

**Blasting Consultant  
for  
Town of Brookline  
Dept. of Planning and Community Development**

Jay Perkins, P.E.

Brierley Associates, Cambridge, MA

Geotechnical Engineer with 35 years experience in underground design and construction.

Currently providing blasting designs and vibration consulting on numerous projects across the US.

# Scope of Work

- Completed Site Visit
- Reviewed proposed development and any geotechnical data.
- Reviewed the submitted Blast Plan.
- Identified the required components of the Blast Plan.
- Identified impacts of blasting on nearby Residences, People, Sanctuary and Baker School.
- Identified Site Safety and Security.
- Provided recommendations for any items not included in the Blast Plan, and additional scope during construction.
- Provided Blasting Assessment Report to the Town.

# Blast Assessment Outline

- Blast Plan
- Public Relations
- Site Safety and Security
- Blast Design
- Impacts of Blasting
- Summary and Recommendations

# Blast Plan

- Public Relations: Pre-Blast Surveys, Notification, Communication, Handouts, etc.
- Blaster Qualifications, Training, Licenses, Permits, Insurance, etc.
- Determine Schedule, Hours of Operation, Estimated Duration, and Sequence
- Provide for Site Safety, Security, Signs and Signals
- Understand the Geology
- Selection of Explosives
- Provide detailed Blasting Designs (geometry and timing) and Perimeter Control
- Conduct Test Blasting, start with conservative blast design parameters (SD>50)
- Misfires (IME Safety Library Publication 17)
- Provide Detailed Post Blast Reports
- ID any Critical Areas, Structures, Utilities, etc.
- Estimate and provide Limits for Ground Vibrations and Air Overpressures
- Conduct Blast Monitoring
- Control Flyrock, Noise and Dust
- Follow all Federal, State and Local Blast Regulations

# Public Relations/Out Reach Program

- Pre-blast Information Handouts
- Meeting with Abutters
- Opportunity for Q&A
- Conduct Pre-blast condition surveys at 300' and 500' radius.
  - Verify video results
  - Also opportunity for Q&A and public relations

