Influence of Geology on Ground Vibrations from Rock Blasting

City of Henderson Community Meeting
Monday, March 27, 2017

Henderson Multigenerational Center
250 S. Green Valley Parkway

Rock Blasting Studies – City of Henderson

2005	Vibration attenuation modeling
	Structure response study
	Close-in monitoring of a buried water tank
2005 - present	Review of blasting permit applications
2016-2017	Influence of geology on vibrations

Dr. Cathy Aimone-Martin

Blasting and Monitoring Consultant to the City of Henderson

President, Aimone-Martin Associates, LLC

25 years Chair Mining, Civil, Explosive Engineering, NM Tech

Specializations in

- mining, quarrying, construction blasting oversight
- instrumentation and measurements
- close-in vibration and air blast pressure control
- underwater blasting and aquatic species protection
- education and training

Projects

- World Trade Center, 2nd Ave.
- Panama Canal
- Dam/Spillway reconstruction
- SFOBB pier demolitions
- Skagway Bridge replacement

Vibration and Air Overpressure Monitoring Basics

involves the use of blasting-type seismographs

geophone

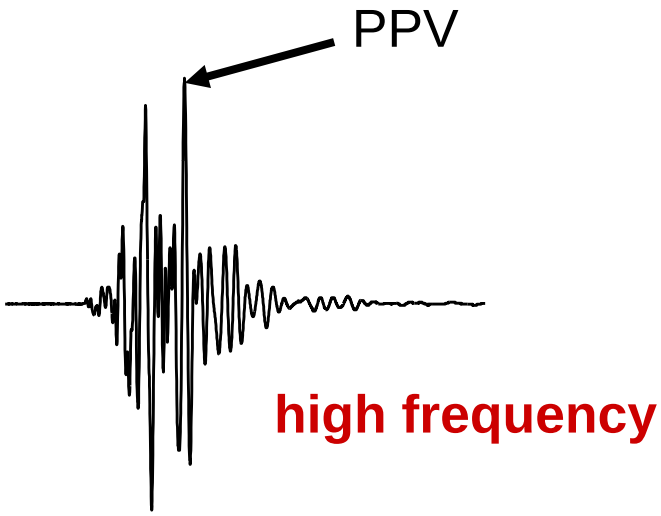
microphone

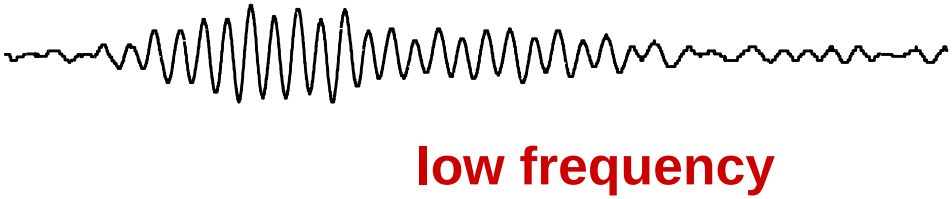
TERMS:

Peak particle velocity (PPV) – maximum ground vibration in terms of velocity (in/s)

“airblast” – air pressure converted to decibels (dB)

frequency – oscillations (cycles) of ground/air motion/second (Hz)





This presentation will focus on blast-induced ground vibrations and factors that affect the amplitude or intensity of vibrations at any one monitoring location

These factors include:

- Blast-site energy (blast design and confinement)
- Attenuation (or decrease) of ground energy between blast site and monitoring location
- Methods used to deploy or couple geophones to the ground
- Geology surrounding the geophone ←

Recommended standards for the manufacture and use of blasting seismographs are set by the International Society of Explosives Engineers (ISEE)

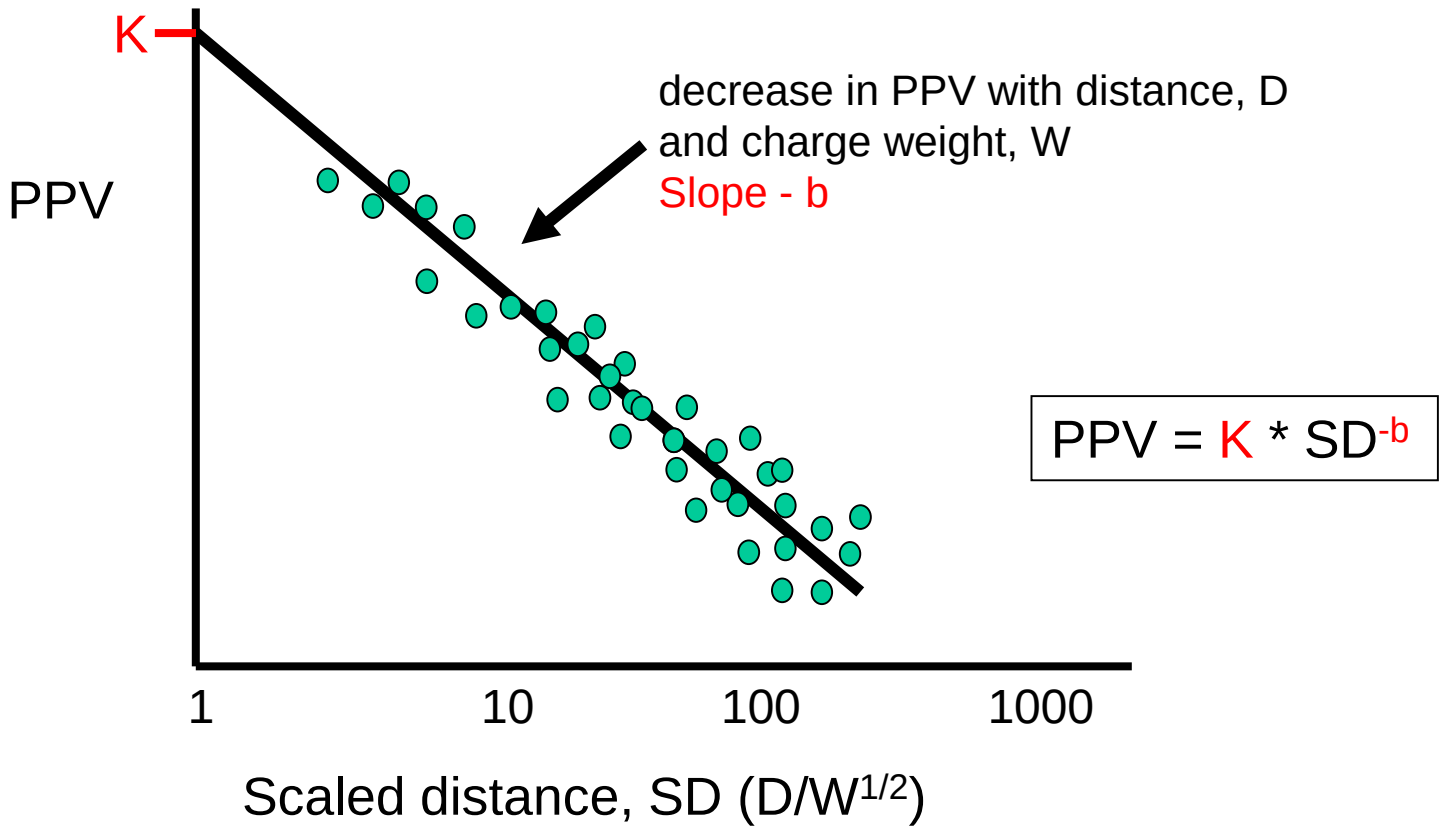
- Seismograph Committee – Field Practice Guidelines
- Standard Committee – Performance Specifications

These professional guidelines ensure that

- users are experienced and trained,
- seismographs are in calibration, and
- uniform field deployment for geophones and microphones is followed

