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September 21, 2006

Mr. Ross Widener
Widener & Associates
10108 32nd Ave W, Suite D
Everett, WA 98204

Re: SR 411, Lexington Bridge Underwater Noise Monitoring Results

Dear Mr. Widener

This memo summarizes the preliminary results from the pile driving monitoring activities associated with the construction of the Lexington Bridge on SR 411. These measurements were obtained side-by-side with your biologist monitoring the affected environment.

This technical memorandum describes the data collected during pile driving efforts at the construction site for the new Lexington Bridge on SR411 during the months of July and August 2006. Ambient underwater sound levels in the river were measured with and without the nearby train traffic on the nearby Burlington Northern Railroad tracks. The ambient sound level results were an RMS of 160 dB with peaks between 170 and 175 dB (see Attachment 1).

Eight 24-inch diameter steel piles were monitored at various water depths. Piles were driven with an ICE Model 60 diesel Pile Hammer (see Attachment 2). The pile hammer energy to drive a pile can be estimated by the stroke length used to drive the pile. Most piles for this structure were driven using 5 to 7 foot hammer strokes with an occasional 9 foot stroke. This equates to 35 to 49 K foot pounds with an occasional drive in excess of 60K ft-lbs. Table 1 summarizes the results for each pile monitored.

Table 1: Summary Table of Monitoring Results.

Pile #	Midwater Hydrophone Depth	Bubble Curtain	Absolute Peak (dB)	Rise Time (Sec.)	Number of Pile Strikes	Average Peak for all Pile Strikes (Pa)	+/- Standard Deviation	RMS Average for all Pile Strikes (Pa)	+/- Standard Deviation	Average Decibel Reduction (dB)
1	4 feet	YES	188	.0011	3	2157	418	370	12	*8
2	4 feet	NO	--	--	1	--	--	--	--	
3	1.5 feet	YES	194	.0066	12	2063	1315	258	150	8
4	1.5 feet	NO	202	.0074	180	4864	1702	576	166	
5	2 feet	YES	188	.0083	82	2015	234	339	43	9
8	2 feet	NO	198	.0049	17	5428	1369	533	70	
6	1.5 feet	YES	187	.0010	64	1918	107	200	19	4
7	1.5 feet	NO	193	.0058	261	3056	283	384	47	

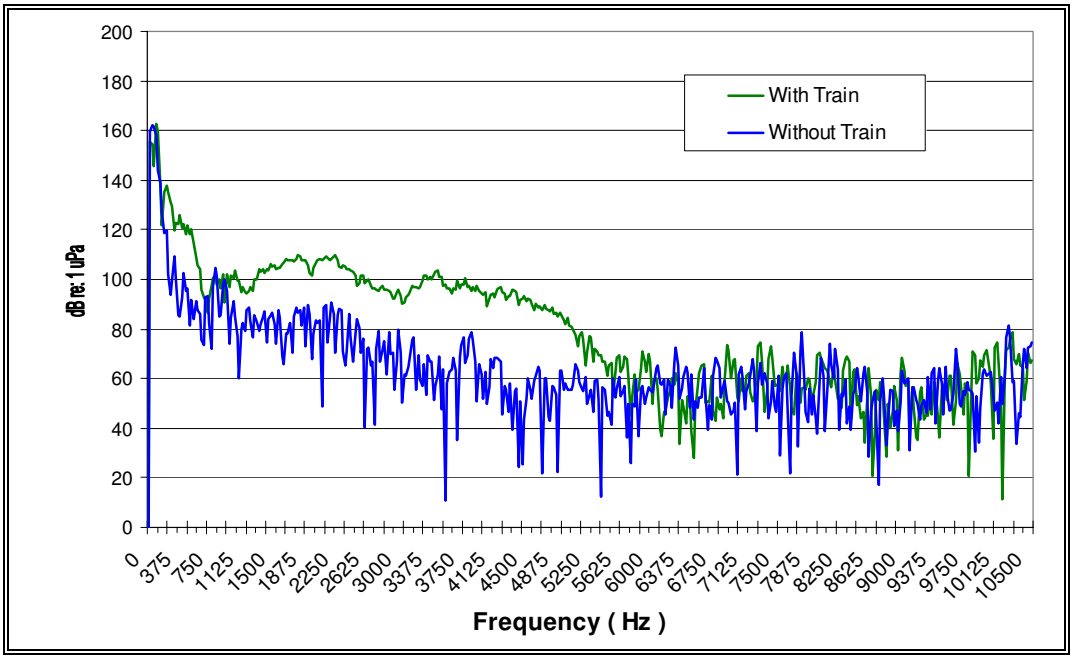
*Pile 2 required only one strike to seat pile and the monitoring equipment failed to record the data. Pile 8 was used for comparison. Purposes.

A bubble curtain was tested on alternate piles. The bubble curtain was used to minimize effects of underwater sound for piles 1, 3, 5 and 6. Peak underwater sound levels ranged from 187 to

202 dB_{peak} during the pile driving activity with an effective average reduction of 4 to 9 dB from the use of bubble curtains. The average sound reduction achieved with the bubble curtain on pile 6 was 4 dB, which was approximately half of the reduction seen with the other piles. This could possibly be because the bubble curtain sitting on a small rock and was not seated properly on the bottom of the river allowing sound to escape through the opening.

Other notes and observations made during the monitoring of the pile driving activity include; piles 1 through 3 and the last pile, pile 8, required few strikes before attaining the bearing required for this temporary work structure. Small fish appeared to be feeding along the west bank of the Cowlitz River. No harm to fish was apparent during the pile driving operation from observations made near the piles. Post analysis of the unweighted frequency distribution of the peak pile strikes in the underwater environment can be seen in Figures 1 through 5 below. Figure 1 is the ambient level frequency distribution in the river before driving piles, and it likely includes sound from the project propagating through the piles already in the river as well as sound propagating from the project itself. It does provide a base line for comparing the effect the pile driving activity has on the existing river sound environment. It does not, however, take into consideration the sensitivity organisms may have to any particular range of frequencies by any form of weighting that is likely important in considering its effect on the species effected.

Figure 1: Unweighted Ambient Underwater Sound



In Figure 2 it was not possible to analyze the sound level from pile driving and compare it with the sound level mitigated by the use of a bubble curtain. Pile 2 was not measured because of equipment malfunction during the single pile strike to set pile 2 so only the pile with the bubble curtain on it was measured and analyzed. I have left the ambient sound levels frequency distribution recorded in Figure 1 to show a relationship to the current ambient level.

