (Y/N)	Report Date	Additional Notes
Brooksville Quarry	3/9/2017	11:09	C/S	N		N	3/15/2017	Mine was noted to be moving closer to residence
Krome Quarry	3/6/17 and 3/817	13:00	340	Y	Cracks in screen door	N	3/9/2017	Investigator stated that owner complained about truck noise and vibrations felt, no blasting occurred on days of complaint
Branford Quarry	11/6/2017			N	Ornaments fell off tree	N	1/11/2018	Notes that seismographs were set to 0.5? Need clarification
White Rock Quarries	8/28/2017	11:00		N		Y	10/19/2017	Airblast of 135db, reason give due to geologogical anomolies and cracking in the ground
White Rock Quarries	9/25/2017	not associated with specific blast		Y	Interior and exterior cracks, water main break	N	10/5/2017	Reports were reviewed and case closed
West Lakes Mine	1/4/2018	9:52		Y	Pool leak	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/4/2018	not associated with specific blast		N	Furniture shaking	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/5/2018	not associated with specific blast		N	Noise, windows rattling, house shaking	N	no date	Reports were reviewed and case closed
West Lakes Mine	12/29/2017	not associated with specific blast		Y	Damage to homes and foundations			
West Lakes Mine	12/29/2017	not associated with specific blast		N	Annoyance, shook chair	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/4/2018	9:30		N	Annoyance, door and window rattling	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/11/2018	11:20		Y	States building moves. Damage to houses and businesses	N	no date	Reports were reviewed and case closed
West Lakes Mine	12/29/2017	not associated with specific blast		Y	General damage claim, annoyance	N	no date	Reports were reviewed and case closed
West Lakes Mine	1/5/2018	not associated with specific blast		N	Questions if damage is occuring	N	no date	Reports were reviewed and case closed
West Lakes Mine	12/28/2017	not associated with specific blast		N	Annoyance, windows shaking	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	12/29/2017	Past 10 days, not associated with specific blast		N	Shaking windows and houses	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/19/2018	see pg. 33 of pt. 1		N	Annoyance	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	12/28/2017	12/22 @ 9am, 12/26 @ 9:40am, 12/28 @ ?		N	Annoyance	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/2/2018	not associated with specific blast		N	Claim submitted by Village of Estero	N	no date	Reports were reviewed and case closed
West Lakes Mine	12/29/2017	time not provided		N		N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/11/2018	not associated with specific blast		N	Annoyance, concerned about property value	N	no date	Reports were reviewed and case closed
West Lakes Mine	1/5/2018	9:30		N	Window rattling	N	no date	Reports were reviewed and case closed

West Lakes Mine	no date	not associated with specific blast		N	Annoyance	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	12/28/2017	not associated with specific blast		Y	Foundation cracks, pool cracks, sinkholes	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	12/29/2017	9:54		N	Only states that a blast occurred	N	1/8/2018	Reports were reviewed and case closed
West Lakes Mine	1/3/2018				Youngquist permit expiration			Details are at the end of the first YB document and the beginning of the second
West Lakes Mine	4/31/17	10am 4/24-4/28		N	Annoyance	N	4/31/17	Reports were reviewed and case closed
West Lakes Mine					paul ford	N	4/17/2017	Reports were reviewed and case closed
West Lakes Mine						N	4/28/2017	Reports were reviewed and case closed
West Lakes Mine	4/6/2017	10:07		N	Annoyance and fear of damage	N	4/13/2017	Reports were reviewed and case closed
West Lakes Mine	4/4/2017	9:30		N	Concern about blasting	N	4/13/2017	Reports were reviewed and case closed
West Lakes Mine	3/14/2017	3/8 @ 12:49, 3/10 @ 10:14, and 3/14 @ 11:58		N	Concern and request for seismograph, stated neighbor had damage to concrete	N	3/21/2017	Reports were reviewed and case closed
West Lakes Mine	2/3/2017	not associated with specific blast		N	Annoyance	N	2/7/2017	Reports were reviewed and case closed

APPENDIX J

FSFM INVESTIGATIVE REPORT FORMATS

BUREAU OF FIRE PREVENTION

REQUEST FOR REVIEW

File Number: _____ **Date:** _____

Name of Investigator: _____

COMPLAINANT INFORMATION

Name: _____

Address: _____

Phone: _____

Email: _____

SUBJECT OF REVIEW INFORMATION

Name: _____

Address: _____

Phone: _____

SUMMARY OF REVIEW

BUREAU OF FIRE PREVENTION

COMPLAINT FOR REVIEW FORM

Case Number: _____ **Date:** _____

Name of Investigator: _____

COMPLAINANT INFORMATION

Name: _____

Address: _____

Phone: _____

Email: _____

SUBJECT OF REVIEW INFORMATION

Name: _____

Address: _____

Phone: _____ **License Number:** _____

SUMMARY OF REVIEW

BUREAU OF FIRE PREVENTION

REQUEST FOR INVESTIGATION

File Number: _____ **Date:** _____

Name of Investigator: _____

COMPLAINANT INFORMATION

Name: _____

Address: _____

Phone: _____

Email: _____

SUBJECT OF INVESTIGATION INFORMATION

Name: _____

Address: _____

Phone: _____

SUMMARY OF COMPLAINT

BUREAU OF FIRE PREVENTION

REQUEST FOR INVESTIGATION

Case Number: Date:

Name of Investigator:

COMPLAINANT INFORMATION

Name:

Address:

Phone:

SUBJECT OF INVESTIGATION INFORMATION

Name:

Address:

Phone: License Number:

