3.7 Site G-165

3.7.1 Site Description

This site was on-campus at Beverly Hills High School and was the only test site where the borehole location permitted meaningful indoor measurements. Testing was performed on 5 Mar 2011 at test depths of 55, 65, and 75 feet. Three indoor accelerometers were installed, mounted roughly center-span inside class rooms 107, 123 and 201. Details on the classroom measurement points are shown in Table 9. The PSTM spectra and indoor/outdoor PSTM differences for each of the classrooms are shown in Figure 32 through Figure 36. For the outdoor measurements the accelerometers were located at distances of 25, 37, 50, 75, 100, and 150 feet extending north from the borehole location. The line of accelerometers was offset from the borehole by 9 ft. Additional observations from the measurements include:

- At 55 ft depth, the hole advanced by 2 ft from the impacts. Force levels were in the range of 5k to 6k lbs. 100 hits were recorded.
- At 65 ft depth, 60 hits were recorded before the drill string advancement (30 inches) halted data collection. Additional drill rod was inserted and 60 more hits were recorded. The load cell failed during the second set of impacts.
- At 75 ft depth, 100 impact hits were recorded and there was no perceptible advancement. Because the load cell failure during the test at 65 ft, no force data were obtained at this test depth and transfer mobilities were not obtained.
- The accelerometer channel for Room 201 suffered from electrical interference during the entire measurement period.

Table 9: Classroom measurement locations at Beverly Hills High School

Room	Distance to Borehole	Room Description / Notes
107	100 ft; S-E of borehole	First floor classroom; basement below; floor noted as being relatively flexible
123	100 ft, N-E of borehole	First floor classroom; also suspended floor but notably stiffer than room 107
201	100 ft, N-E of borehole	Second floor classroom (directly above room 123)

3.7.2 Results for G-165

- Force levels at the 55 ft and 65 ft test depths were particularly low (3k to 8k lbs) although this was partially offset by the fact that the ambient noise levels at G-165 were lower than that encountered at the Wilshire Boulevard test sites.
- The coherences for the 55 ft test were relatively good through the 60 Hz 1/3 octave bands and still reasonable at higher frequencies.
- The coherences for the 65 ft test were good through up to the 100 Hz 1/3 octave band and then dropped off rapidly at higher frequencies.

- The best fit LSTM is flat up to 63 Hz at the 50 foot distance, and the fall off with distance is faster at the higher frequencies than the lower frequencies. The minimum drop off occurs in the 20 Hz band with only a 2 VdB loss from 50 to 200 ft.
- Comparisons of indoor and outdoor vibration levels were made by taking differences between the indoor and the closest outdoor PSTM spectra. For classroom 107 the closest accelerometer was the 100-foot position, and for classrooms 123 and 201 the 75-foot accelerometer data were used. PSTM data are shown (Figure 31, Figure 33, and Figure 35) for both the classroom and the outdoor reference measurement at each of the 3 test depths. Differences between these spectra for the three test depths are shown in Figure 32 (room 107), Figure 34 (room 123), and Figure 36 (room 201). Note that PSTM differences are plotted only at those frequencies where the PSTM coherence was above 0.1 for both the indoor and outdoor measurement.
    - **Classroom 107:** This classroom exhibited the largest outdoor/indoor level increase of the three rooms studied, with a 20-dB amplification observed at 10 Hz. Interior levels were approximately 10 dB higher than outdoor levels 25 and 50 Hz. This is consistent with the field observation that the floor in room 107 appeared to have unusually low stiffness.
    - **Classroom 123:** This classroom was also on the ground floor, and also with a suspended floor. As can be seen in Figure 34, no distinct resonances were observed, with mean differences near 0 dB at 10 Hz, falling gradually to -5 dB at 40 Hz.
    - **Classroom 201:** This second floor classroom lies directly above room 123. Here the PSTM differences suggest some amplification (5 – 10 dB) occurring in the 25 Hz band, but otherwise little amplification or attenuation with respect to the outdoor levels.