Figures 3 through 5 demonstrate the effect on the frequency distribution of sound from the peak pile strike on the underwater environment with and without the use of a bubble curtain.

This information may be useful in the future when it is determined at what frequencies beings living in that environment are sensitive to sound.

Figure 2: Pile 1 Unweighted Frequency Distribution Compared with Ambient

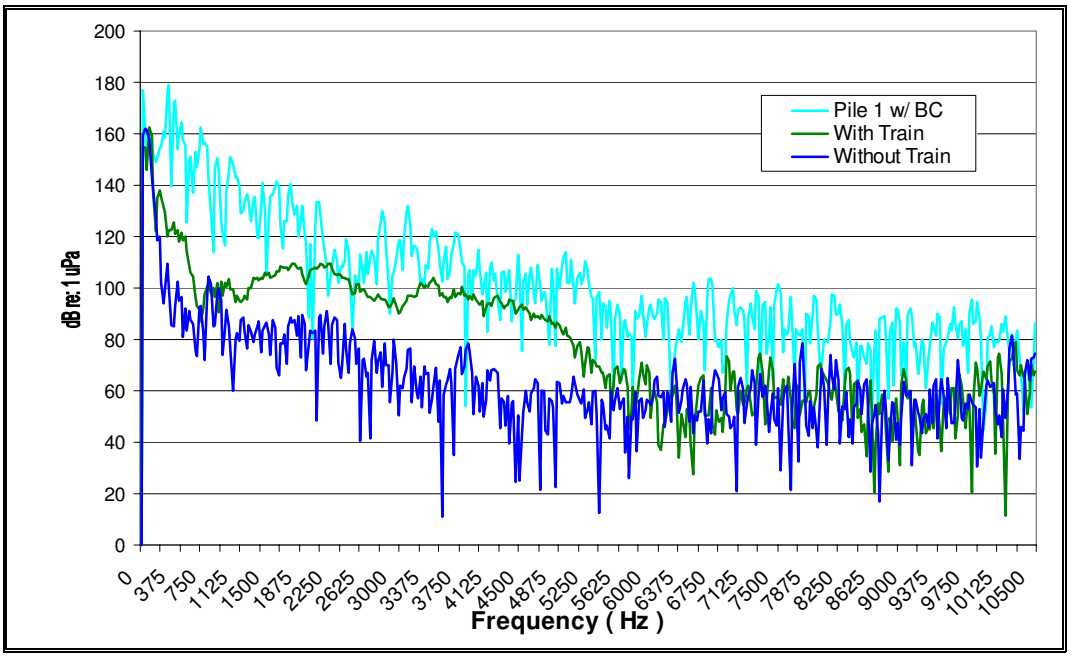


Figure 3: Pile 3 & 4 Unweighted Frequency Distribution

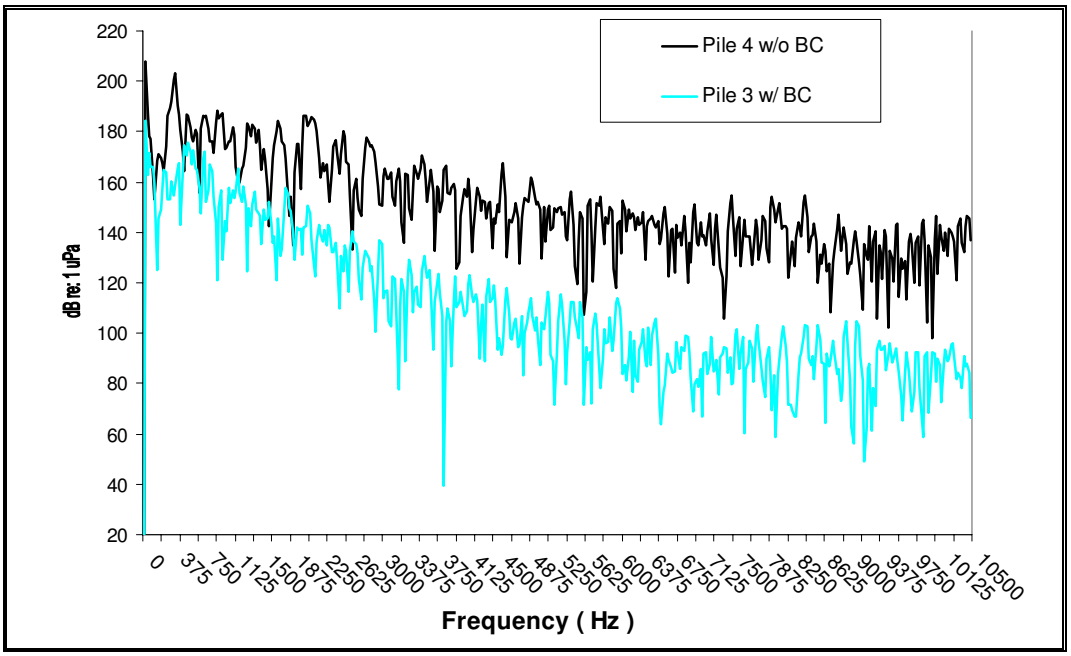


Figure 4: Pile 8 & 5 Unweighted Frequency Distribution Compared with Ambient

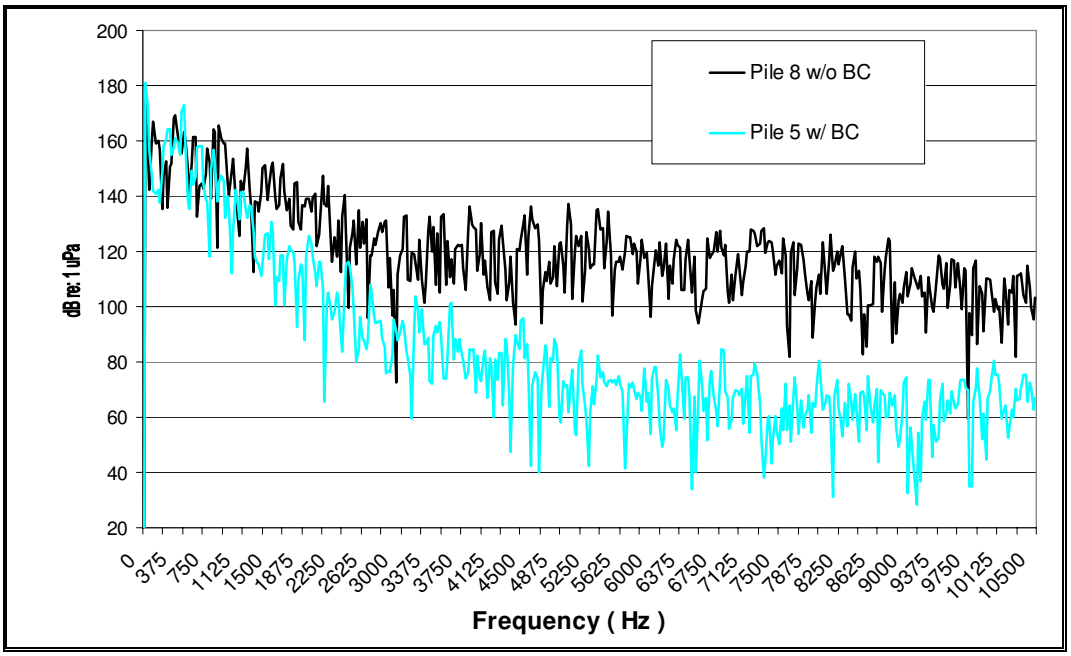
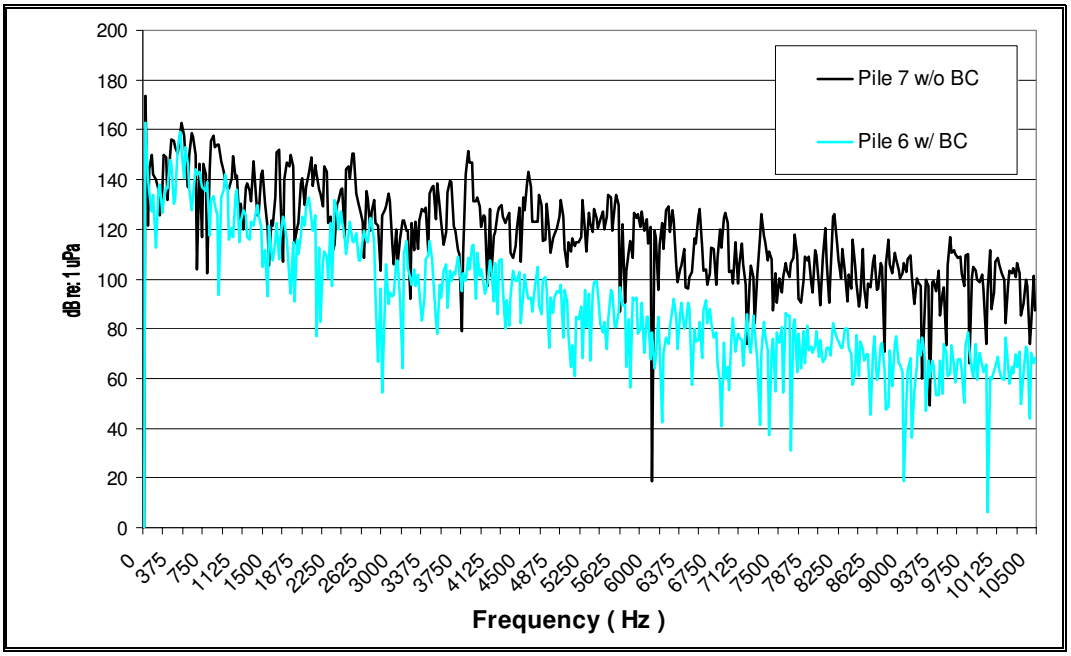


Figure 5: Pile 6 & 7 Unweighted Frequency Distribution Compared with Ambient



Appended to this technical memorandum are the post processed data sheets for the peak pile strike for each of the piles monitored. This is the form we typically use to report the data that is acquire in our pile monitoring programs. We still have the raw data on file and may be able to further process this into useable information. If you would like to do something different or would like to get the raw data please contact me, Larry Magnoni at (206) 440-4544 or Jim Laughlin at (206) 440-4643.

Sincerely,

Larry J. Magnoni
Acoustical, Air Quality and Energy Engineer
LM/ljm
Attachments

- Ambient Sound Level Analysis Sheet
- Pile Driver Data Sheet
- Unweighted Peak Sound Waveform Analysis Sheets for each Pile