Summary of Complaint

BUREAU OF FIRE PREVENTION

COMPLAINT FOR REVIEW FORM

Case Number: _____ **Date:** _____

Name of Investigator:

_____

COMPLAINANT INFORMATION

Name: _____

Address: _____

Phone: _____

Email: _____

SUBJECT OF REVIEW INFORMATION

Name: _____

Address: _____

Phone: _____ **License Number:** _____

SUMMARY OF REVIEW

BUREAU OF FIRE PREVENTION

REQUEST FOR INVESTIGATION

Case Number: Date:

Name of Investigator:

COMPLAINANT INFORMATION

Name:
Address:
Phone:

SUBJECT OF INVESTIGATION INFORMATION

Name:
Address:
Phone:
License Number:

SUMMARY OF COMPLAINT

APPENDIX K

PUBLIC OUTREACH PLAN

APPENDIX K: PUBLIC OUTREACH PLAN

K.1 INTRODUCTION

RESPEC has developed a Public Outreach Plan for stakeholders who are interested in the state of Florida's regulations governing the limits of blast vibrations produced by construction materials mines in Florida. The Public Outreach Plan outlines a clear process for building and maintaining trust among all of the stakeholders involved, with a primary focus placed on effective communication between Florida, construction materials operations, and residents who live near those operations. The purposes of the Public Outreach Plan are to inform all stakeholders about the study conducted by RESPEC on behalf of the Florida State Fire Marshal (FSFM) and provide a protocol for providing future updates should study activities and conclusions continue to evolve.

K.2 KEY STAKEHOLDERS

RESPEC has identified the following key stakeholders:

- Residents and neighbors near construction materials mines that blast
- Construction materials mining operations that blast
- Explosives manufacturers and service providers that sell or operate in Florida
- Independent seismologists
- Community leaders
- Local government and regulators
- State government and regulators.

K.3 PUBLIC OUTREACH PLAN

The three cornerstones to the Public Outreach Plan include the following:

- Releasing RESPEC's final report to the stakeholders
- Planning and holding public meetings
- Implementing a framework for continuing education.

K.4 STUDY RELEASE

The FSFM will release the RESPEC study to the key stakeholders for comments and review. The study document should be reviewed by all interested stakeholders. The primary mechanism for releasing the study will be uploading the original PDF document that is submitted by RESPEC to the FSFM website (and enabling download). For at least a short period, the FSFM should ensure that the study has high visibility on the home webpage. The current blasting information does not currently have high and immediate visibility.

The FSFM will need to compose and issue public announcements to govern the protocol for accepting comments about the study. In soliciting comments, the FSFM should provide a clear statement

regarding how the FSFM and the state of Florida intend to use the information and conclusions from the study.

The FSFM will issue multimedia announcements to ensure that all sectors of the affected stakeholder community are alerted to the study. Social media, newspapers, radio announcements, and mailing should be used to market the results of the study, planned public meetings, or planned work resulting from the study. Social media (e.g., Twitter, LinkedIn, and Facebook) should not be overlooked because many key stakeholders use social media, and social media also provides an opportunity for unknown stakeholders to be informed. Mailed announcements should be sent to neighbors of mines, the mining operators, local community officials, and local explosives and seismic contactors. While providing as much notice as possible is best, a minimum of 4 weeks' notice is recommended to minimize schedule conflicts.

K.5 PUBLIC MEETING

The FSFM will conduct at least one meeting per construction materials mining region in Florida to publicize the study to all stakeholders. The FSFM will invite state and local regulators; state and local politicians; community leaders, such as homeowner association (HOA) officers; residents within 5 miles of the blasting; mining companies; explosives contracting companies; and seismograph monitoring companies to the public meetings. Mailed announcements regarding the public meetings should be sent to all of the key stakeholders, and electronic and social media communication should also be used. The FSFM will use the following presentation tools (provided by RESPEC) when conducting outreach:

- **A PowerPoint presentation.** The PowerPoint presentation will target audiences with little or no knowledge regarding drilling and blasting to ensure that the FSFM caters to all of the key stakeholders. The presentation will cover background information on the study, the study itself, the results of the study, and the plans moving forward.
- **Posters.** Two posters will be used to provide the general findings from the study. One poster will identify the biggest questions investigated during the study, and the second poster will present the damage levels at which certain types of blast damage occur. The purpose of the posters is to educate key stakeholders about the study.

The FSFM will allow key stakeholders to voice their concerns about the study and future plans. The FSFM will design and distribute a feedback survey that will be made available in paper form to all of the attendees of each public meeting; the form and the slideshow should also be made available electronically on the FSFM website.

K.6 CONTINUING EDUCATION

Continuous public outreach is vital because neighborhoods, regulatory personnel, and mining operations personnel and ownership can change frequently. Methods for the FSFM to pursue continuing stakeholder communication and education should include the following:

- **Sustained efforts to provide future public meetings.** The FSFM will conduct annual regional meetings to refresh and update communities about the study and the progress of any follow-up work.

- **Maintaining and improving the FSFM's current webpage material related to blasting.** Considerable opportunity exists for the FSFM to convey its commitment to providing a sound technical basis for blasting regulations and provide an electronic home for the most current continuing education information and products.
- **Surveys.** The planned public meetings will provide a means of collecting contact information for the stakeholder community. Once this information has been collected, the FSFM will have a straightforward means to contact stakeholders (either electronically or by mail) to periodically solicit their current concerns and questions.

The FSFM must continuously survey the key stakeholders to ensure that all of the concerns and questions are addressed. The FSFM must continuously modify the presentation material if any of the key stakeholders do not understand the topics or have questions.