3.7.3 Plots and Tables

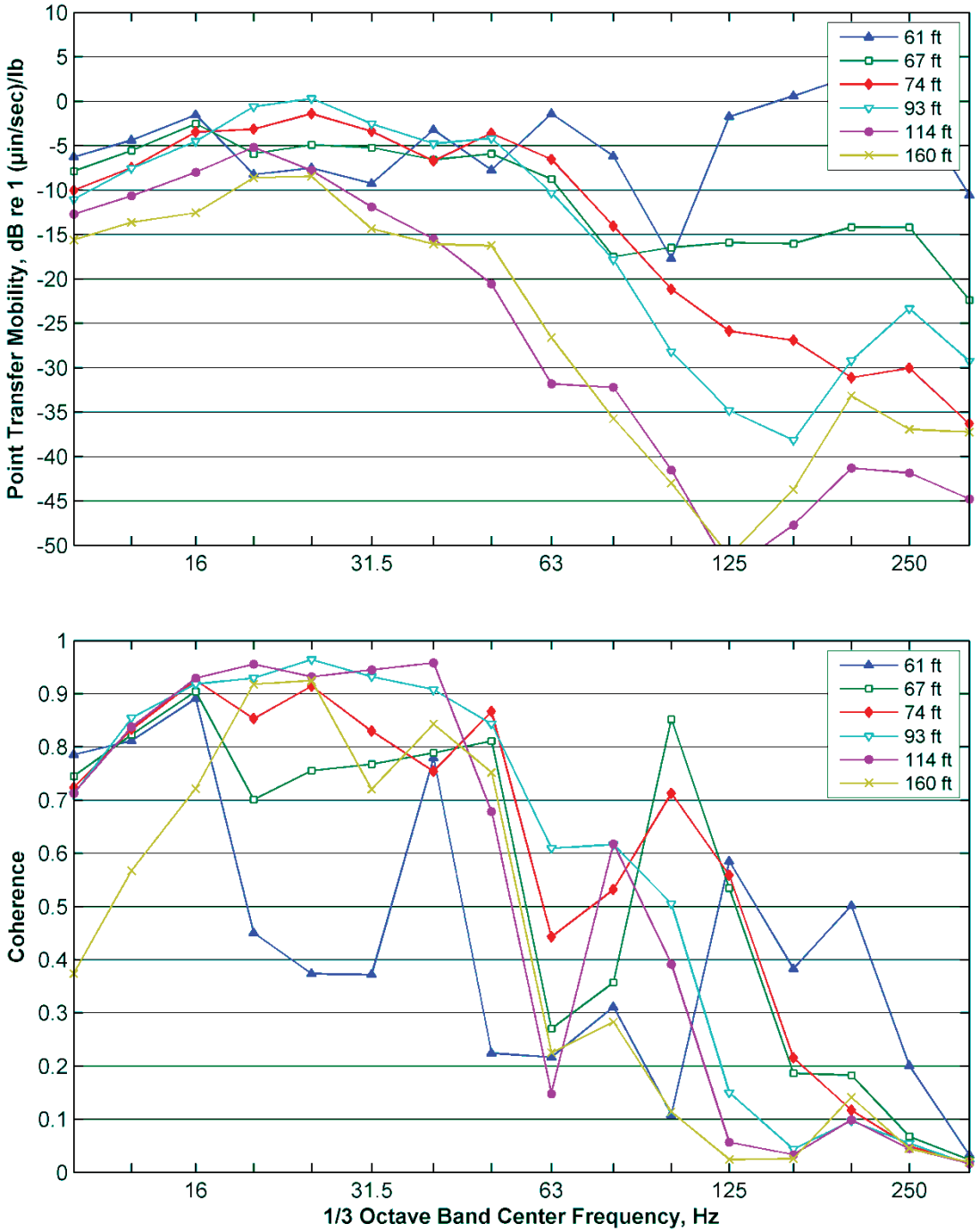

Figure 28: G-165. Measured PSTM at Depth of 55 ft

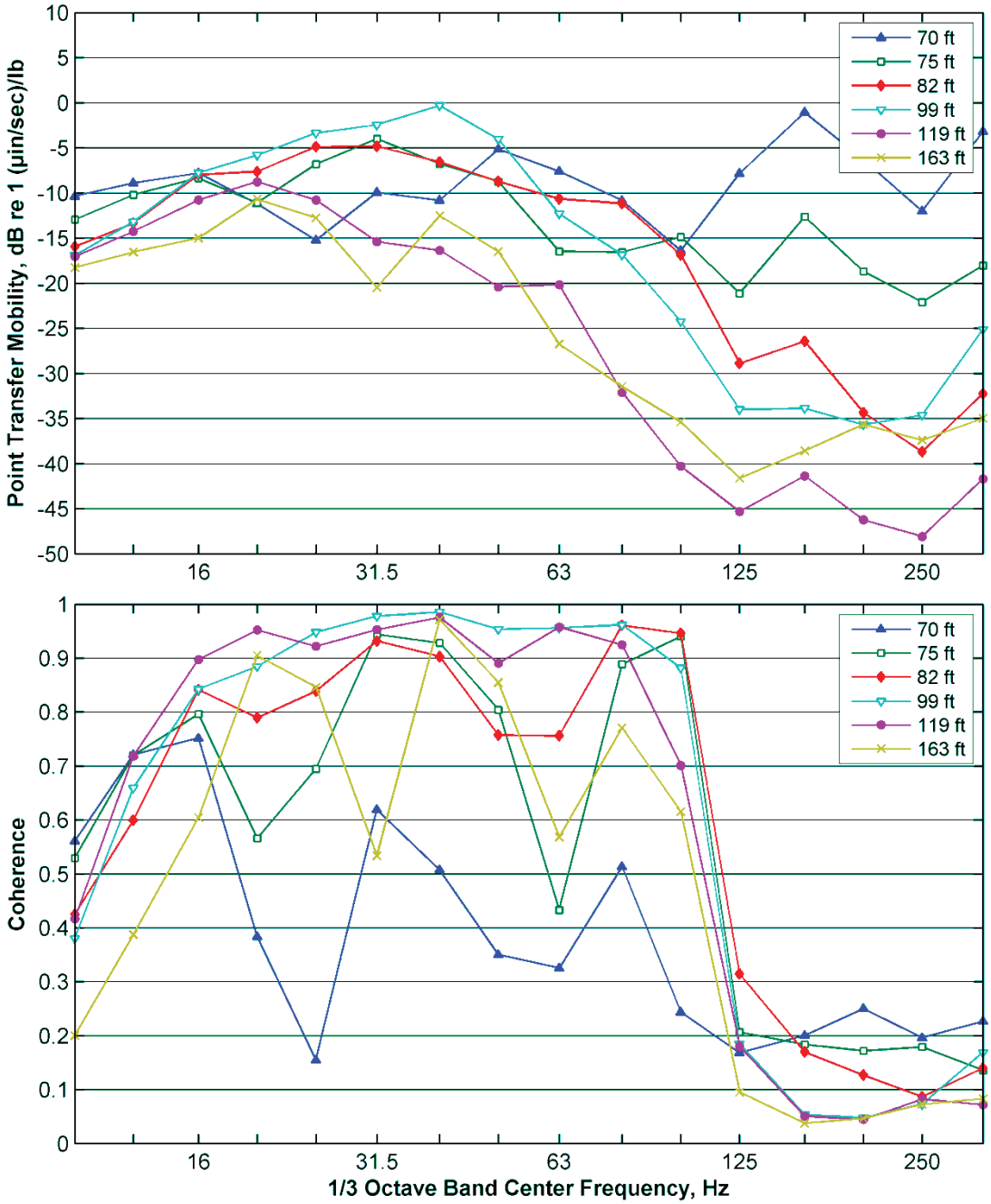

Figure 29: G-165. Measured PSTM at Depth of 65 ft

Table 10: G-165. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	22.43	2.05	-4.16	**63**	87.94	-36.42	-2.73
12.5	25.30	1.83	-4.17	**80**	95.60	-43.77	-2.39
16	32.02	-0.11	-4.22	**100**	99.23	-49.28	-2.16
20	17.71	2.55	-1.03	**125**	164.63	-87.20	-1.01
25	17.67	5.40	-2.67	**160**	155.82	-80.89	-1.15
31.5	37.95	-3.96	-4.20	**200**	114.29	-58.03	-1.83
40	30.15	0.18	-4.22	**250**	112.15	-57.57	-1.84
50	43.53	-7.96	-4.08	**315**	82.78	-40.90	-2.52