cc: Jim Laughlin MS NB82-138
John C. Heinley MS 47390
day file
file

Ambient Sound Level Analysis Sheet

Ambient With & Without Train

Figure a. Waveform

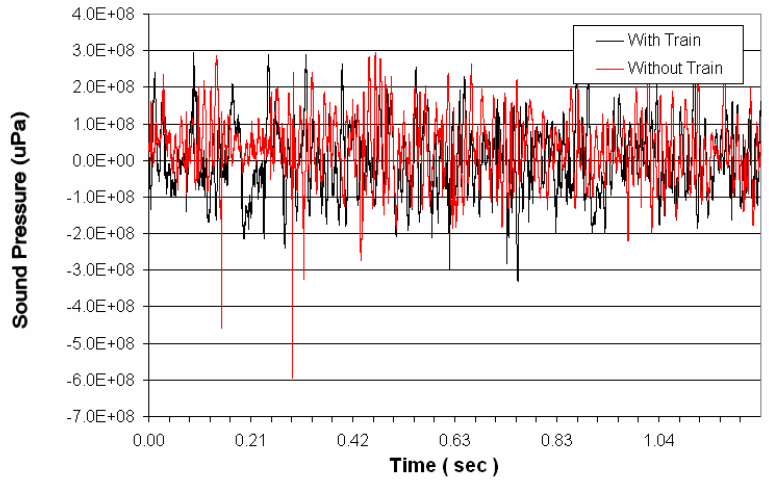


Figure b. Narrow Band Frequency Spectra

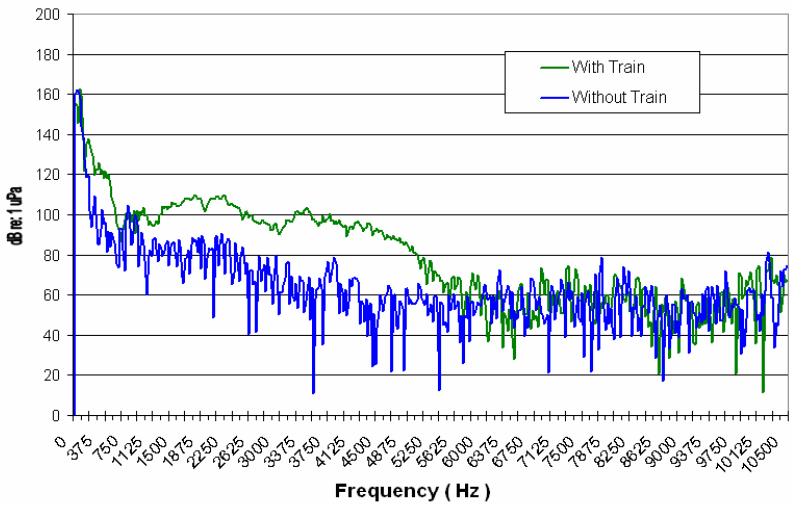


Figure c. Accumulation of Sound Energy

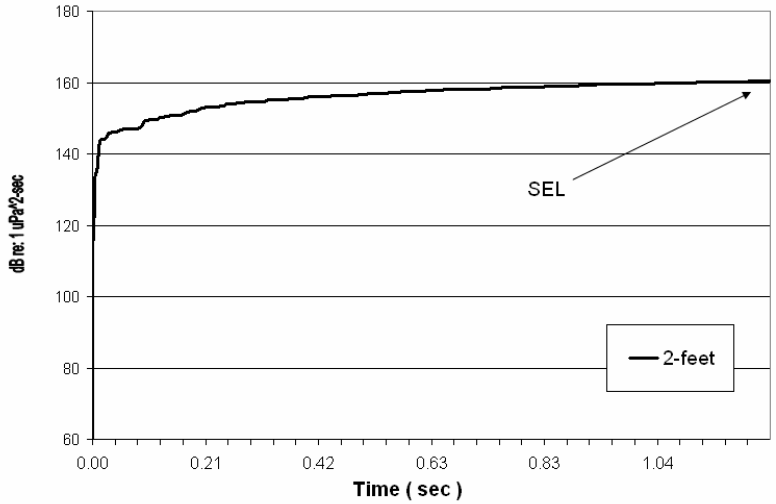


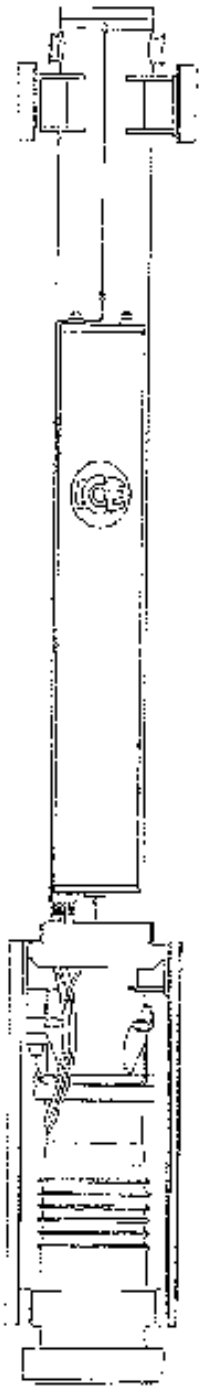
Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

2-feet - 00:00:00	Peak	RMS90%*	SEL
With Train	170	160	160
Without Train	175	160	160

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Model 60S
Fuel-Injected Diesel Pile Hammers



Clean • Efficient • Reliable

Designed and engineered for light-weight driven pile applications.

- High-pressure fuel injection provides easy starts even in extreme weather & soft soil conditions.
- Dual injectors optimize fuel atomization and delivery for clean, efficient operation.
- Remote variable fuel pump.
- Operates on vegetable-based fuel & lubricants without modification, contributing to a clean and toxin-free jobsite.
- Hydraulically-operated remote throttle permits precise control of stroke to match hammer energy to any job or pile condition.
- Upper & lower polymeric ram bearings minimize wear and maximize energy transfer.
- Lower cylinder and other critical components are chemically-treated for superior surface hardness and fatigue resistance.
- Ferro-chromium alloy forged ram & anvil exceed strength of cast rams & anvils for durability and long life.
- Weighs less than competitive hammers to move more easily from pile to pile.
- Swinging, fixed and sliding lead set-ups available in 16 and 8 ft. sections.
- Four models of light-to-heavy-duty lead spotters for precise pile positioning.

Working Specifications

Ram	7,000 lbs (3175 kg)
Maximum energy	72,900 ft-lbs (98.9 kNm)
Rated continuous energy	60,000 ft-lbs (81.4 kNm)
Minimum energy	26,000 ft-lbs (35.2 kNm)
Speed (blows per minute)	41-69

Weights

Bare hammer	13,900 lbs (6305 kg)
Typical weight (w/8' pile cap in 26" leads)	15,900 lbs (7210 kg)

Capacities (adequate for average day of operation)

Diesel fuel tank	18 gal (70 l)
Lube oil tank	8 gal (30 l)

Dimensions of Hammer

Width (side to side)	26" (660 mm)
Depth	37.5" (950 mm)
Centerline to front	17" (430 mm)
Centerline to rear	20.5" (520 mm)
Length (hammer only)	17'-0" (5080 mm)
Operating length (top of ram to top of pile)	26'-9" (8050 mm)

Model 60S

Fuel-Injected Diesel Pile Hammers

ICE 60S DIESEL PILE HAMMER BEARING CHART

This chart is based on the Gates formula given below and is provided as a convenience only for those applications where this formula is specified. The Gates formula has been recommended for use by the U.S. DOT Federal Highway Administration. The formula calculates ultimate pile capacity. The FHWA recommends using a factor of safety of 3.5 with the Gates formula. ICE has no preference for this formula over any other.

Ultimate bearing (tons) = [illegible] where E = hammer energy (ft-lbs) and N = hammer blows per inch at final penetration.

Blows per Min.	Ram Stroke (ft-in)	Hammer Energy (ft-lbs)	Pile Set (Blows per inch) 2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20
[illegible]	[illegible]	[illegible]	239	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	370	375	[illegible]	[illegible]	[illegible]	411	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
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CAUTION: Driving at ten blows per inch is considered practical refusal. Driving in excess of [illegible] for more than [illegible] inches of driving or driving in excess of 20 blows per inch at all is considered improper use and will void the hammer warranty.