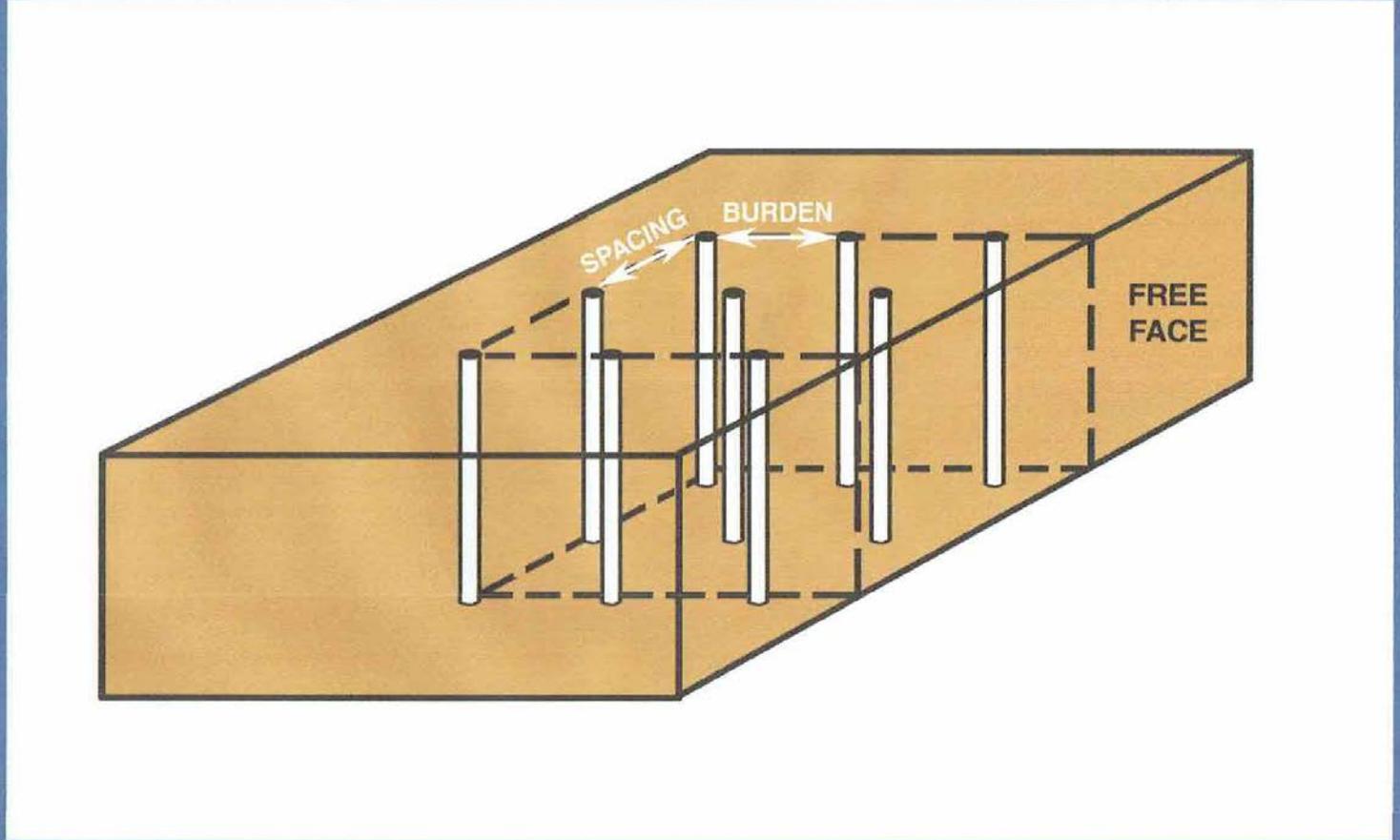
# Site Safety and Security

- Worker daily safety meetings
- FD on Site
- Blast Area Security: Designated Access Points and Safe Areas, Sentry Locations (see plan)
- Charged Hole Area: Posted, Guarded and Barricaded
- Warning Signals: 3 (5 minutes), 2 (1 minute), 1 (all clear).
- Sherman Road: Closed to vehicle and pedestrian traffic.
- Shot Cast Control (flyrock): Matting and blast rock berms.
- Blast Monitoring: Seismographs to measure PPV and AOP at 5 locations.