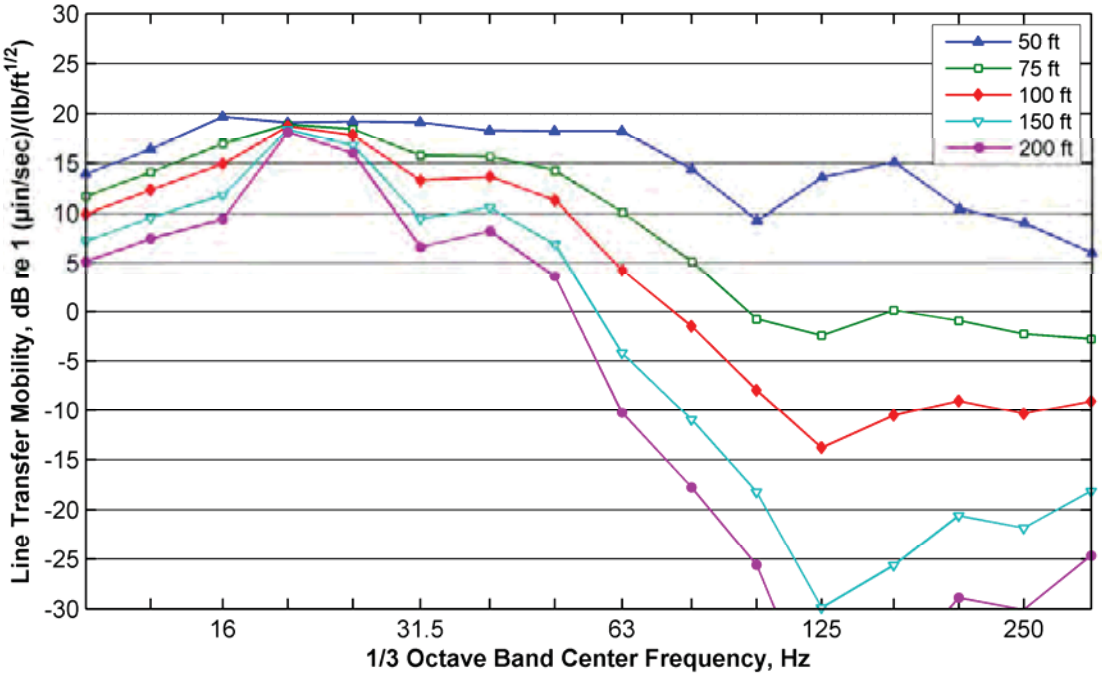

Figure 30: G-165. Best Fit LSTM

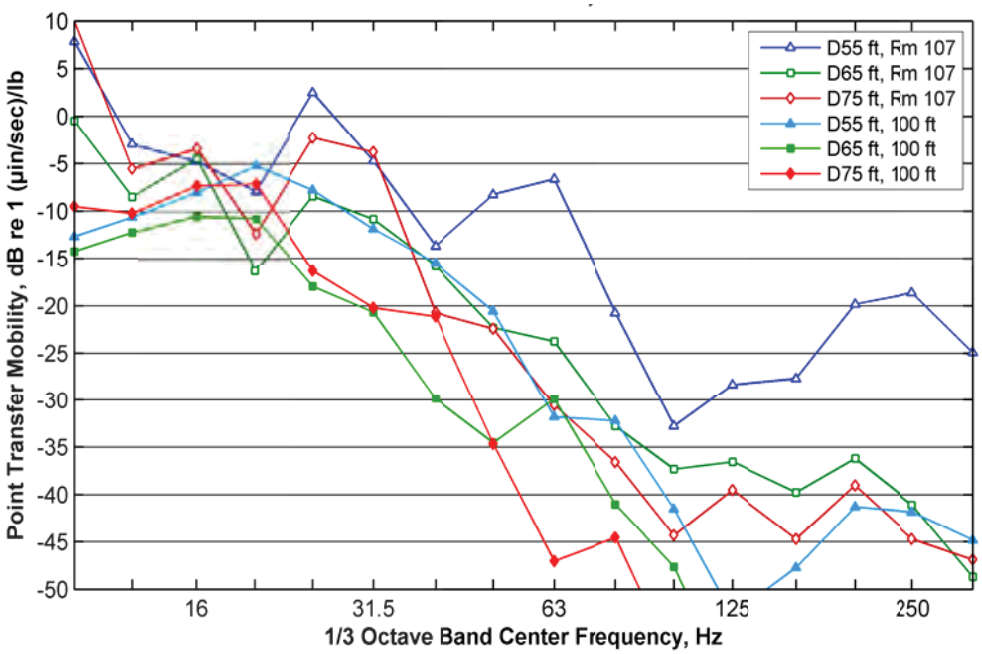

Figure 31: PSTM Spectra for Classroom 107

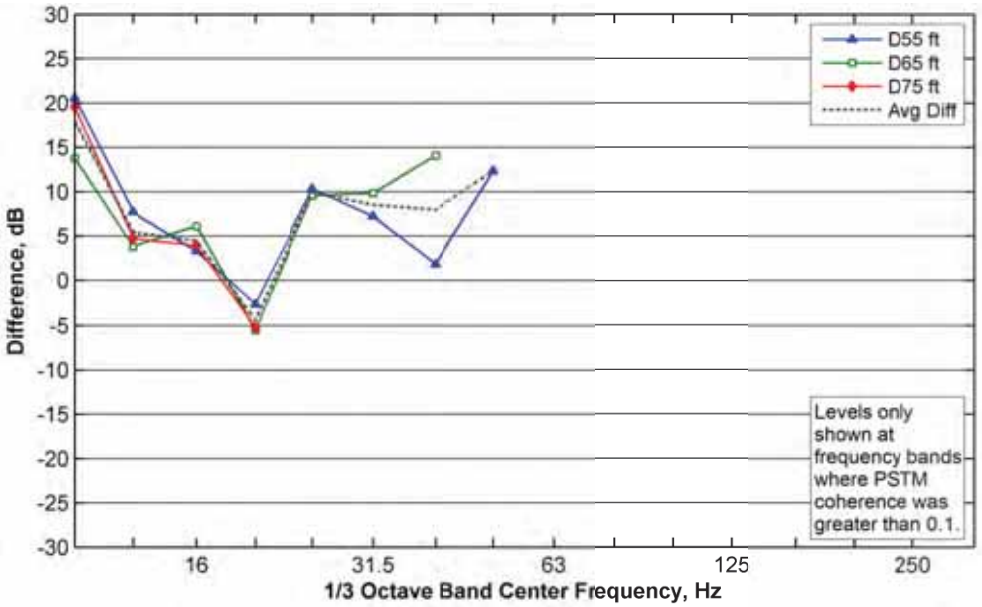

Figure 32: PSTM Difference (Indoor – Outdoor) for Room 107

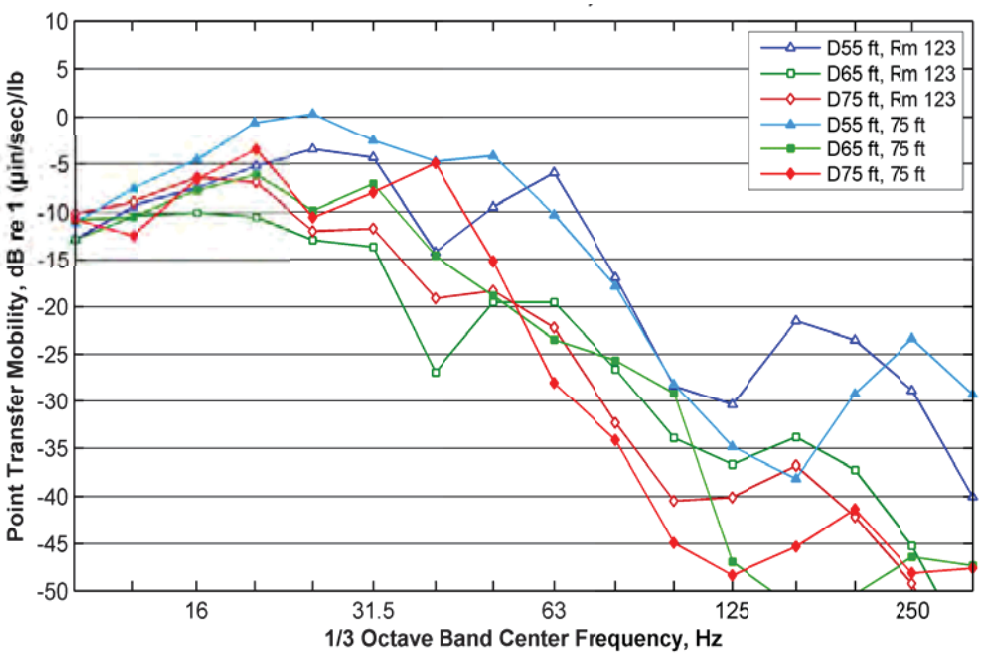

Figure 33: PSTM Spectra for Classroom 123

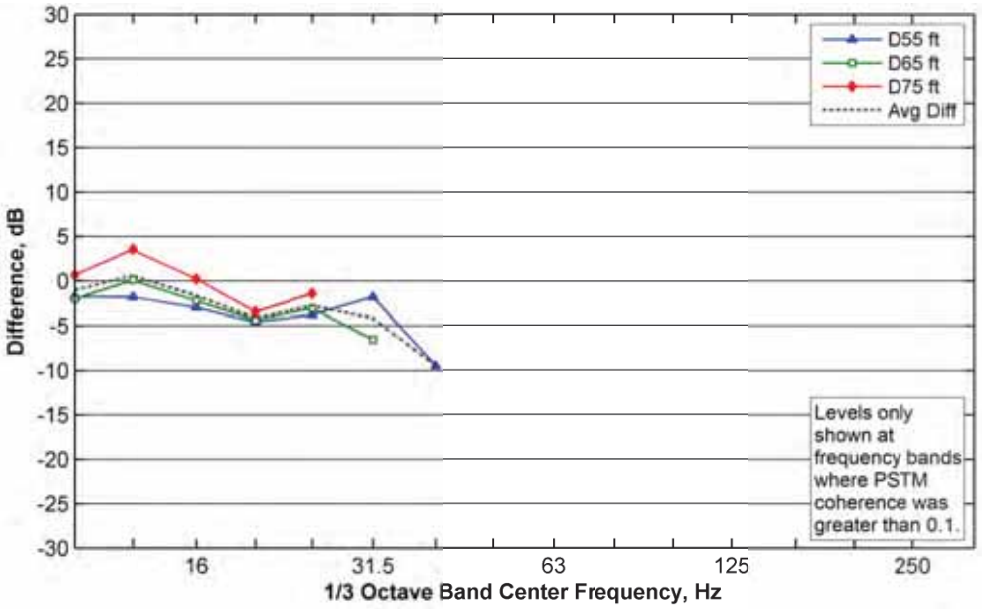

Figure 34: LSTM Difference (Indoor – Outdoor) for Room 123

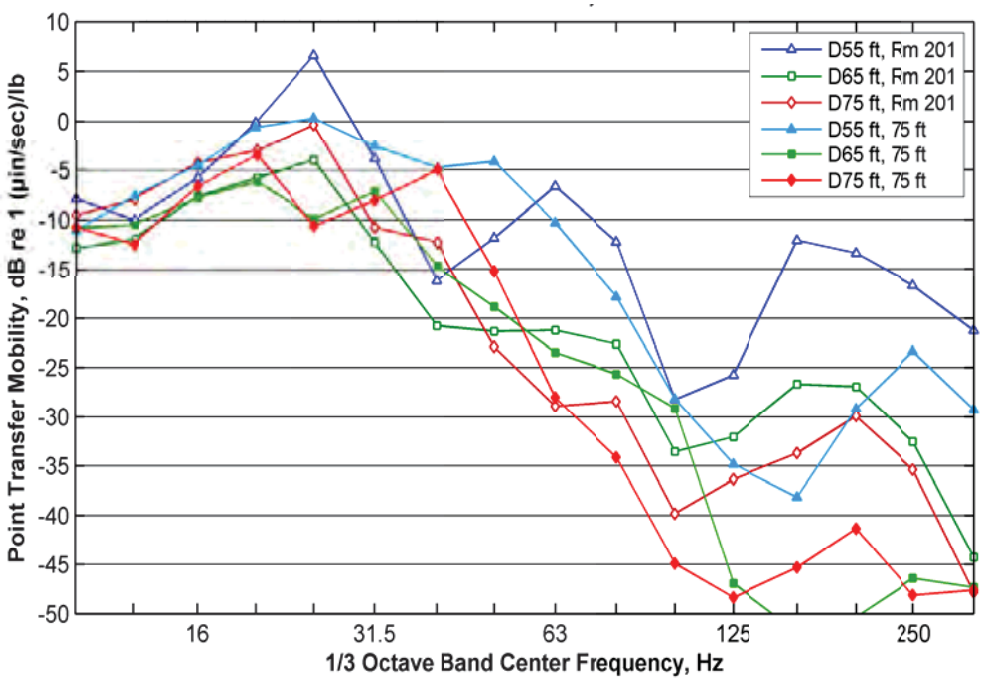

Figure 35: PSTM Spectra for Classroom 201

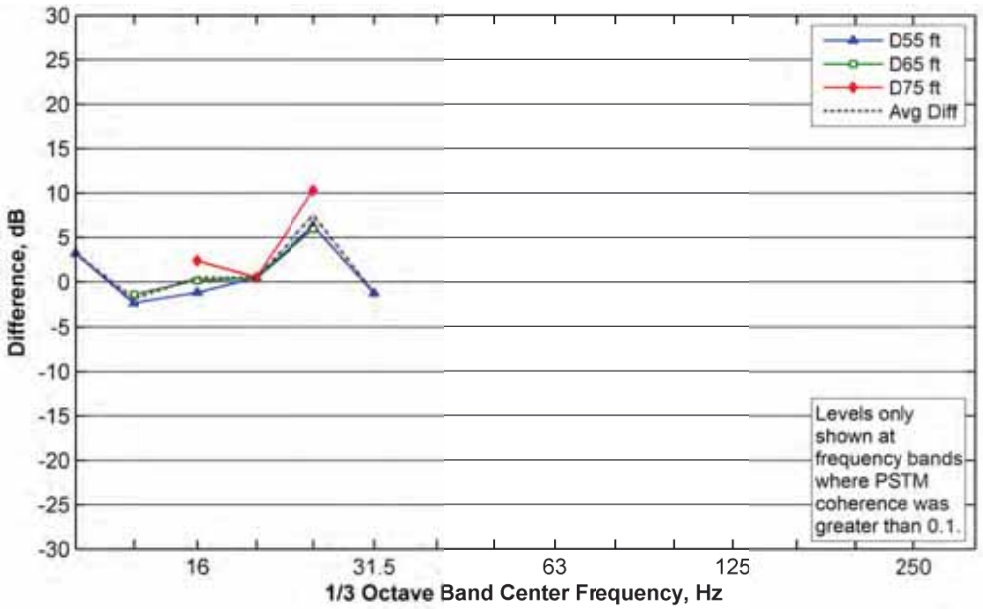

Figure 36 – PSTM Difference (Indoor – Outdoor) for Room 201

3.8 Site G-166

3.8.1 Site Description

This site was also on the Beverly Hills High School campus, along the western edge of the Lacrosse field. Testing was performed on 19 Mar 2011, at test depths of 55, 65, and 75 feet. The accelerometers were located at distances of 25, 40, 60, 90, 140, and 165 feet, extending north from the borehole location. The line of accelerometers was offset from the borehole by 4 ft. Additional observations from the measurements include:

- At the 55 ft test depth, the load cell was advanced 2 ft by the impacts. Peak force levels were 4k to 5k lbs, among the lowest observed in the 12 tests. 100 hits were recorded.
- At the 65 ft depth, 100 impact hits were recorded before the drill string advancement (30 to 36 inches) halted data collection. No force data was available for this test depth due to instrumentation problems, although the large advancement observed implies very low forces.
- At the 75 ft depth, 100 impact hits were recorded with 6 inches advancement during the first 30 hits, and no perceptible advancement for the remainder of the test. The force levels rose from 4k to 25k lbs during the test.

3.8.2 Results for G-166

- Coherences were good through 160 Hz for all the measurements except the farthest accelerometers for each depth, which still had good coherence in 1/3 octave bands below 63 Hz.
- The LSTM decreases with distance more rapidly at the higher frequencies than at lower frequencies. There minimum decrease with distance is in the 16 Hz band.
- The best fit LSTM has a spectral peak on the 63 Hz band for the 50 ft distance, which is seen in the PSTM of the closest accelerometer location at the shallowest depth. However, there is a distinct dip in coherence for that band at the 55 foot test depth. .