LEADS/SPOTTERS

ICE manufactures leads with 20", 26" 32" and 36" guide rails for all ICE and other pile hammers. Standard components are available in 8' increments for swinging, fixed and sliding lead setups. Two designs are available to provide the most cost-effective configuration for every job. Four models of spotters and three spotter power unit sizes are available.

DRIVE CAPS

ICE offers a drive cap base/insert system for all ICE lead sizes as well as for pipe leads. Drive cap inserts are available for practically any pile type and size. The ICE drive cap system maintains pile top position under the hammer, protects the hammer from peak stresses, minimizes pile top deformation, and transmits maximum force to pile.

INTERNATIONAL CONSTRUCTION EQUIPMENT, INC.
Corporate offices:
301 Warehouse Drive, Matthews NC 28104
Phones: 704-821-8200 888-ICEUSA1 (423-8721)
Fax: 704-821-8201

Pile 1 w BC

Figure a. Waveform

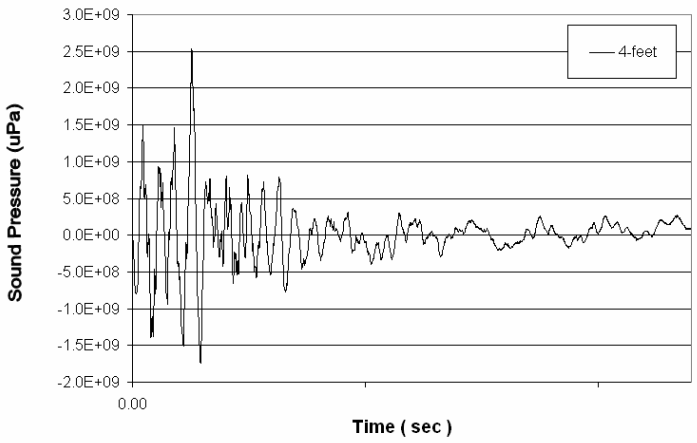


Figure b. Narrow Band Frequency Spectra

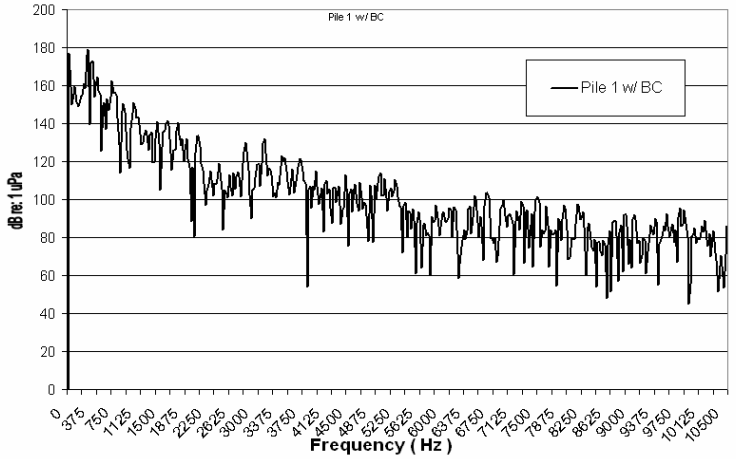


Figure c. Accumulation of Sound Energy

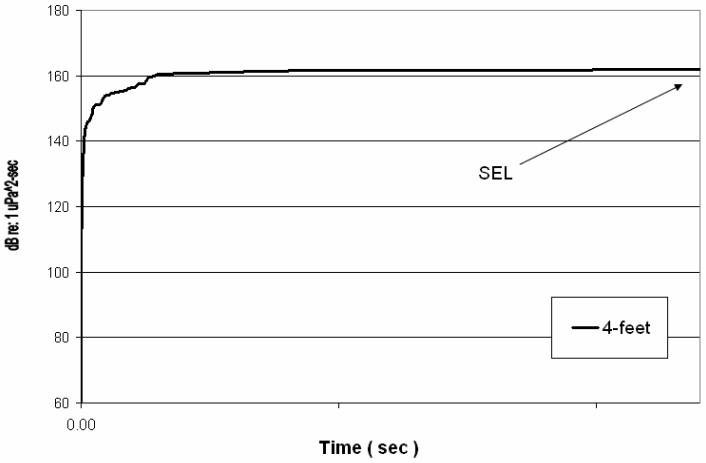


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

37-feet - 11:15:16	Peak	RMS90%*	SEL
4-feet	188	175	162

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 3 w BC

Figure a. Waveform

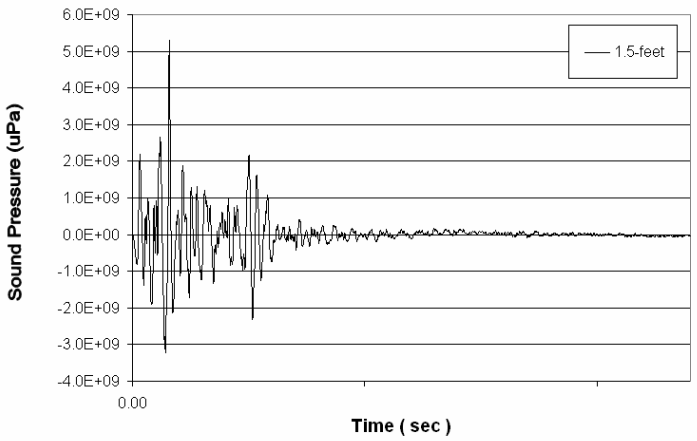
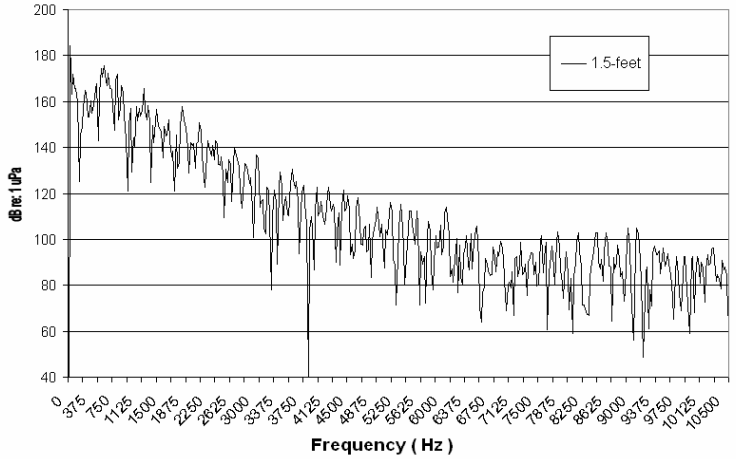