Plotting and analyzing ground vibration measurements

1. Attenuation modeling used to design blasts and predict PPV

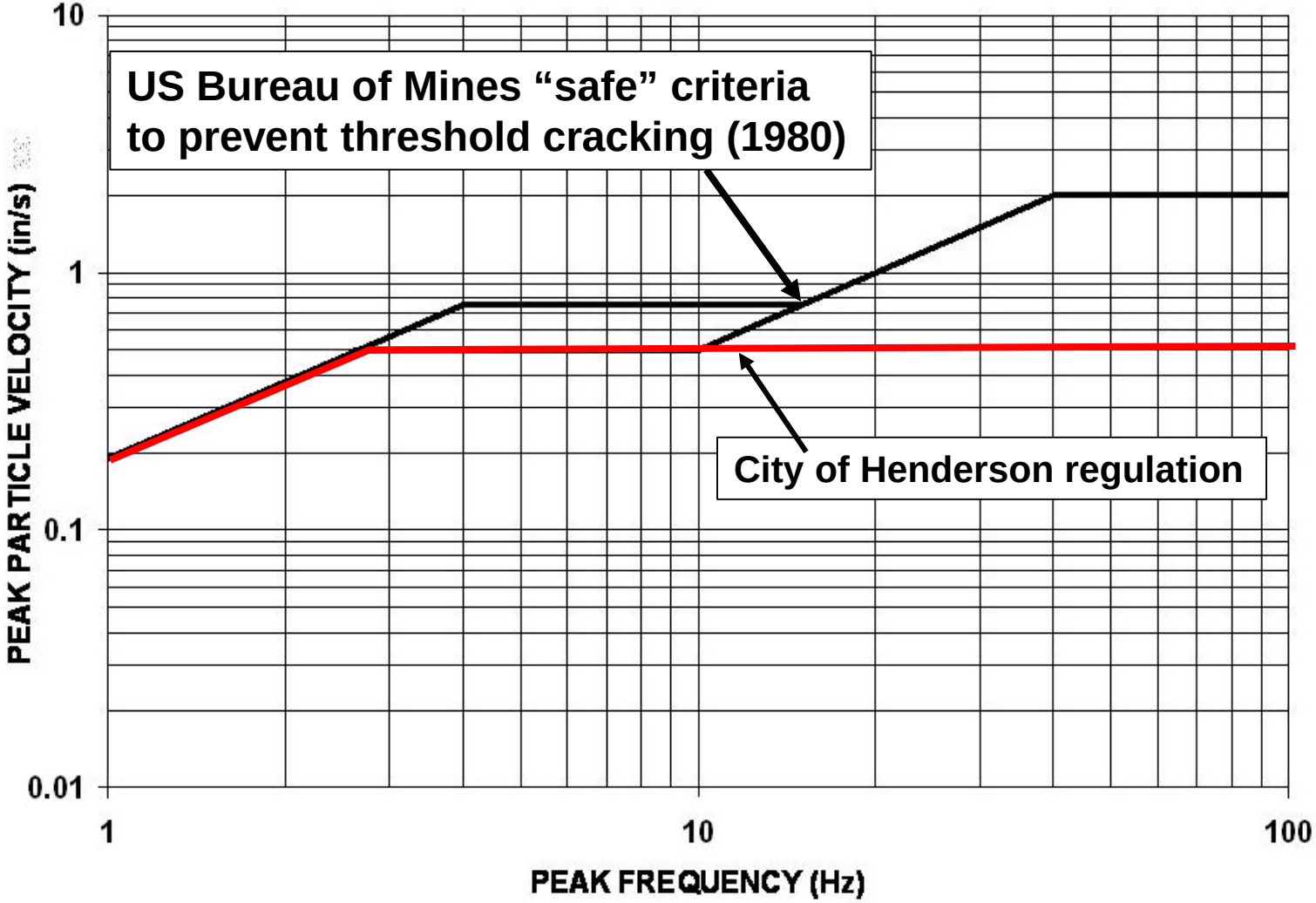


$$PPV = K * SD^{-b}$$

K seismic energy in the ground at the blast site

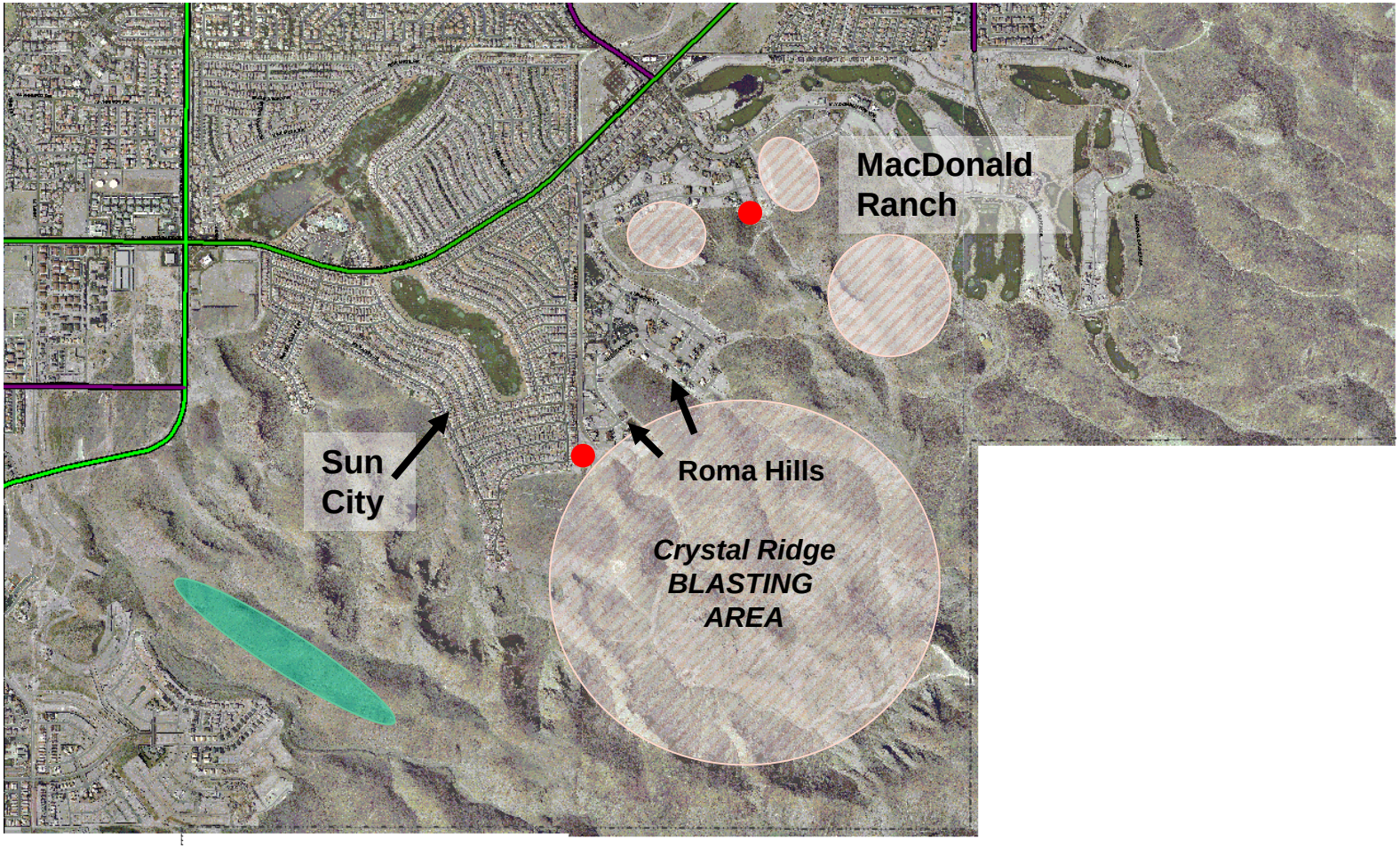
b rate of decrease in PPV with distance as influence by geology

2. Compliance with vibration regulations and safe standards



March 2005 - Studies conducted for the City of Henderson

- Vibration attenuation modeling – influence of geology and terrain
- Structure Response to Blasting & Environmental Impacts