3.8.3 Plots and Tables

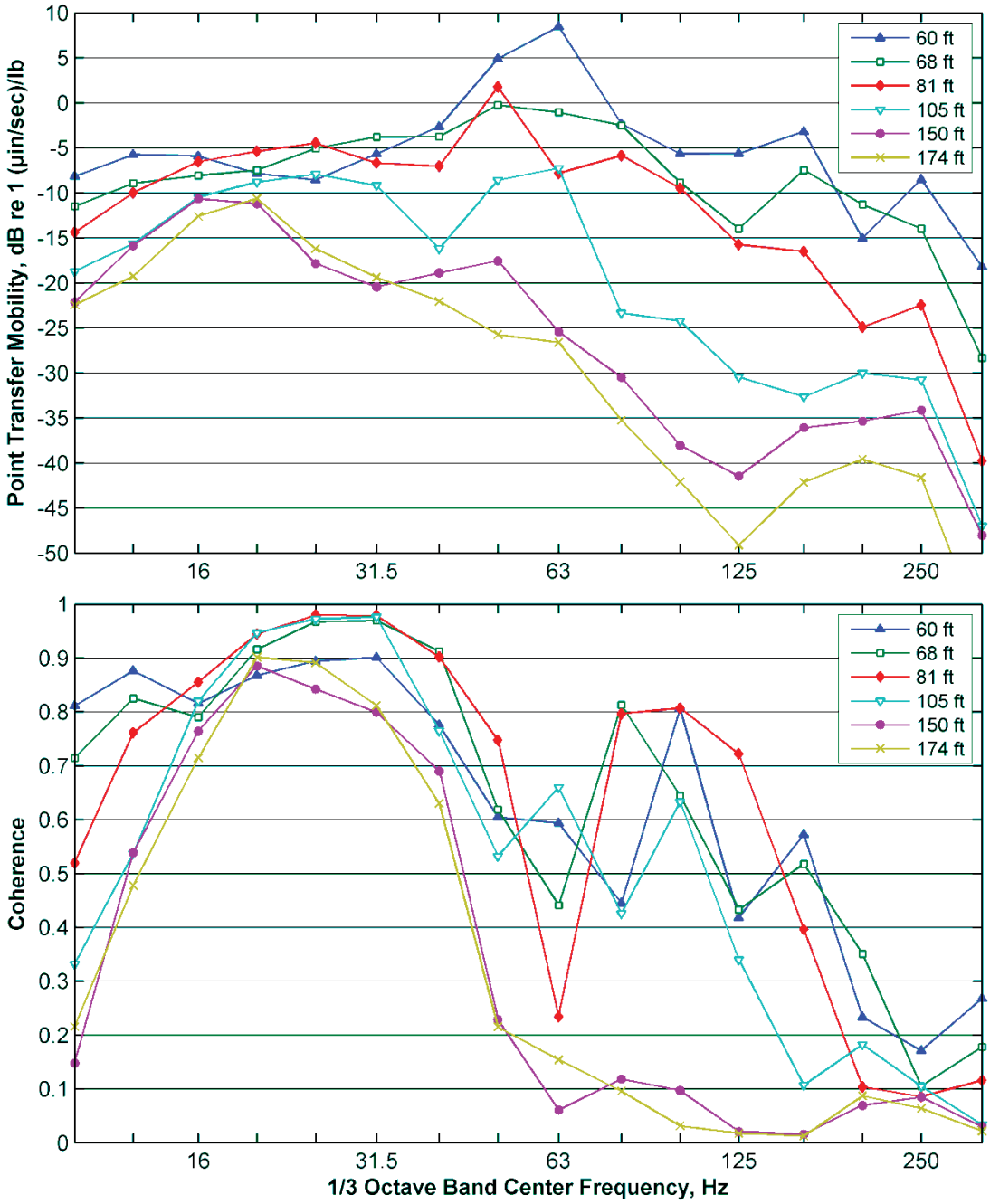

Figure 37: G-166. Measured PSTM at Depth of 55 ft

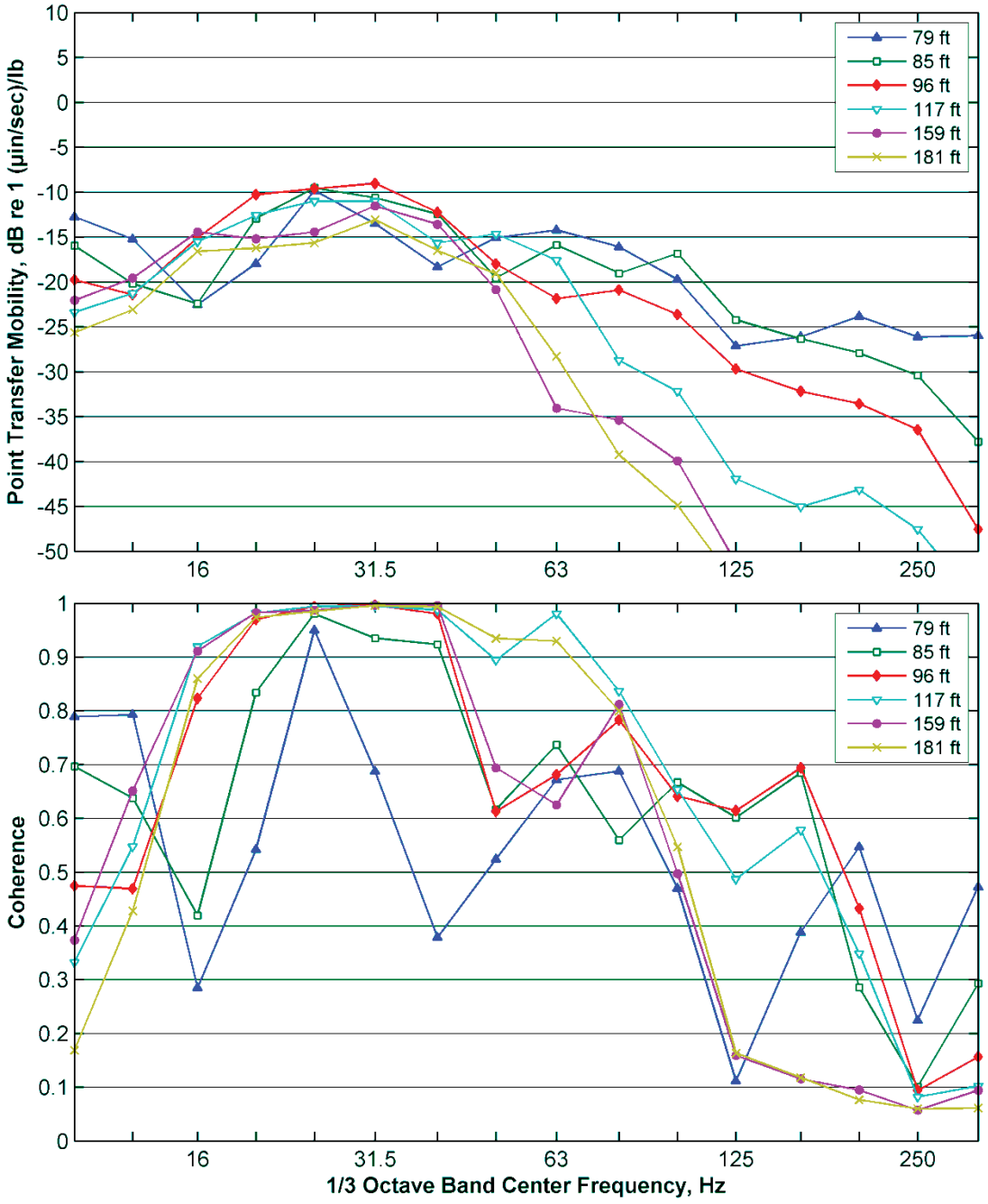

Figure 38: G-166. Measured PSTM at Depth of 75 ft

Table 11: G-166. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	34.67	-6.44	-4.13	**63**	111.57	-48.31	-2.20
12.5	24.81	-0.25	-4.23	**80**	125.44	-58.92	-1.80
16	11.27	4.73	-2.14	**100**	136.53	-66.96	-1.53
20	14.28	5.60	-2.94	**125**	150.72	-77.97	-1.22
25	27.56	1.14	-4.20	**160**	156.92	-81.03	-1.15
31.5	27.83	0.85	-4.20	**200**	117.63	-60.87	-1.73
40	33.87	-3.40	-4.21	**250**	131.87	-69.04	-1.47
50	71.55	-24.18	-3.33	**315**	121.84	-69.26	-1.46