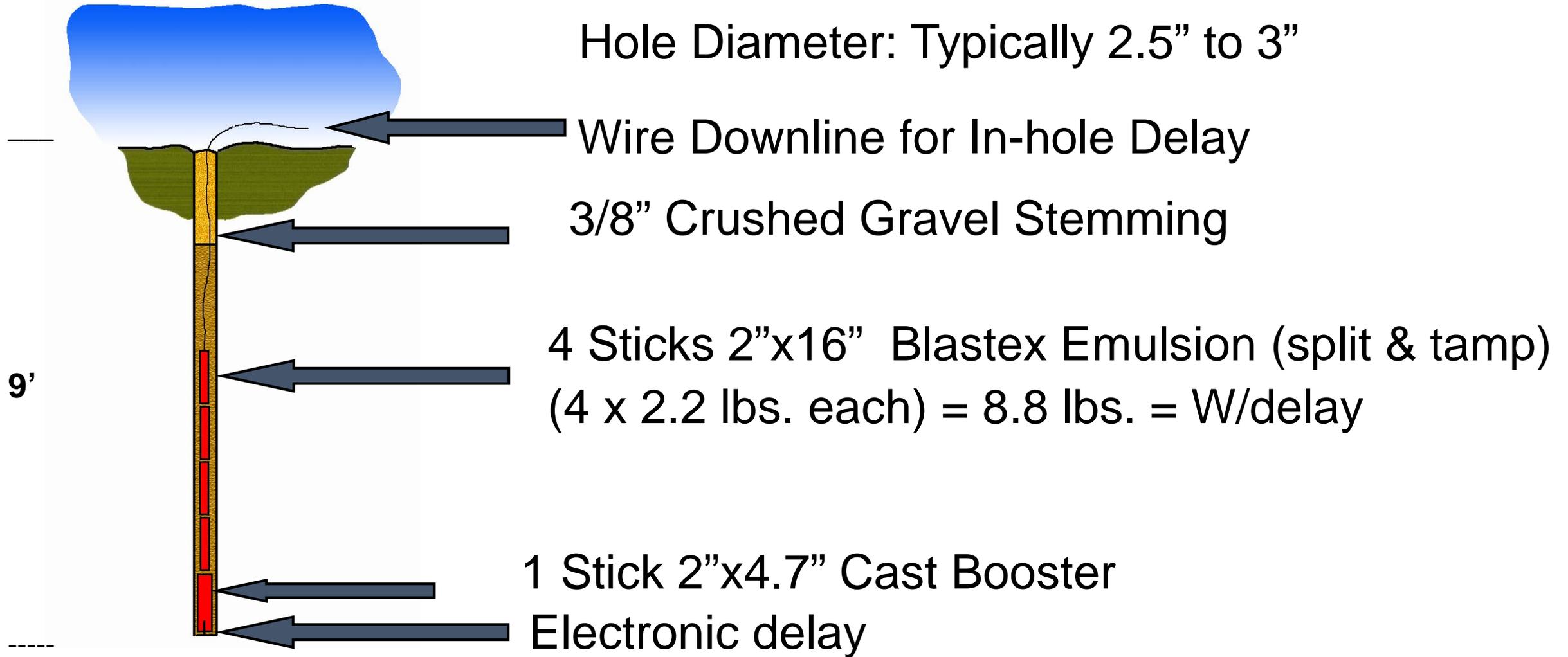
# BLAST DESIGN

## Typical Bench Blasting

### Three Dimensional View of Drill Holes for - Bench Blasting



# Typical Production Hole Loading



**BLAST DESIGNS**

**PUDDINGSTONE DEVELOPMENT - Brookline, MA**

Brierley Associates

30-Aug-18

Blast No.	Depth (ft.)	No. of holes	Max. W/delay (lbs.)	(1) Dist. Owner (ft.)	(2) Est. PPV (in/sec)	(3) Est. AOP (psi)	(4) Est. AOP (dBL)	(5) Dist. Outside (ft.)	(2) Est. PPV (in/sec)	(3) Est. AOP (psi)	(4) Est. AOP (dBL)
TB1	6 - 9	12	2.9	110	<b>0.256</b>	0.001	<b>108.6</b>	820	<b>0.010</b>	0.0003	<b>99.8</b>
TB2	6 - 9	40	2.3	106	<b>0.270</b>	0.001	<b>108.3</b>	810	<b>0.020</b>	0.0003	<b>99.9</b>
TB3	8 - 12	36	13.7	104	<b>1.166</b>	0.001	<b>113.6</b>	800	<b>0.045</b>	0.0003	<b>100.2</b>
P (27-42)	5 - 9	TBD	1.8	27	<b>1.950</b>	0.003	<b>120.6</b>	650	<b>0.012</b>	0.0004	<b>102.3</b>
P (43-59)	7 - 16	TBD	4.4	43	<b>1.928</b>	0.003	<b>118.8</b>	700	<b>0.022</b>	0.0004	<b>101.6</b>
P (60-79)	8 - 16	TBD	8.7	60	<b>1.958</b>	0.002	<b>117.6</b>	700	<b>0.038</b>	0.0004	<b>101.5</b>
P (80-125)	16	TBD	35.0	125	<b>1.838</b>	0.002	<b>114.5</b>	700	<b>0.117</b>	0.0004	<b>101.5</b>

(1) Distance to nearest Hancock Village building.