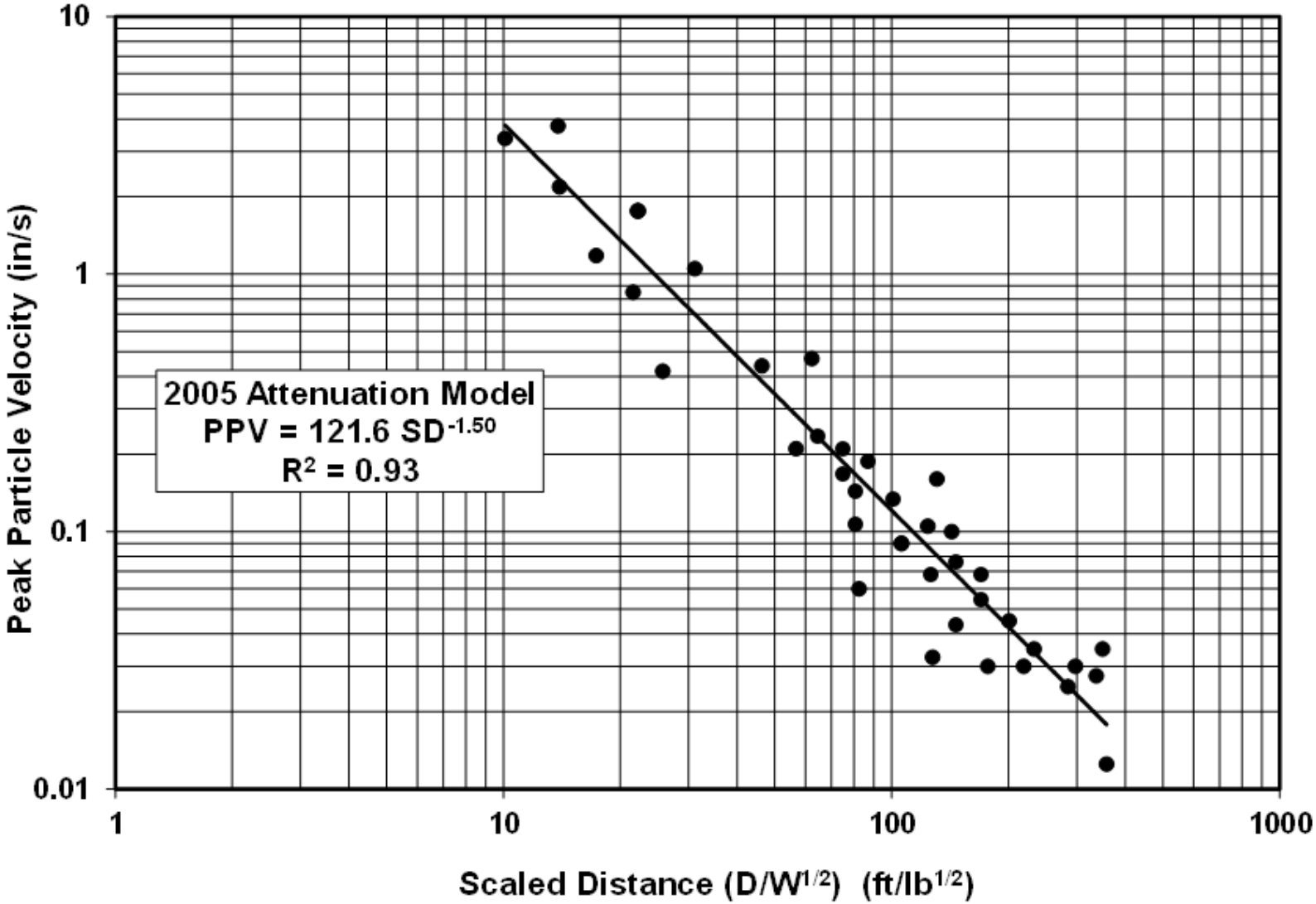


N

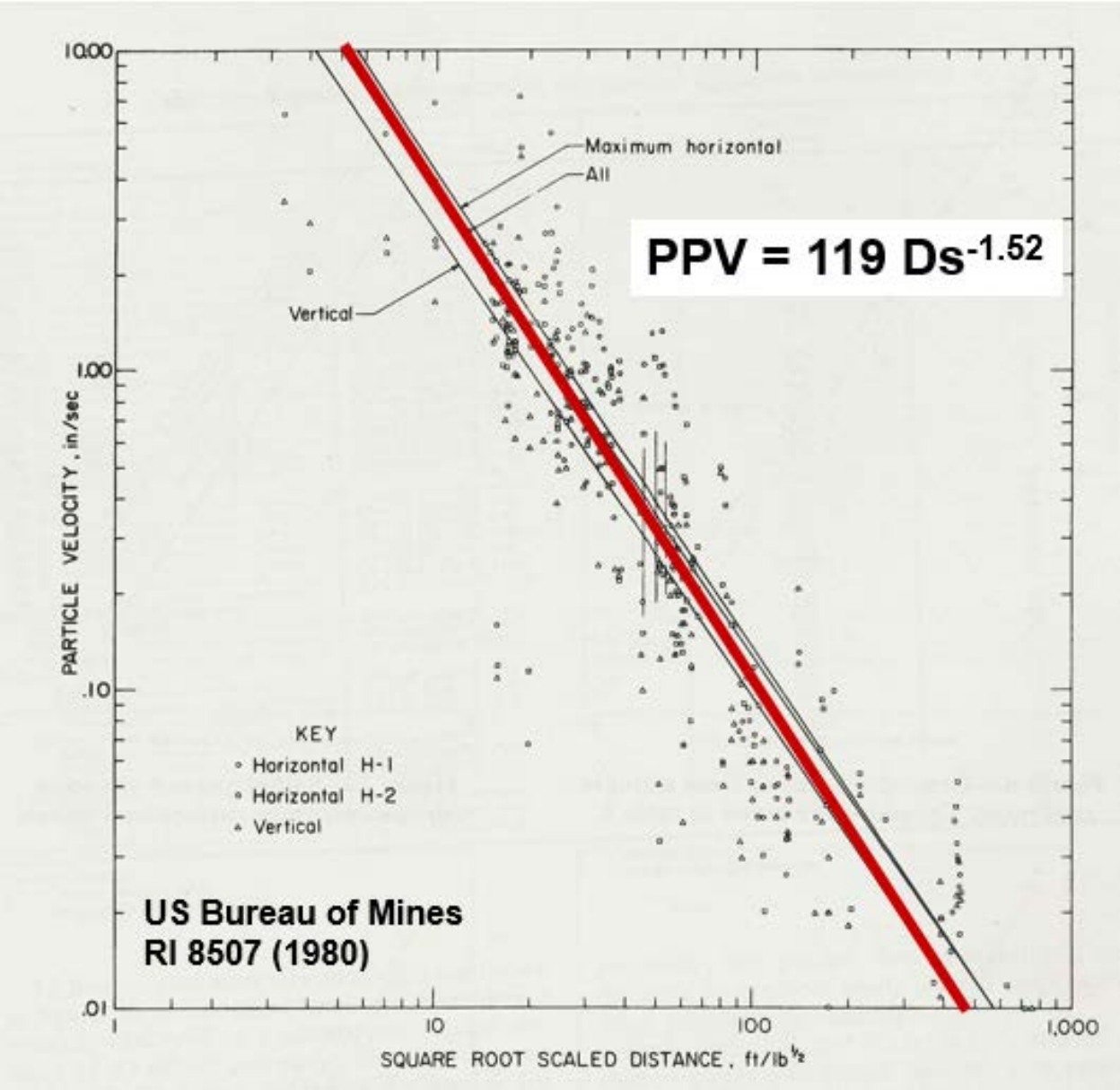
City of Henderson Attenuation Model for all directions