Figure b. Narrow Band Frequency Spectra



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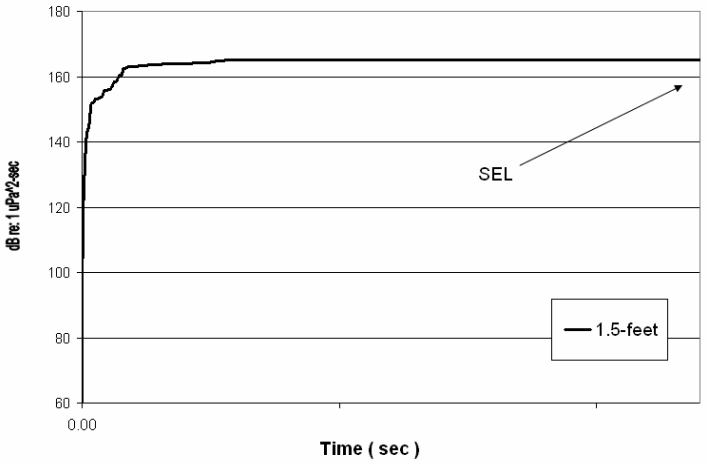


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

37-feet - 11:01:07	Peak	RMS90%*	SEL
1.5-feet	194	181	165

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 4 w/o BC

Figure a. Waveform

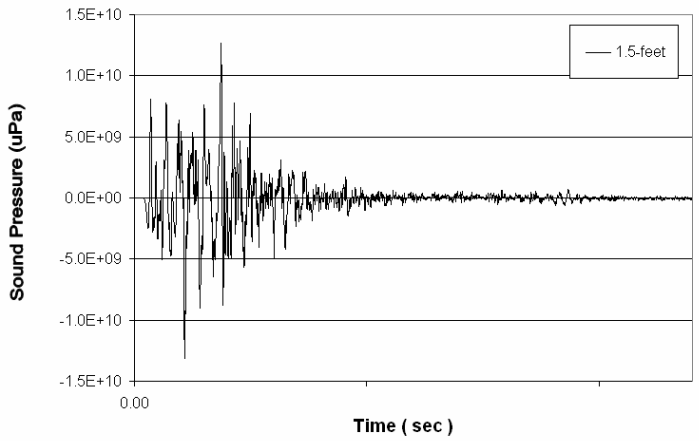


Figure b. Narrow Band Frequency Spectra

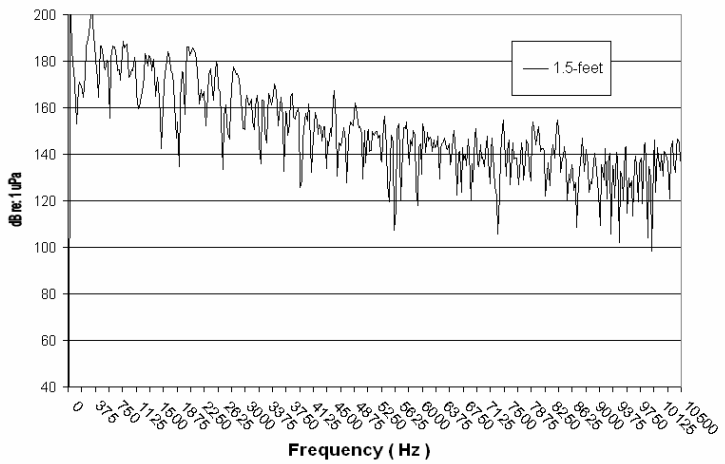


Figure c. Accumulation of Sound Energy

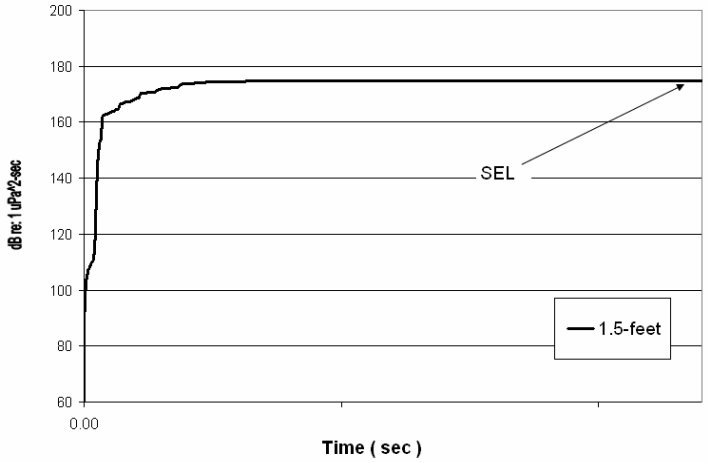


Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

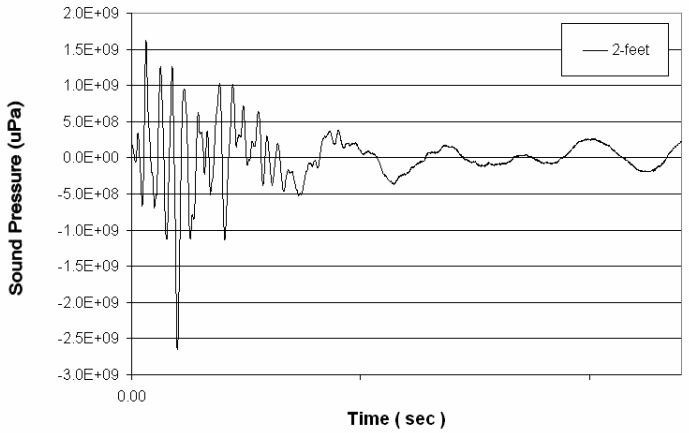
37-feet - 11:52:15	Peak	RMS90%*	SEL
1.5-feet	202	191	175