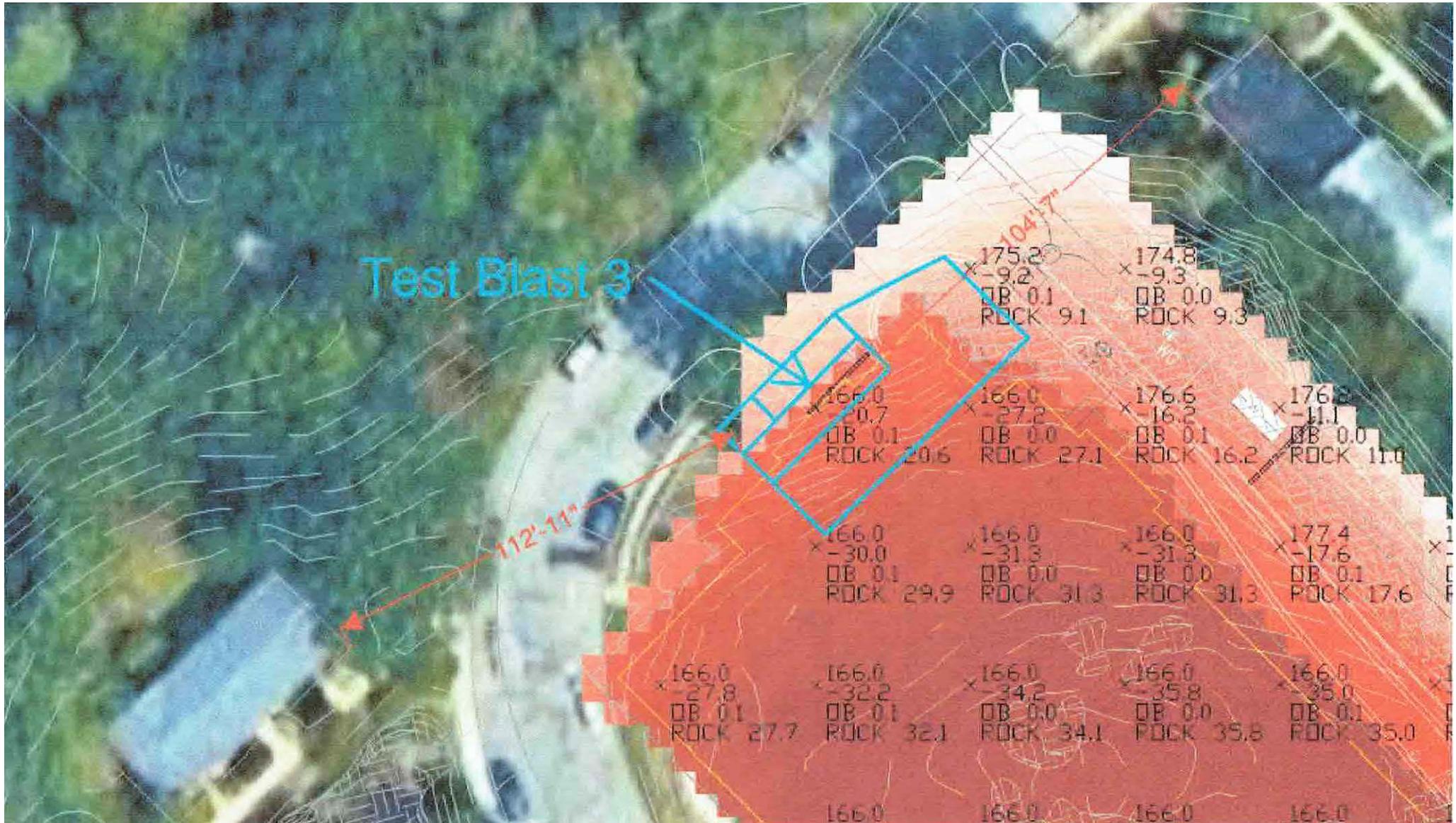
(2)  $PPV = 242(D/(W)^{0.5})^{-1.6}$ , in/sec

(3)  $AOP = 0.1(D/(W)^{0.3})^{-1.1}$ , psi (confined condition; Blaster's Handbook Table 26.7).

(4)  $dB = 20 \log (P/P_o)$ , where  $P_o = 3 \times 10^{-9}$  (psi)

(5) Distance to nearest private residence (Beverly Road) or Baker School.

TBD: Based on test blast results.



# IMPACTS OF BLASTING

## Undesirable Side Effects of Blasting

- Elastic Ground Vibrations
- Air Blast Overpressure
- Flyrock

# Monitoring Ground Vibrations - Seismographs

## Vibration Parameters – measures ground motion

*Particle Velocity*, inches/second (in/sec) in three directions.