slope, b (-1.5) indicative of uniform geology

K-factor of 122 typical of geologies throughout the US

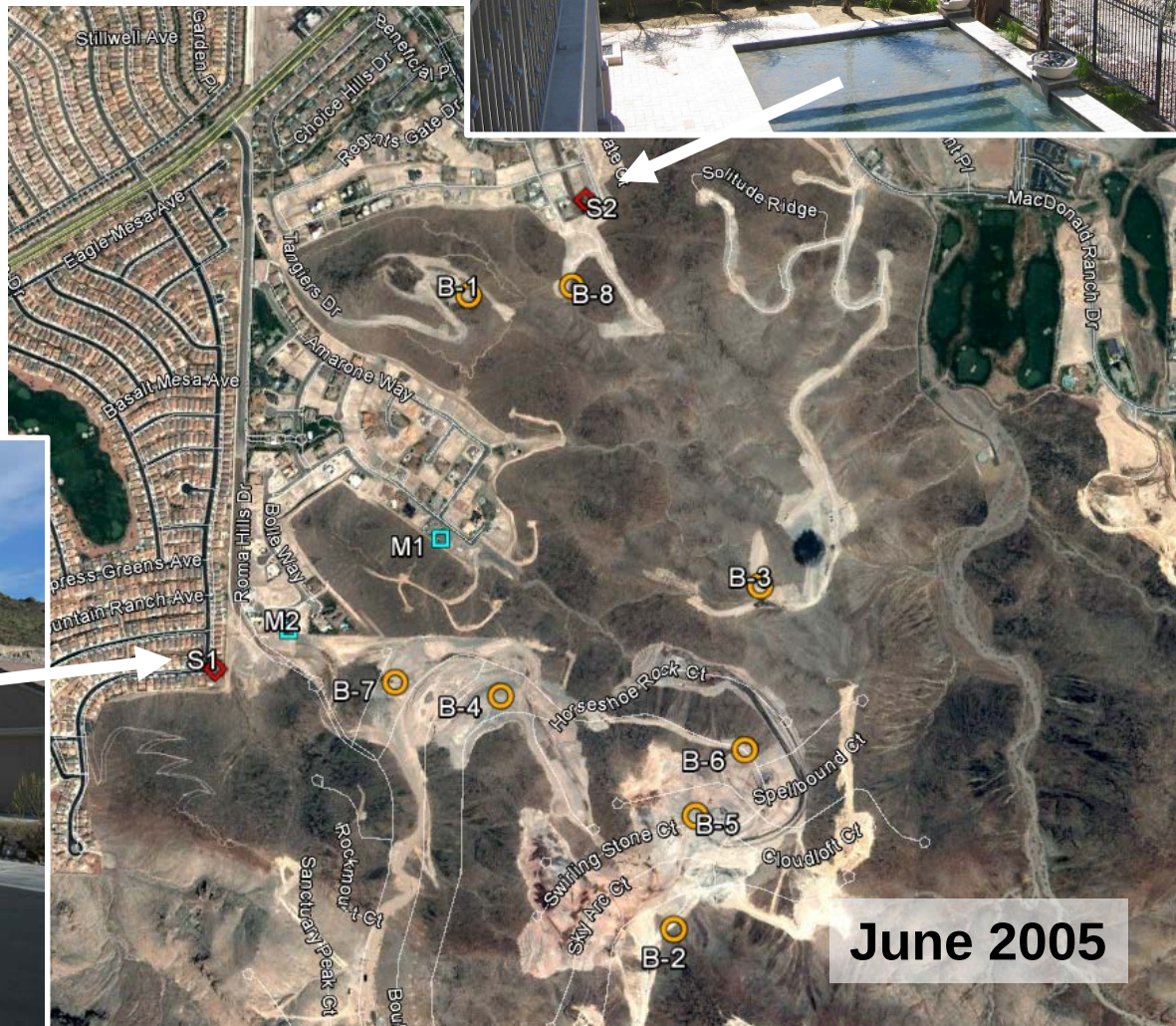


The US Bureau of Mines found similar trend for coal mine blasting

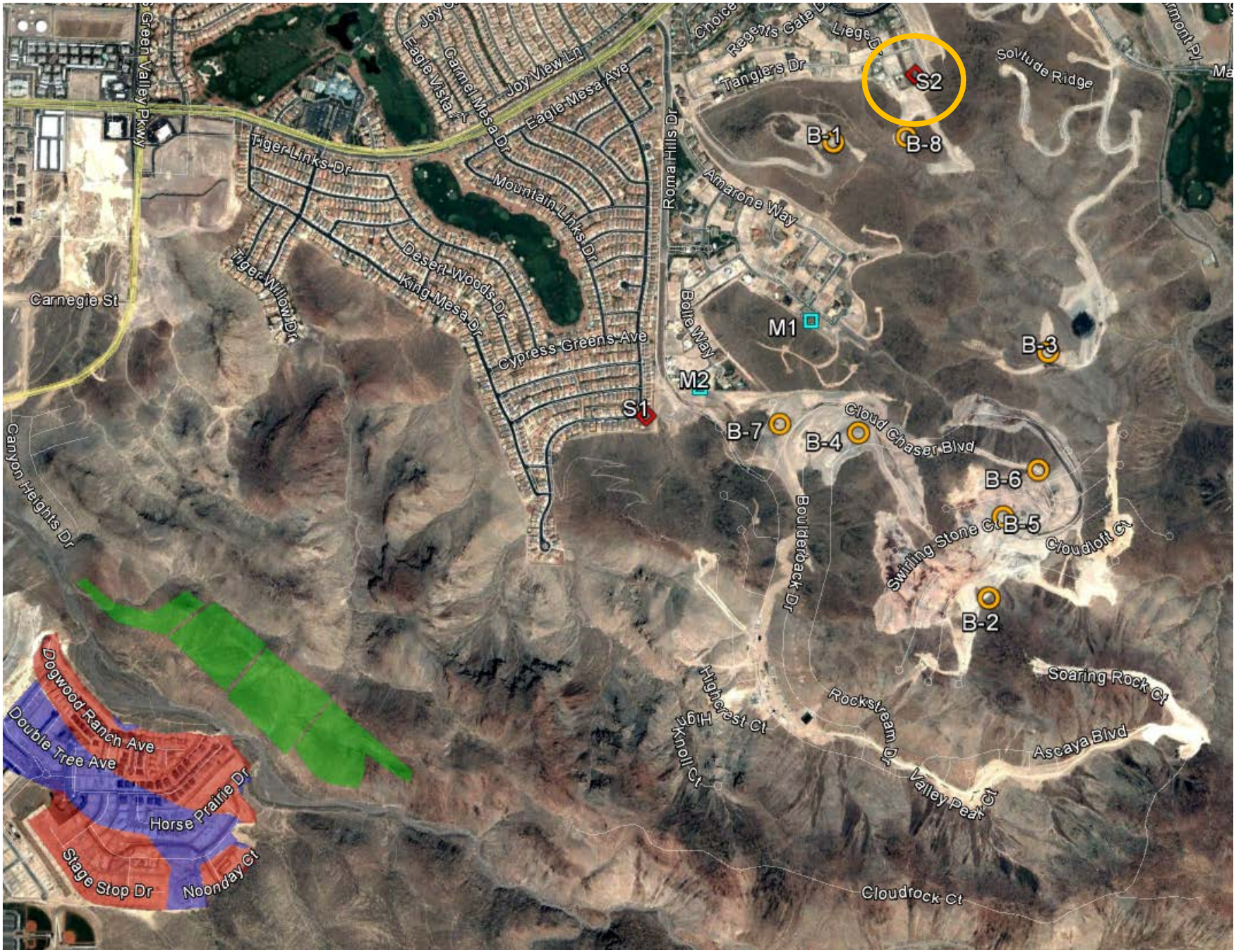


March-April 2005

Structure Response Study
(High Mesa and Big Horn Ridge)