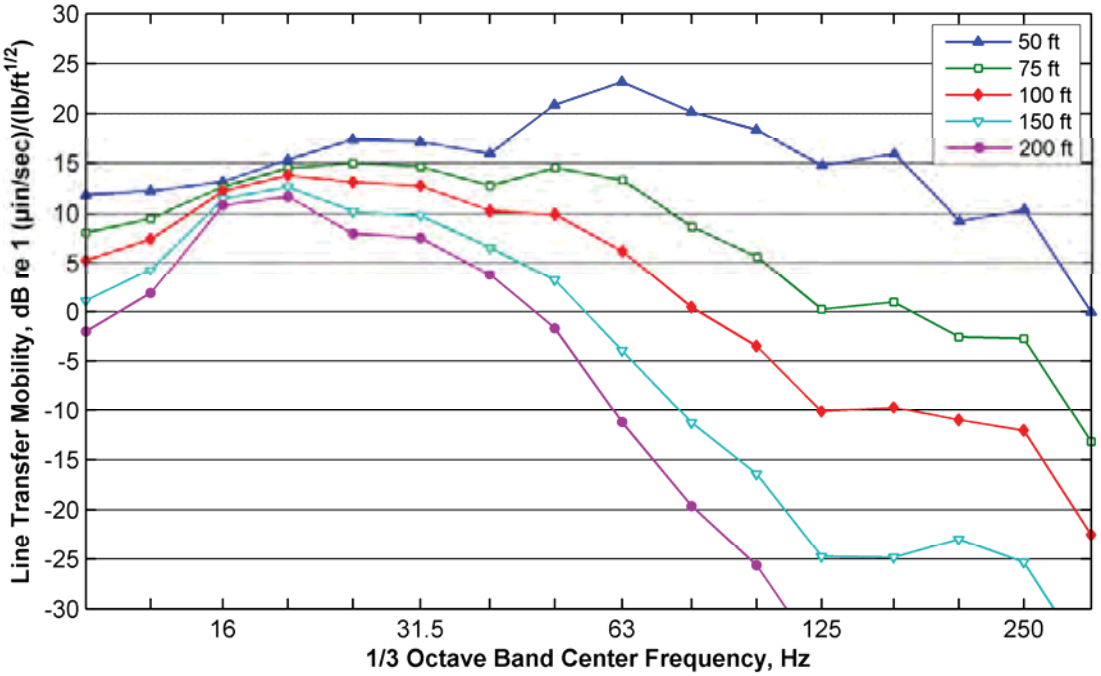

Figure 39: G-166. Best Fit LSTM

3.9 Site G-173

3.9.1 Site Description

This site was located on Missouri Avenue, approximately 50 feet east of the intersection of Missouri and Fox Hills, and 75 feet west of the prior test done at SB-2. Testing was performed on 21 and 22 Jan 2011, at test depths of 60, 70, and 80 feet. The line of accelerometers was set up extending south along the sidewalk on Fox Hills at distances of 12, 24, 37, 62, 87, 137 feet. This resulted in similar spacing to the normal distances used by starting closer and compensating for the abnormally high borehole offset (24 feet). Because vehicular traffic on Fox Hills was intermittent, background interference from traffic was minimal during the test. Following are some observations from the measurements:

- At 60 ft depth, there was no perceptible load cell advancement of the hole from the impacts. Force levels ranged from 20k to 25k lbs. 100 hits were recorded.
- At 70 feet, 100 impact hits were recorded with no perceptible advancement. Force levels were approximately 15k lbs throughout.
- At the 80 foot depth, there was very little (2 inches) advancement from the impacts. The drill crew supervisor reported silty sand at this depth. Measured force levels were 7k to 10k lbs.

3.9.2 Results for G-173

- The PSTM for impact hits at all three depths were similar indicating potentially lower attenuation rate for vibration.
- The coherences were good between 25 and 125 Hz for most tests but lower (and somewhat erratic) at 25 Hz and below.
- The LSTM shows a relatively constant decrease in distance across all frequency bands, with a slight increase in fall-off in the higher frequency bands.