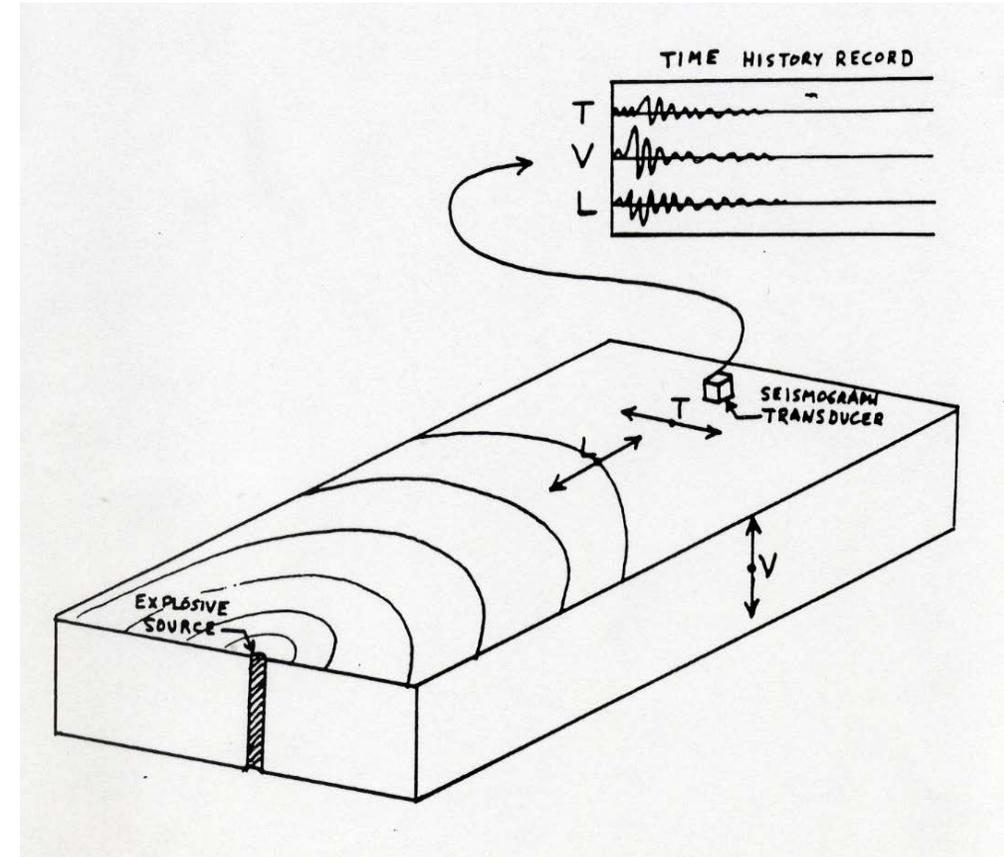
**(standards of damage are based on the particle velocity).**

*Displacement*, inches (in)....0.008" (paper thin)

*Acceleration*, inches per second<sup>2</sup> (in/sec<sup>2</sup>)

*Frequency*, cycles per second, or Hertz (Hz)

**Vibration intensity increases: 3x for each 1/2D**



# Monitoring Locations

- Owner Controlled on-site residence: 27' to 110'
- Baker School: 720'
- Beverly Road Residence: 750'
- Harvard Vanguard Medical Associates: 1,200'
- Hoar Sanctuary: 100'