June 2005


Green Valley Pkwy
Joy View Ln
Eagle Vista
Carmel Mesa Dr
Eagle Mesa Ave
Tiger Links Dr
Mountain Links Dr
Roma Hills Dr
Regents Gate Dr
Tanglers Dr
Solitude Ridge
Amarone Way
Tiger Willow Dr
Desert Woods Dr
King Mesa Dr
Cypress Greens Ave
Carnegie St
Bolle Way
Canyon Heights Dr
Cloud Chaser Blvd
Boulderback Dr
Swirling Stone Ct
Cloudloft Ct
Soaring Rock Ct
Rockstream Dr
Highcrest Ct
High Knoll Ct
Ascaya Blvd
Valley Peak Ct
Cloudrock Ct
Dogwood Ranch Ave
Double Tree Ave
Horse Prairie Dr
Stage Stop Dr
Noonday Ct
S1
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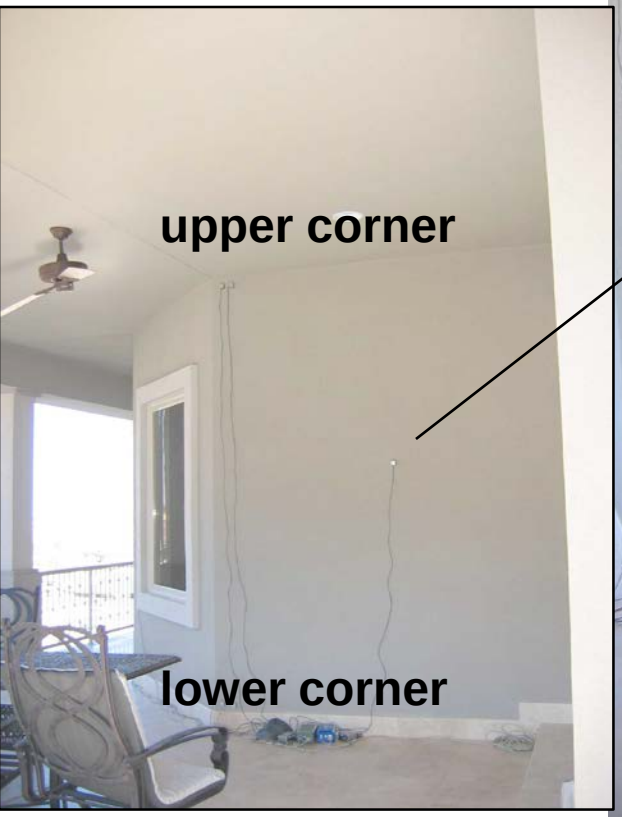
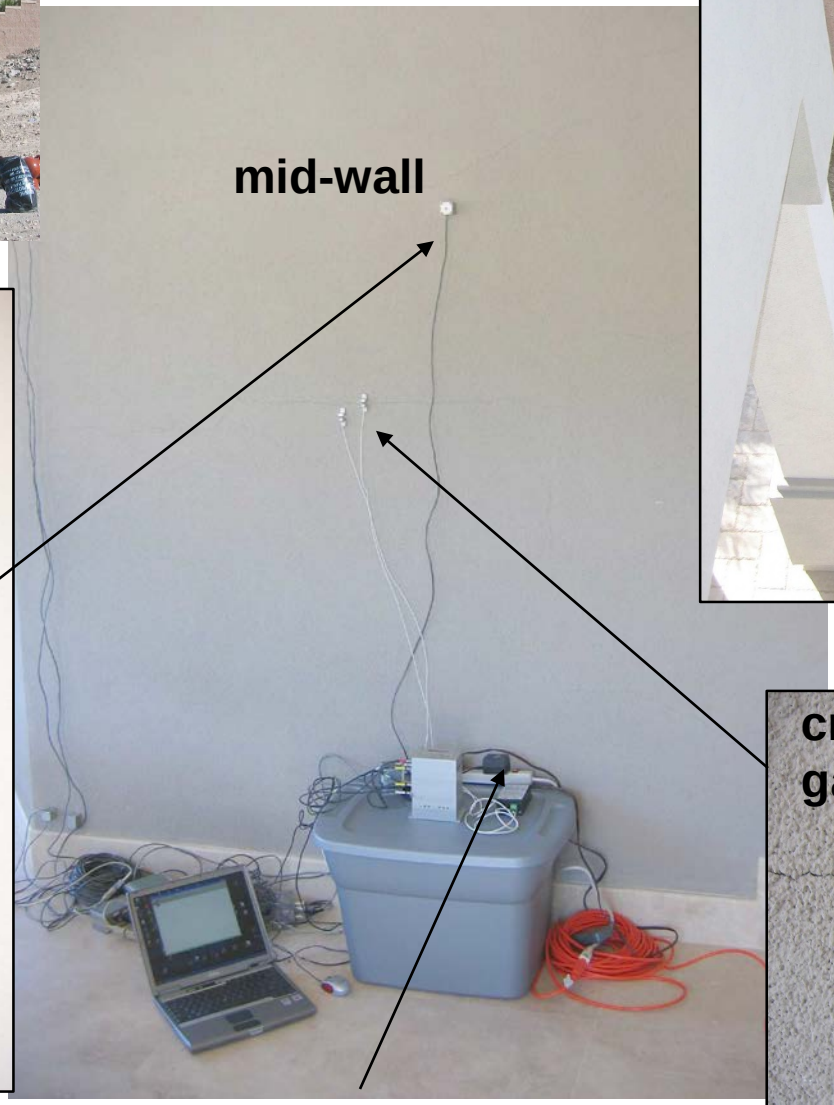
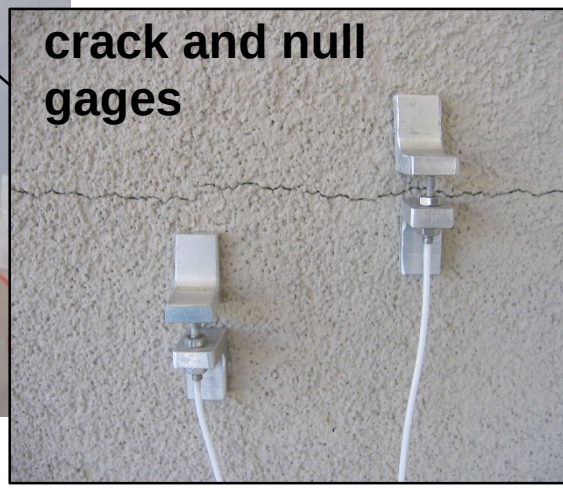