3.9.3 Plots and Tables

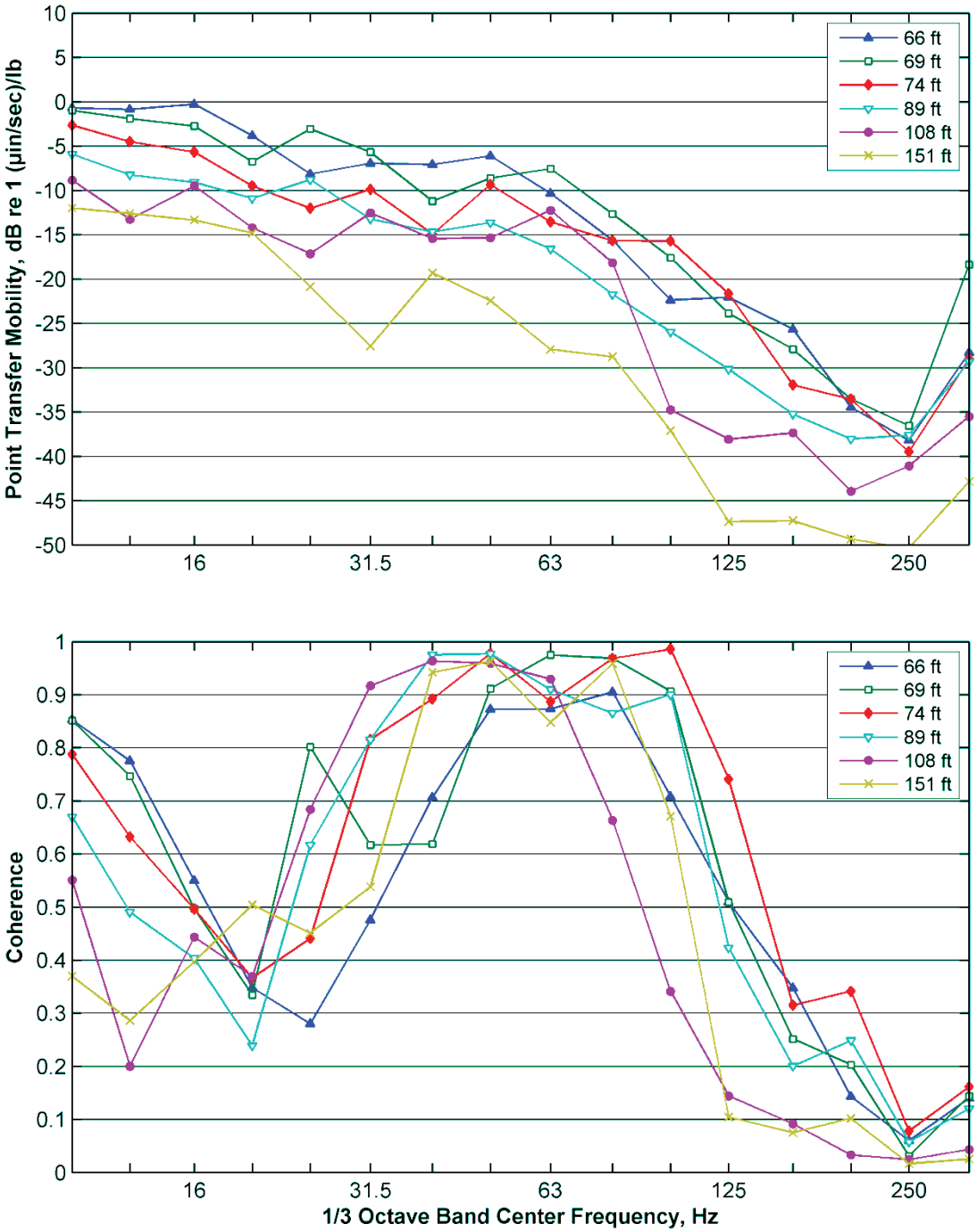

Figure 40: G-173. Measured PSTM at Depth of 60 ft

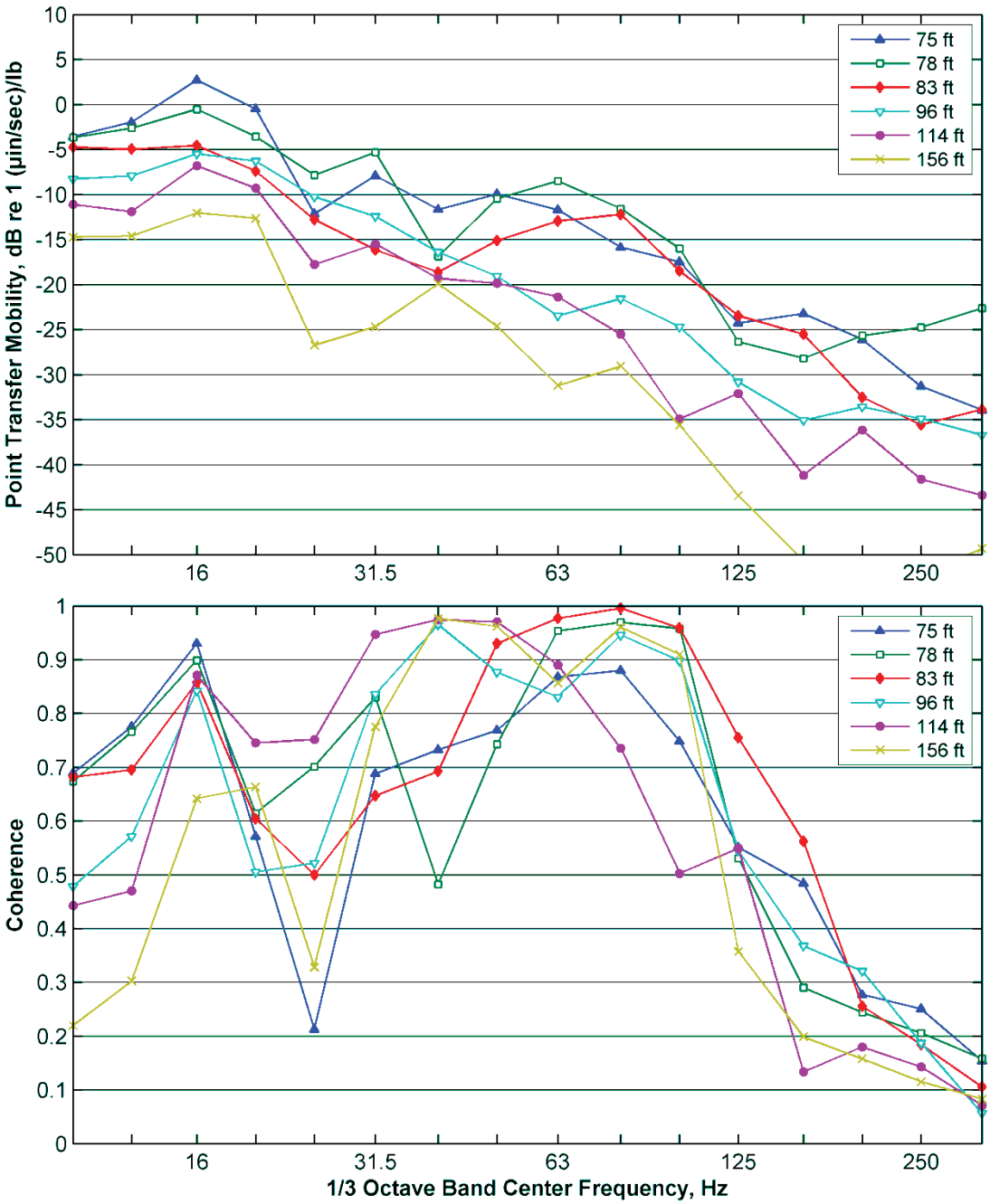

Figure 41: G-173. Measured PSTM at Depth of 70 ft

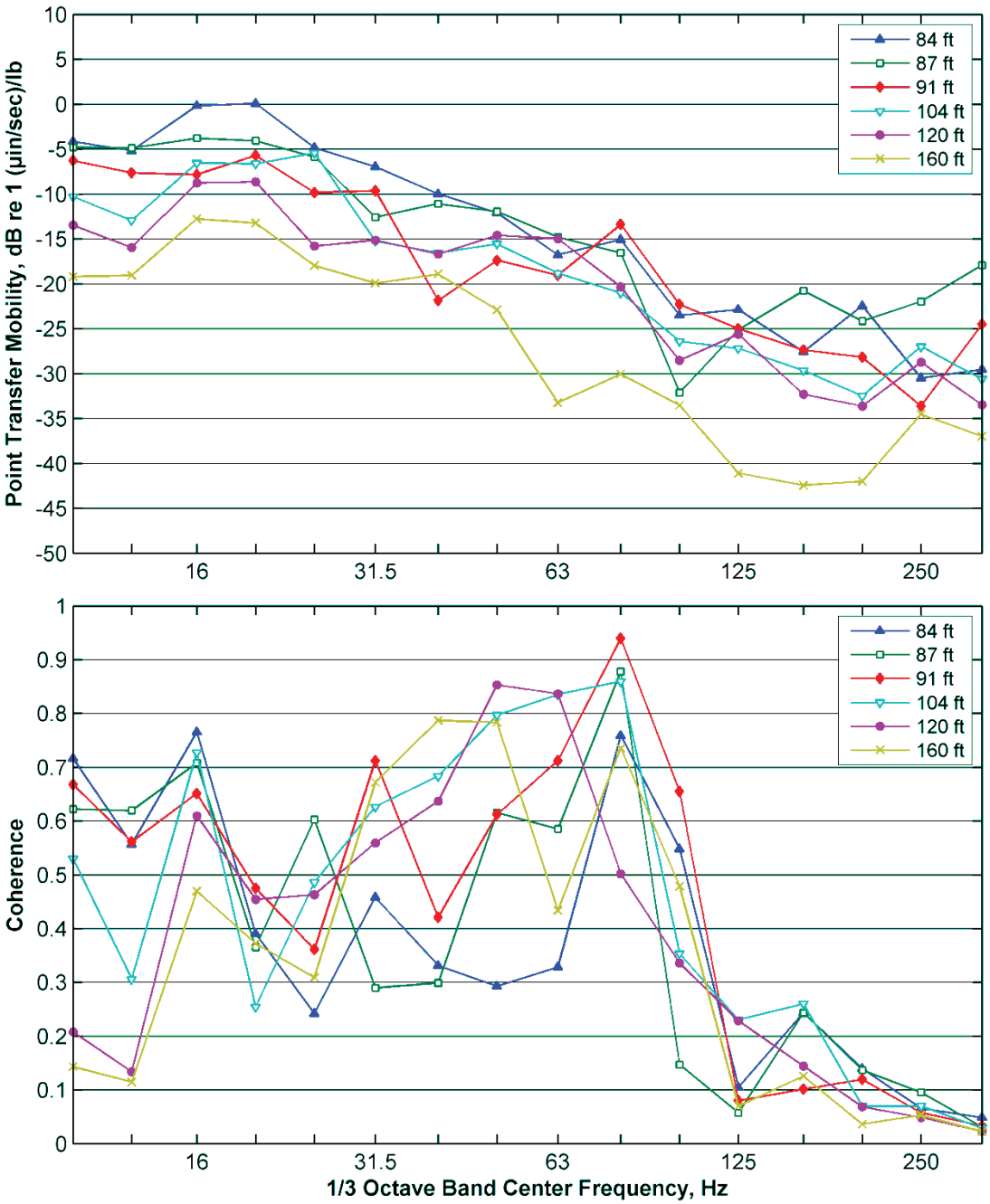

Figure 42: G-173. Measured PSTM at Depth of 80 ft

Table 12: G-173. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	63.23	-17.45	-3.66	**63**	81.27	-33.56	-2.86
12.5	65.43	-19.23	-3.58	**80**	58.70	-21.56	-3.46
16	49.00	-8.40	-4.07	**100**	66.57	-29.98	-3.04
20	35.92	-2.06	-4.23	**125**	76.21	-37.49	-2.67
25	59.58	-17.97	-3.64	**160**	74.84	-38.57	-2.62
31.5	67.93	-23.43	-3.36	**200**	50.34	-25.54	-3.26
40	21.23	1.48	-4.18	**250**	13.56	-5.11	-4.17
50	55.05	-17.02	-3.68	**315**	60.14	-29.78	-3.05