# USBM (RI 8507, 1980) Results

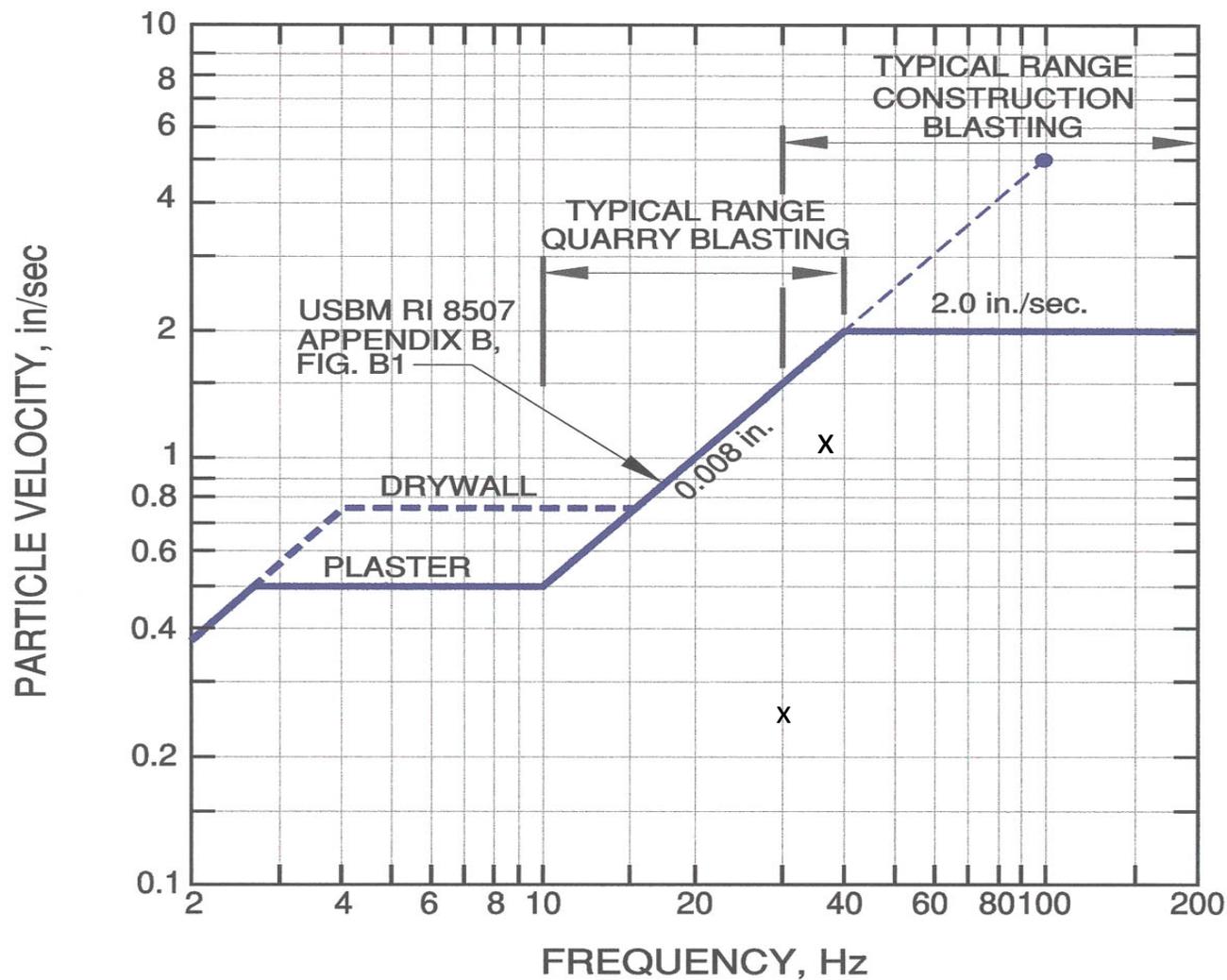
## Safe Vibration Limits

For residential 1-2 story structures.

Safe limit with <5% probability of cosmetic damage.

Safe limit much higher for massive engineered structures, underground structures, pipelines, etc.

X = Test Blast PPV Estimates (Hancock Village)