upper corner
lower corner

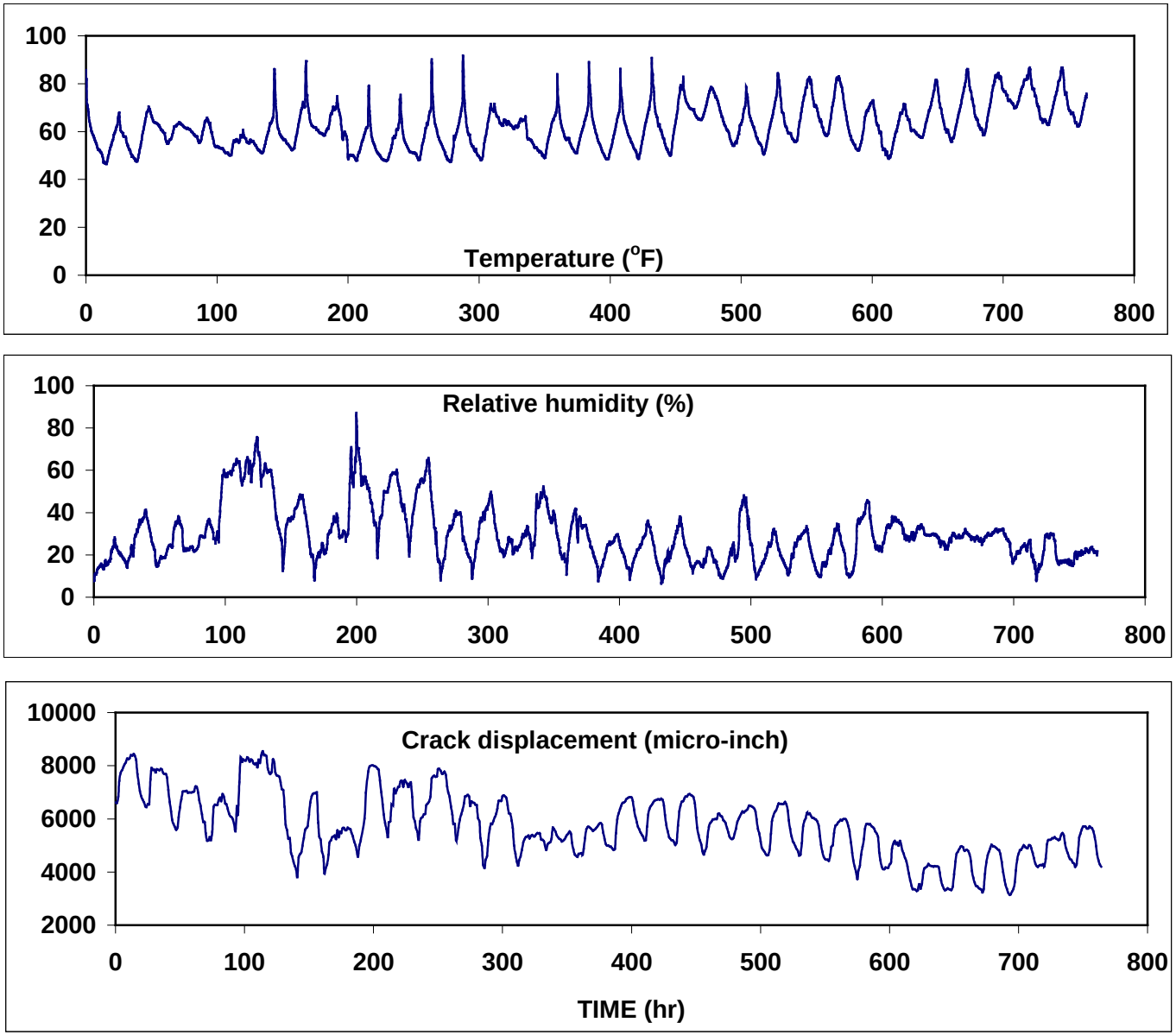

mid-wall
temperature/humidly sensor

Exterior
seismograph


crack and null
gages

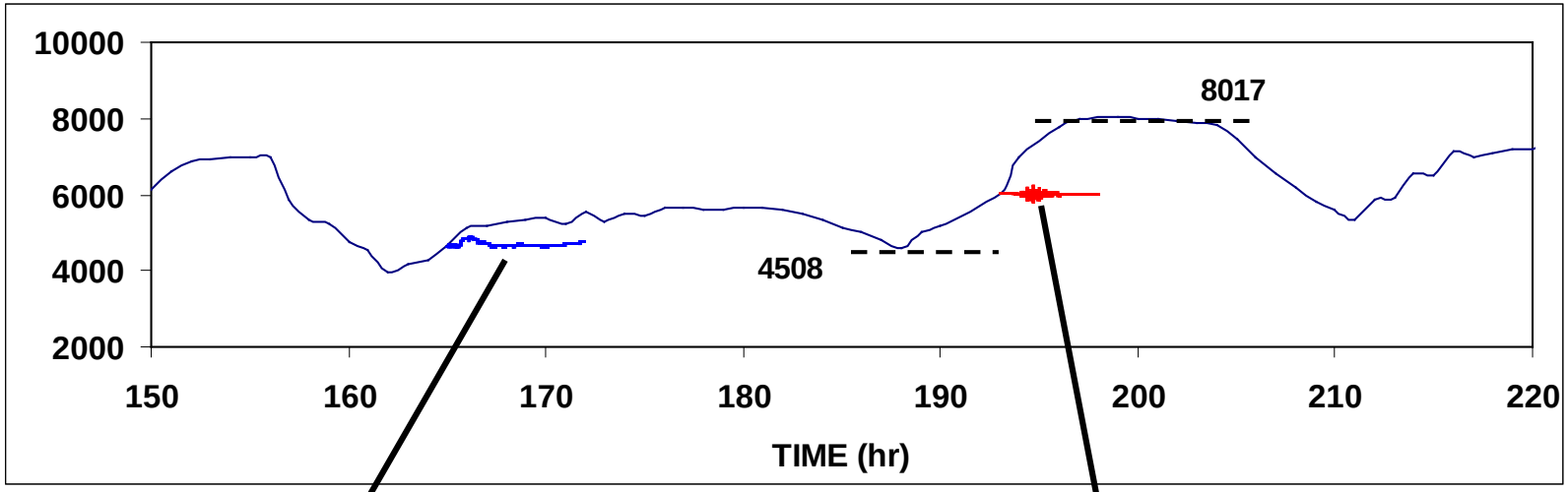
weather-induced change in crack width:

daily	6844 micro-inch
over 5 weeks	8212 micro-inch



largest blast-induced 244 micro-inch

33 mph wind-induced 277 micro-inch



Crack displacement during wind gust 3/23/05 at 2:15 am

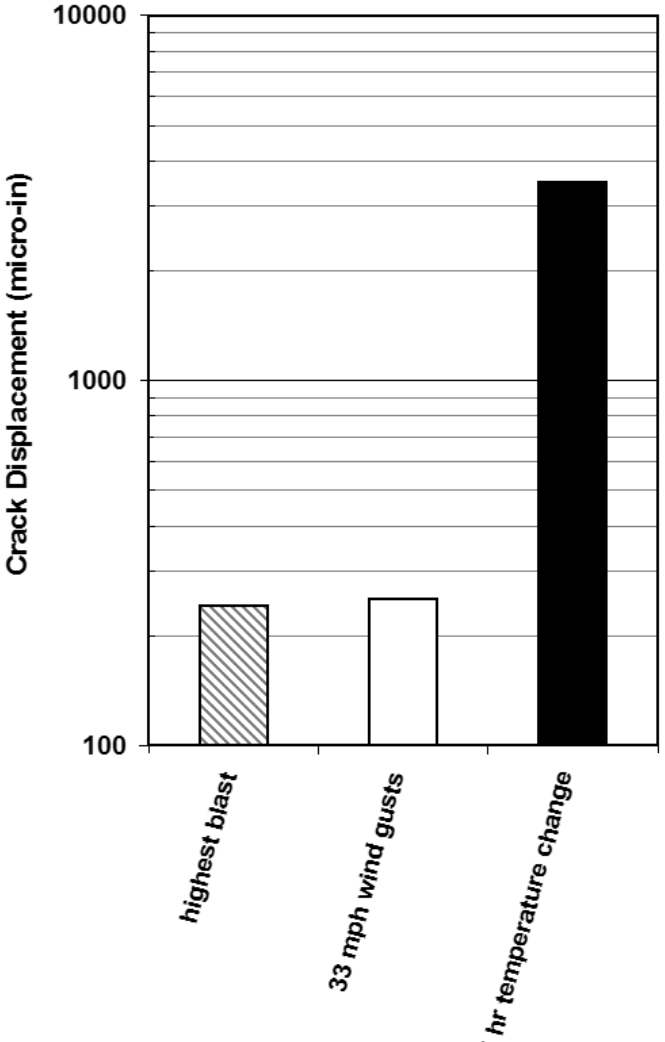
Crack displacement during blast 3/23/05 at 2:47 pm

Conclusions drawn from this study :

Compared with blasting near the PPV limit (0.45 in/s)