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 5 w/ BC

Figure a. Waveform



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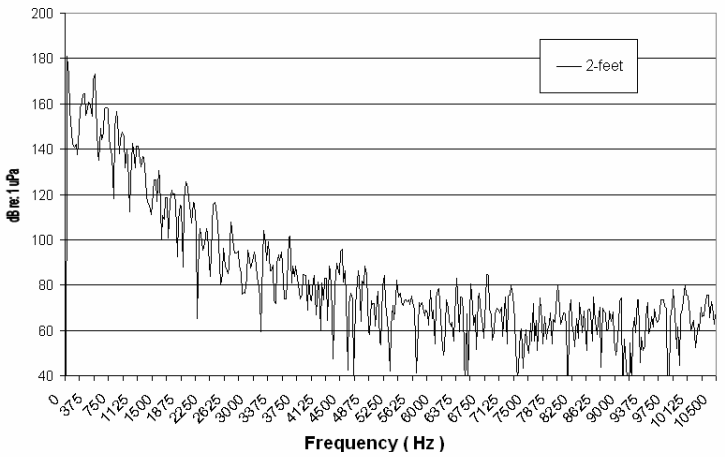

Figure c. Accumulation of Sound Energy

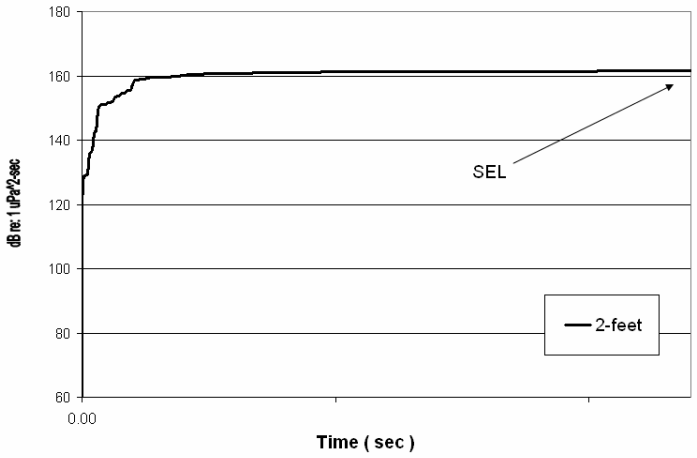

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

32.8-feet - 15:34:04	Peak	RMS90%*	SEL
2-feet	188	174	162

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 6 w BC

Figure a. Waveform

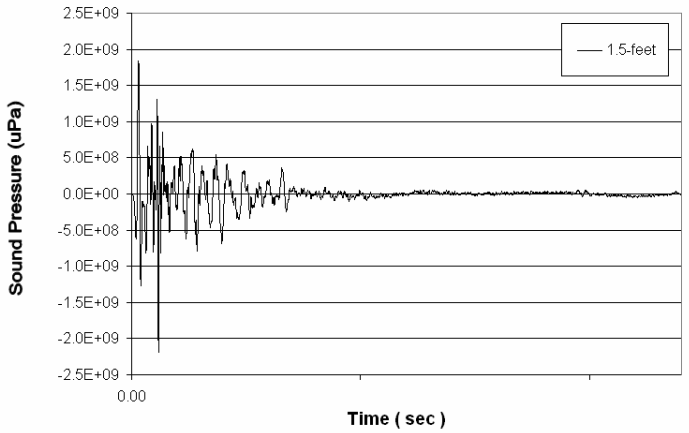

Figure b. Narrow Band Frequency Spectra

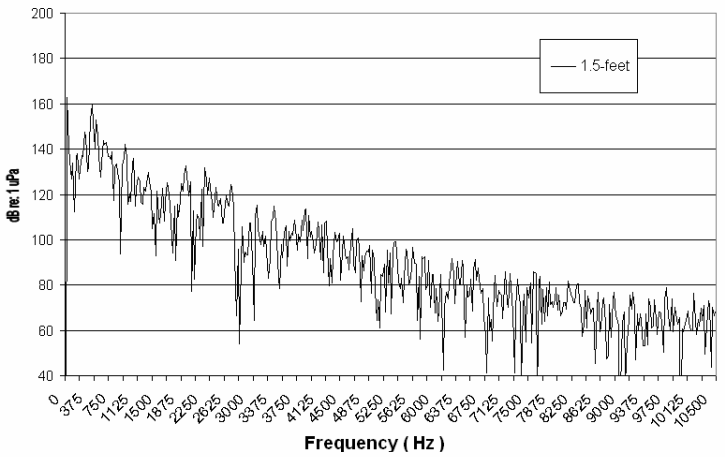

Figure c. Accumulation of Sound Energy

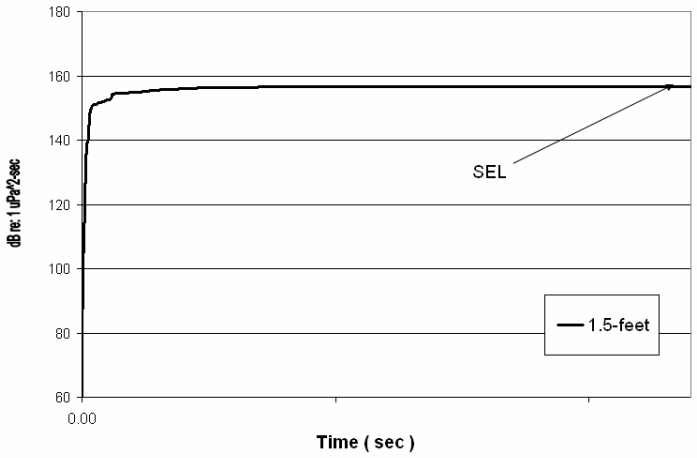

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

33-feet - 16:03:35	Peak	RMS90%*	SEL
1.5-feet	187	173	157

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 7 w/o BC

Figure a. Waveform

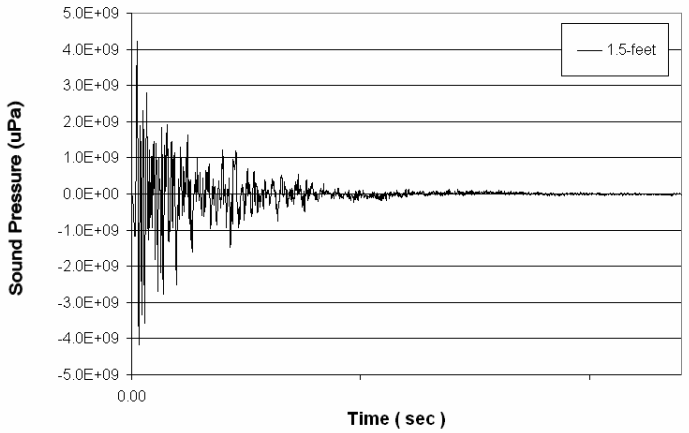