# Human-Induced Vibrations

# Typical Floor Vibrations

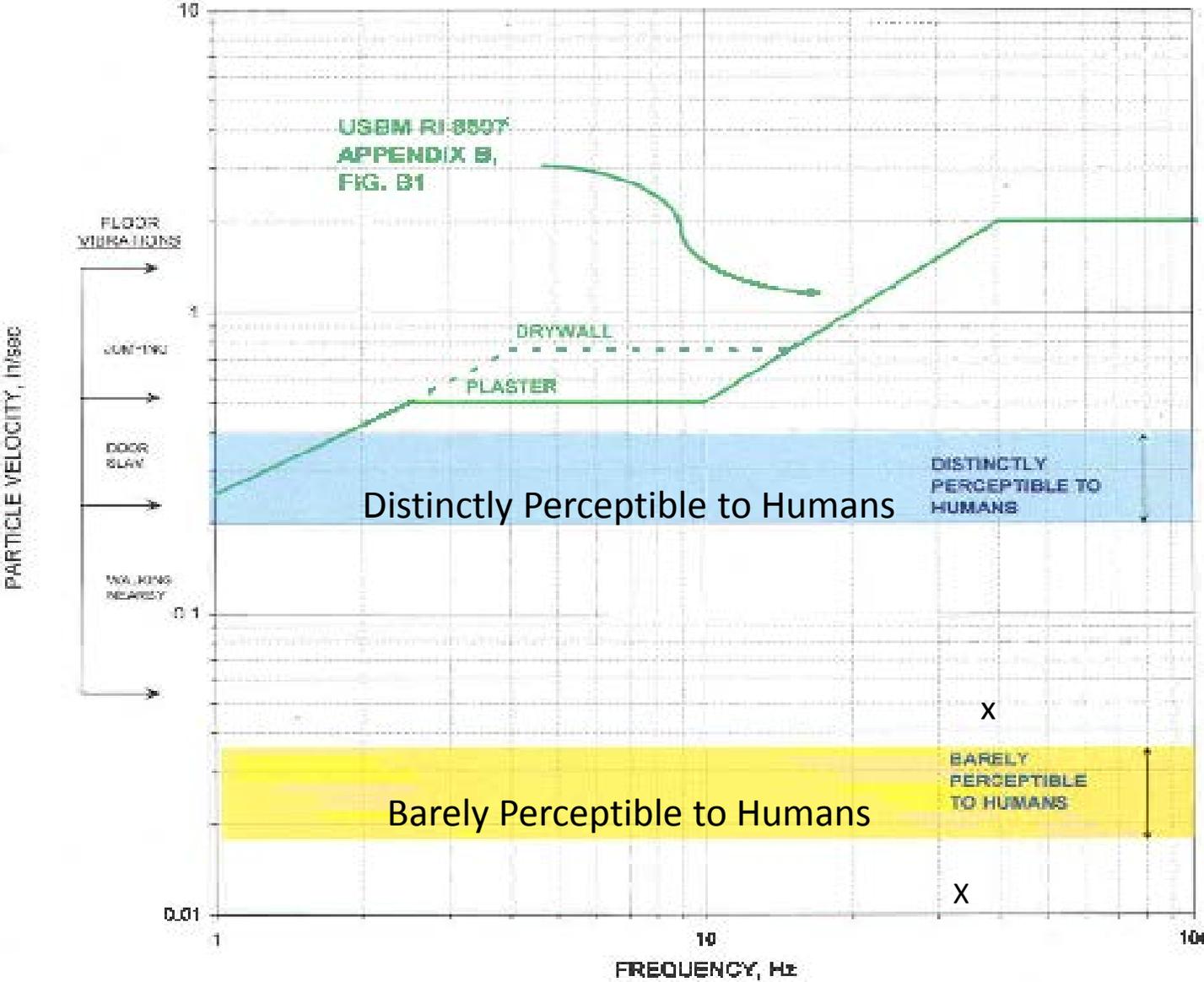
X = Test Blast PPV Estimate  
(Beverly Road and Baker School)

## Floor Vibrations

Running >

Door Slam >

Walking >



# Air Overpressure Damage Criteria

## Blast Pressures (air concussion):

Measured in pressure and converted to dB(L)