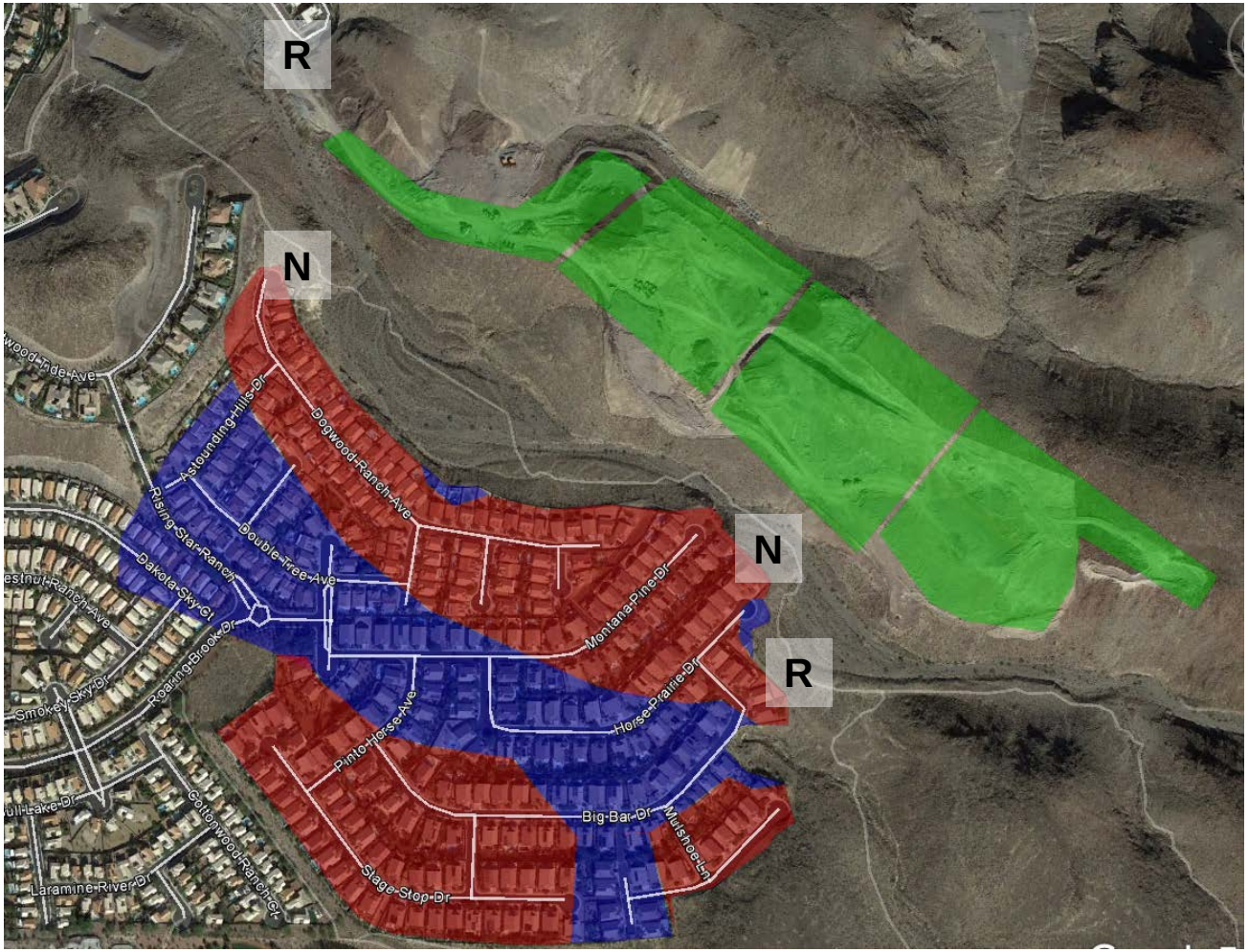
- wall strains from weather changes were 72 time greater
- crack displacements were 34 times great than the blast near the

33 mph wind gusts produced crack displacements 10% greater than those produced from blasting near the regulatory limit



2016-2017 Study of the Sunridge Communities:

Are houses built on “fill” subjected to ground vibrations that are different from houses founded on a “cut”, natural (undisturbed) ground, and rock?



Fill
Cut
Blast Area
N Natural
R Rock

(prepared by VCE based on Google Earth imagery)

Aimone-Martin was provided

- vibration records from VCE that included blast information
- maps of blast and seismograph locations
- map of cut/fill areas

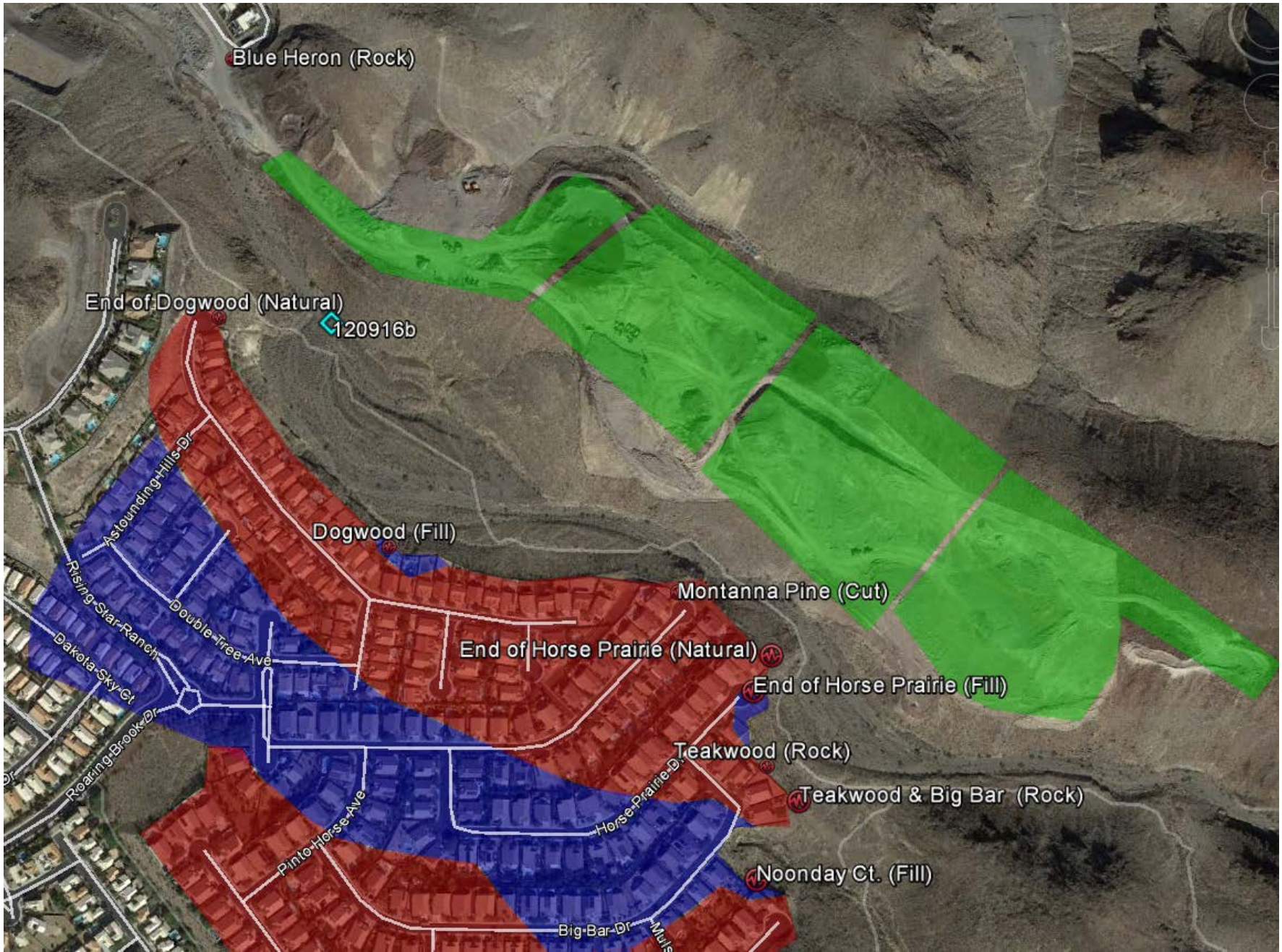
Measurements were plotted

- with the site attenuation model developed in 2005 and
- within the City of Henderson limit of 0.5 in/s

Preliminary assessments were made based on the following:

- geology of seismograph locations designated by fill, cut, natural (virgin) soil, and rock near the surface from VCE
- redundant monitoring provided by Aztec for side-by-side comparisons