Figure b. Narrow Band Frequency Spectra

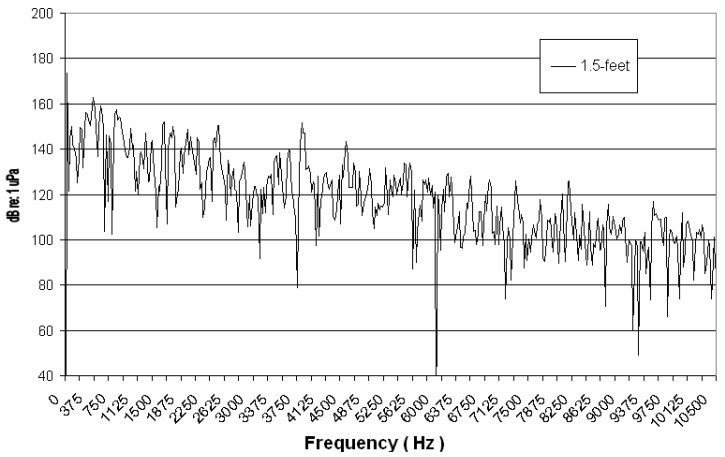

Figure c. Accumulation of Sound Energy

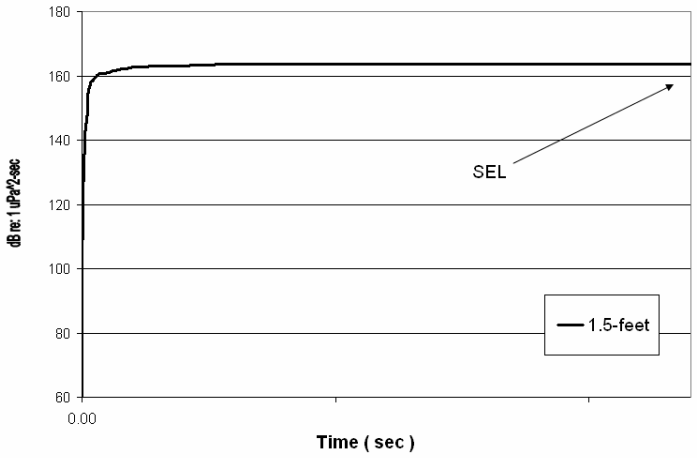

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

32.8-feet - 16:18:52	Peak	RMS90%*	SEL
1.5-feet	193	181	164

*Impulse averaged over 90% of accumulated energy (5% to 95%)

Unweighted Peak Sound Waveform Analysis Sheets for each Pile

Pile 8 w/o BC

Figure a. Waveform

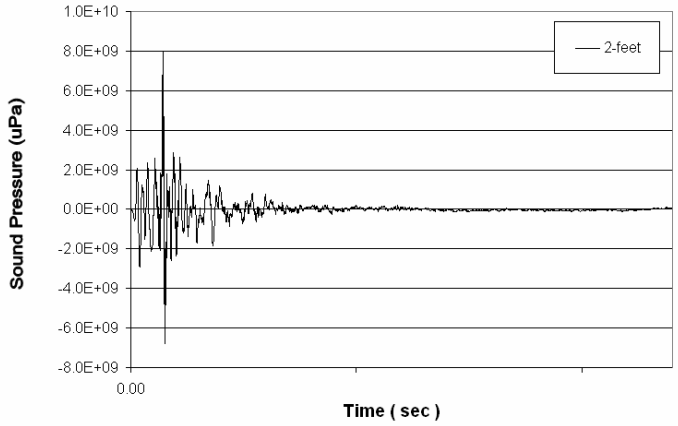

Figure b. Narrow Band Frequency Spectra

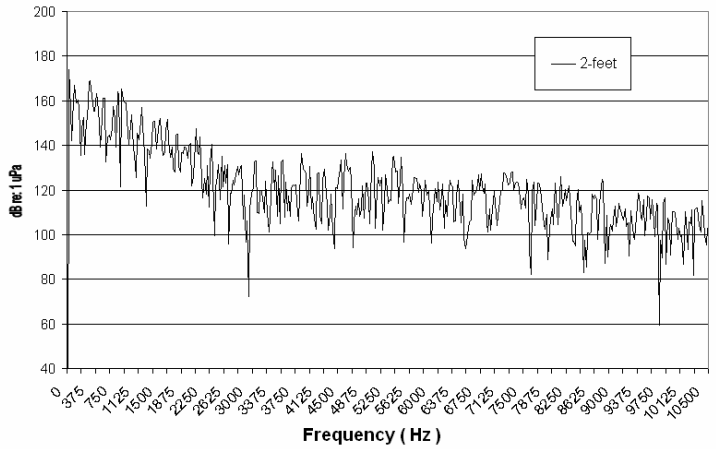

Figure c. Accumulation of Sound Energy

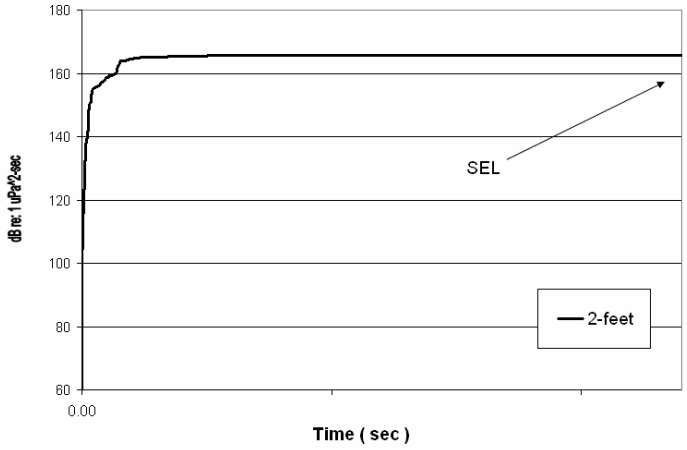

Figure d. Sound Pressure and Sound Energy Levels

Signal Analysis Sound Pressure / Energy Levels

32.8-feet - 16:35:43	Peak	RMS90%*	SEL
2-feet	198	184	166

*Impulse averaged over 90% of accumulated energy (5% to 95%)