Measured at Linear Peak weighting scale

108-120dB: Test Blast Estimate

133dB (L): Typical Blast Limit

140dB: ~Equivalent to 40 mph wind speed

150dB: Some Windows Break

170dB: Most Windows Break

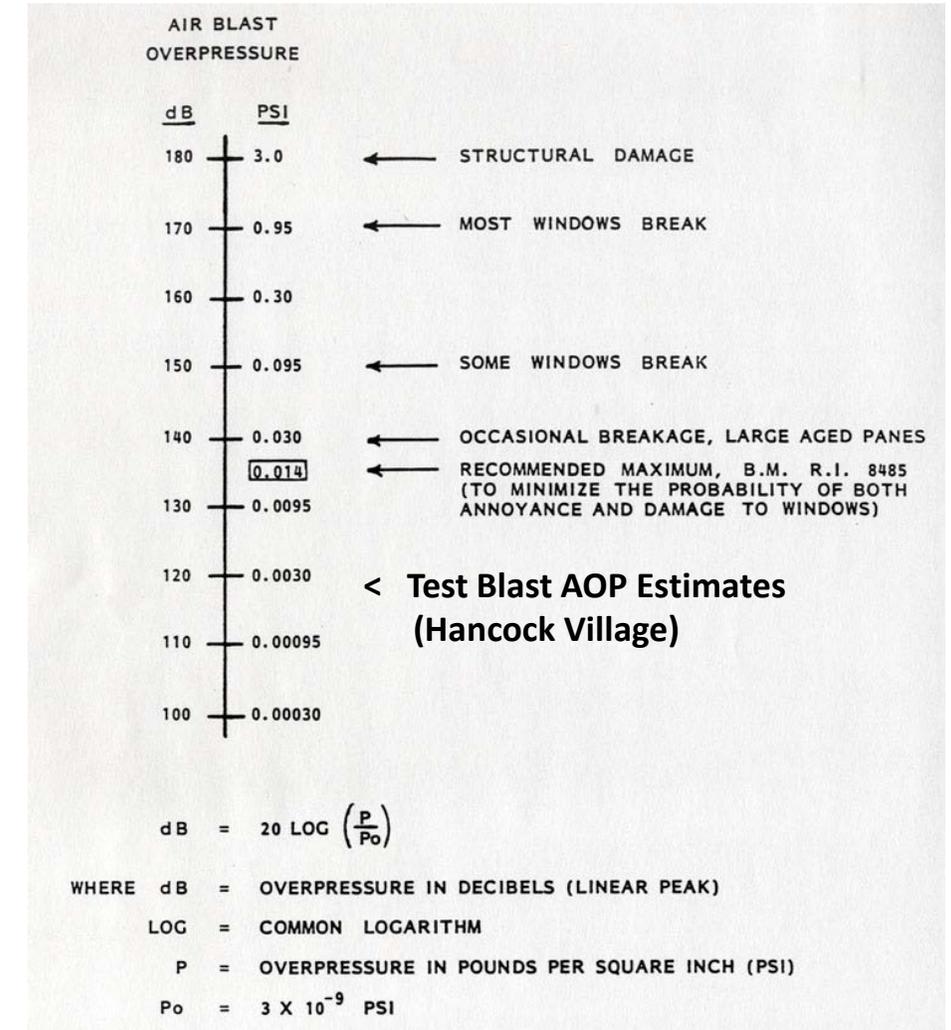
180dB: Structural Damage

## Noise:

High frequency: Measured at A, B weighting scales.

Sound levels decrease at 7 to 9 dB at 2 times the distance.

In the shadow, can be dampened with slightly tilted barrier.



# Flyrock

- Undesirable throw of rock fragments from a blast round.
- Throw of blasted rock beyond the safe blasting area.

## Prevention

- Matting (11,000 lbs. each); Double Matting
- Construction of Blast Rock Berms



**Townhouses at 150' in Background**



**Conservation/Wetlands Area in Background**



**Apt. Building 80' Right**



**Apt. Building 80' in Background**

# Summary

- Start with Qualified Blasting Contractor. (MD&B)
  - Provide good public relations and pre-blast surveys.
  - Provide for good Site Safety and Security
  - Conduct Test Blasts, using conservative blast design parameters.
  - Generate Regression Analysis and revise blast designs accordingly.
  - Use Safe Vibration and AOP Limits (USBM) to prevent cosmetic damage to residential structures.
- 
- Elastic Displacements generated from vibrations are paper thin when vibration limits not exceeded.
  - AOP generally not a concern when vibration limits not exceeded.
  - Flyrock can be the biggest threat from blasting.

# Recommendations

- Use Electronic Initiation (EBIS), provides highest level of safety and control.
- Cover all blast holes with double layer of blasting mats.
- Project Geotechnical Engineer to evaluate post rock wall stability, and provide recommendations for temporary rock wall support.
- Blasting Consultant present on site during test blasts.
- Submit Blaster's post blast reports including seismograph event reports for review within 24 hours of blast.
- Submit updated Regression Analysis and revised Blast Designs to Blasting Consultant for review.
- Control noise (barriers) and dust (return air vapor injection system).
- ....
- ....

# QUESTIONS



# Blast Plan

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