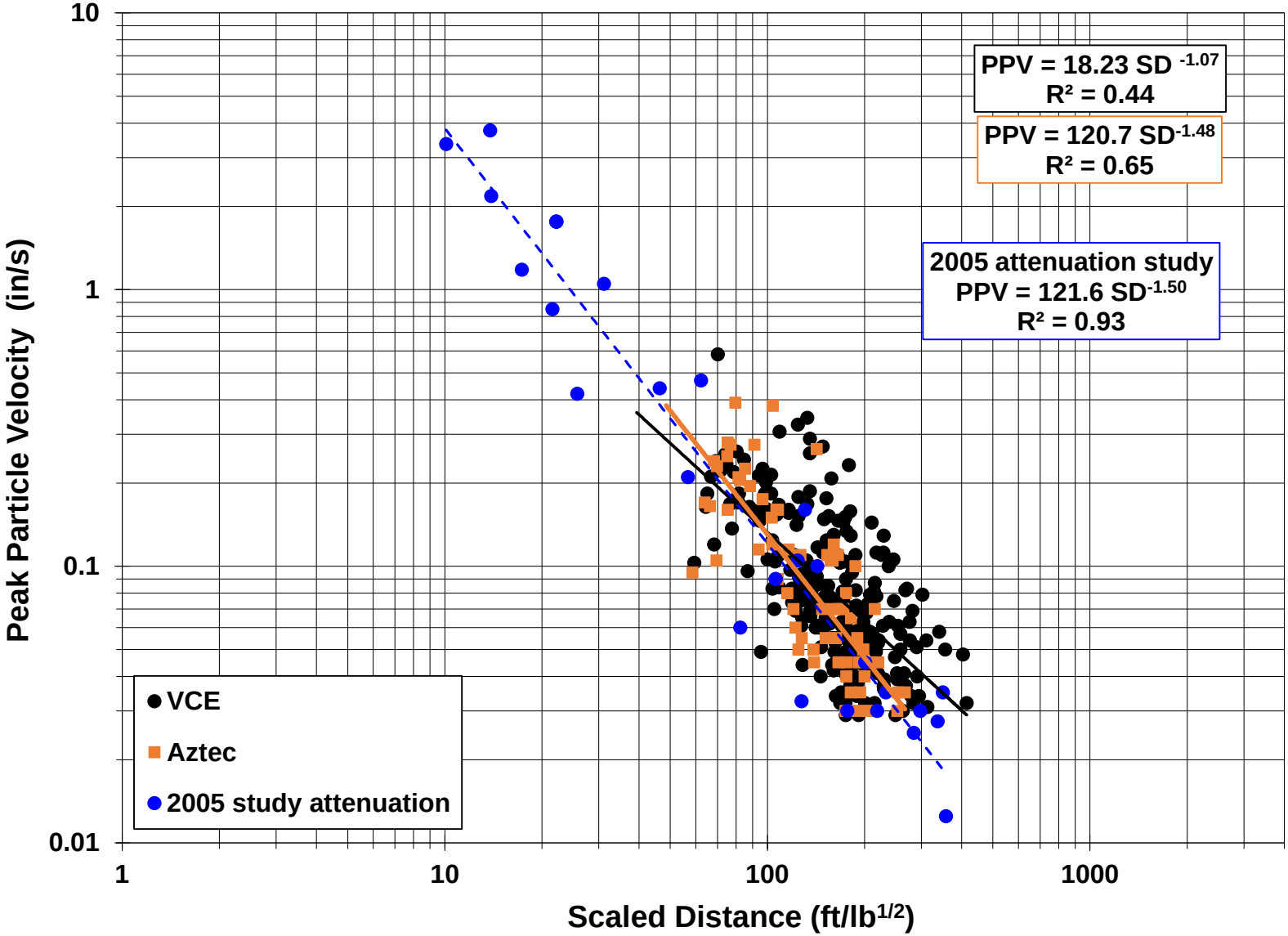
9 monitoring locations: 3 Fill, 1 Cut, 3 Rock, 2 Natural



Data available from VCE 10/19/16 to 3/14/17 and
from Aztec 2/8/17 to 3/14/17

	VCE			Aztec		
	deployed	triggered		deployed	triggered	
Cut	110	86	(78%)	32	22	(67%)
Natural	117	87	(74%)	30	25	(69%)
Rock	27	23	(85%)	12	9	(75%)
Fill	106	52	(49%)	24	12	(50%)
	360	248		98	68	

Aztec data fall exactly in line with 2005 attenuation model
VCE data show slightly higher upper bound scatter



VCE data scatter is attributed to coupling method of geophone that often included a sandbag weight overlying the geophone

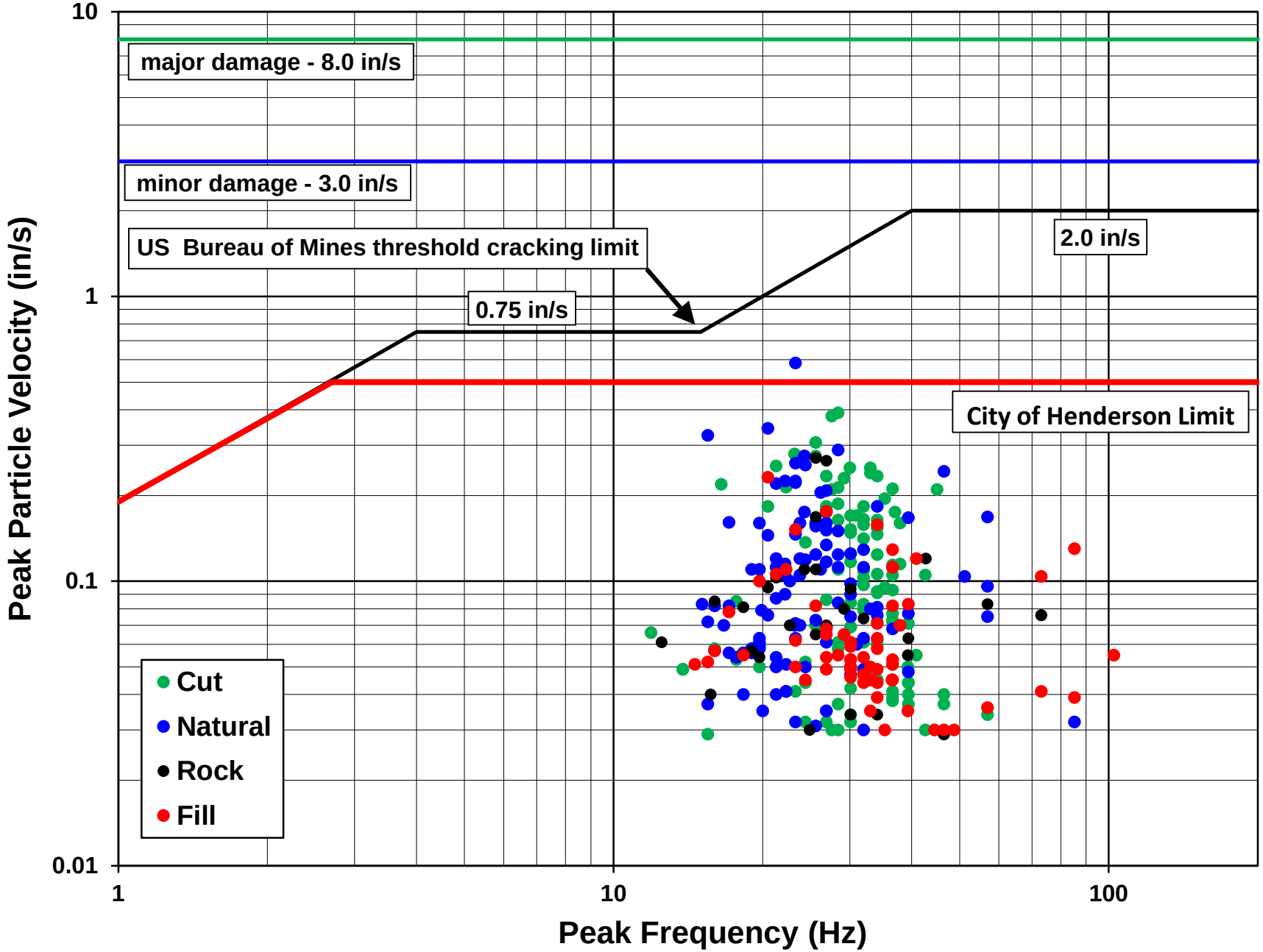
- this is an optional ISEE- approved method for coupling to the ground

- method often results in slight higher measurements which is considered to be conservative

sandbag

buried

Seismograph measurements



Preliminary findings

- Blasting is not the cause of cracking structures

- The presence of fill tends to attenuate vibrations more than cut, rock, and natural soils

There will be a summary White Paper of findings on the website

QUESTIONS