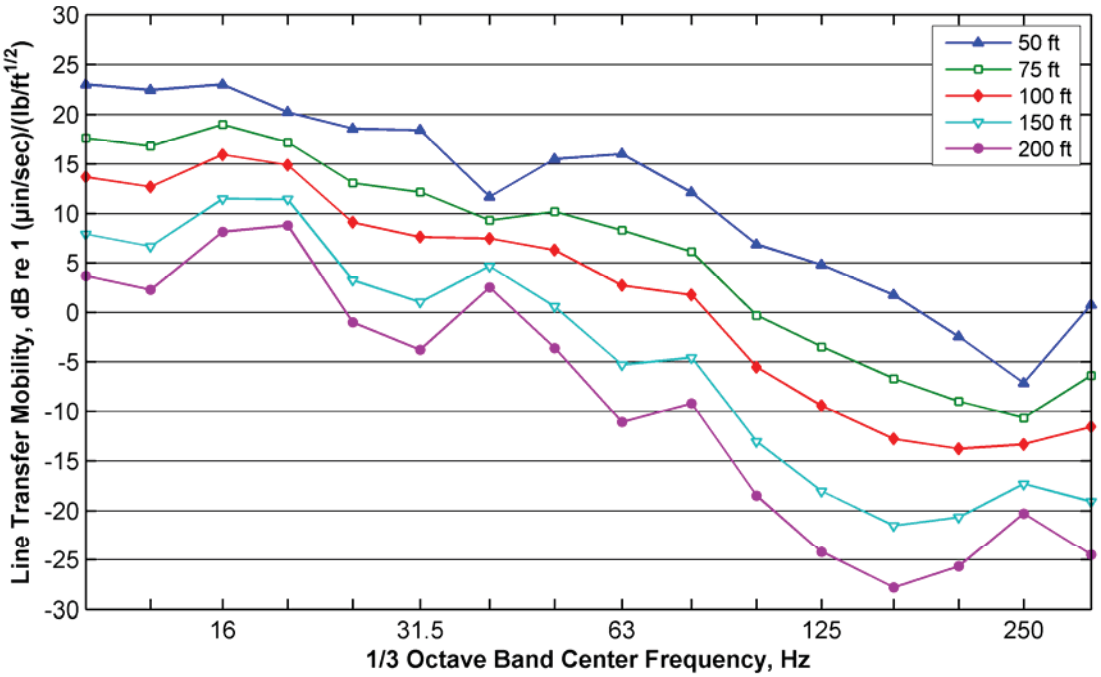

Figure 43: G-173. Best Fit LSTM

3.10 Site G-176

3.10.1 Site Description

This site was located on Warner Avenue between Thayer and Rochester, a residential street with no apparent background vibration sources. The closest street with significant traffic was approximately 500 ft away from the line of accelerometers. Testing was performed on 27 and 28 Dec 2010, at test depths of 80, 90, and 97 feet. The accelerometers were arrayed downhill along Warner Avenue at distances of 25, 37, 50, 75, 100, and 150 feet from the borehole. The signal to noise ratio was very low for the closest three accelerometers and because of electromagnetic interference. The signals at the farther three accelerometers were good. The following are some observations from the measurements:

- Two sets of 100 hits each were collected at the 80 foot test depth. Force levels ranged from 10k to 13k lbs.
- At the 90 foot test depth two set of 100 hits each were recorded. Force levels were in the 7k to 9k lbs range.
- At the 97 foot depth a single set of 100 hits was recorded. Force levels were in the 6k to 7k lbs range.

3.10.2 Results for G-176

- The coherences were surprisingly low for measurements at the closest three accelerometers.
- The PSTM for all depths were similar showing potentially lower attenuation rate for vibration.

3.10.3 Plots and Tables

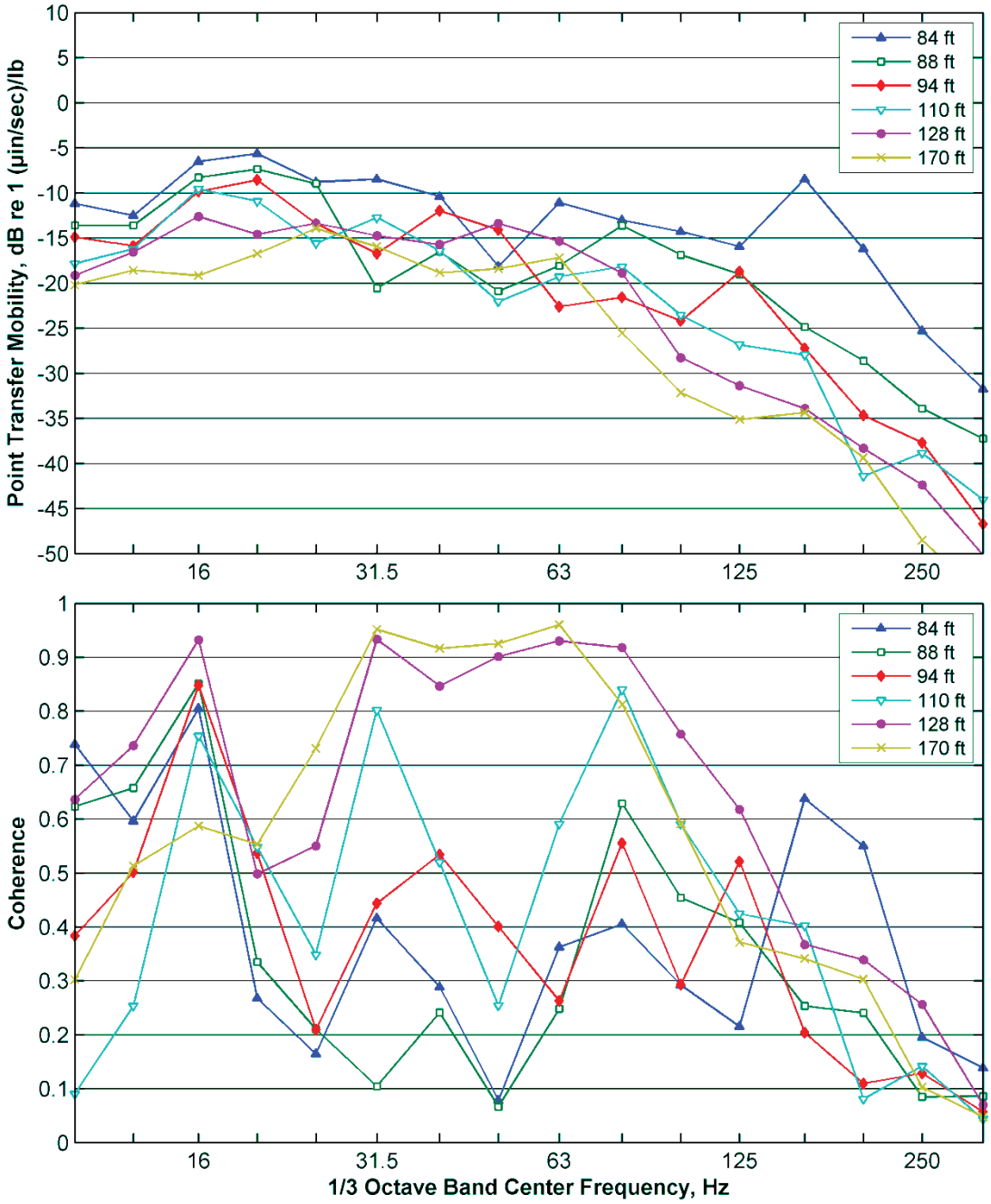

Figure 44: G-176. Measured PSTM at Depth of 80 ft

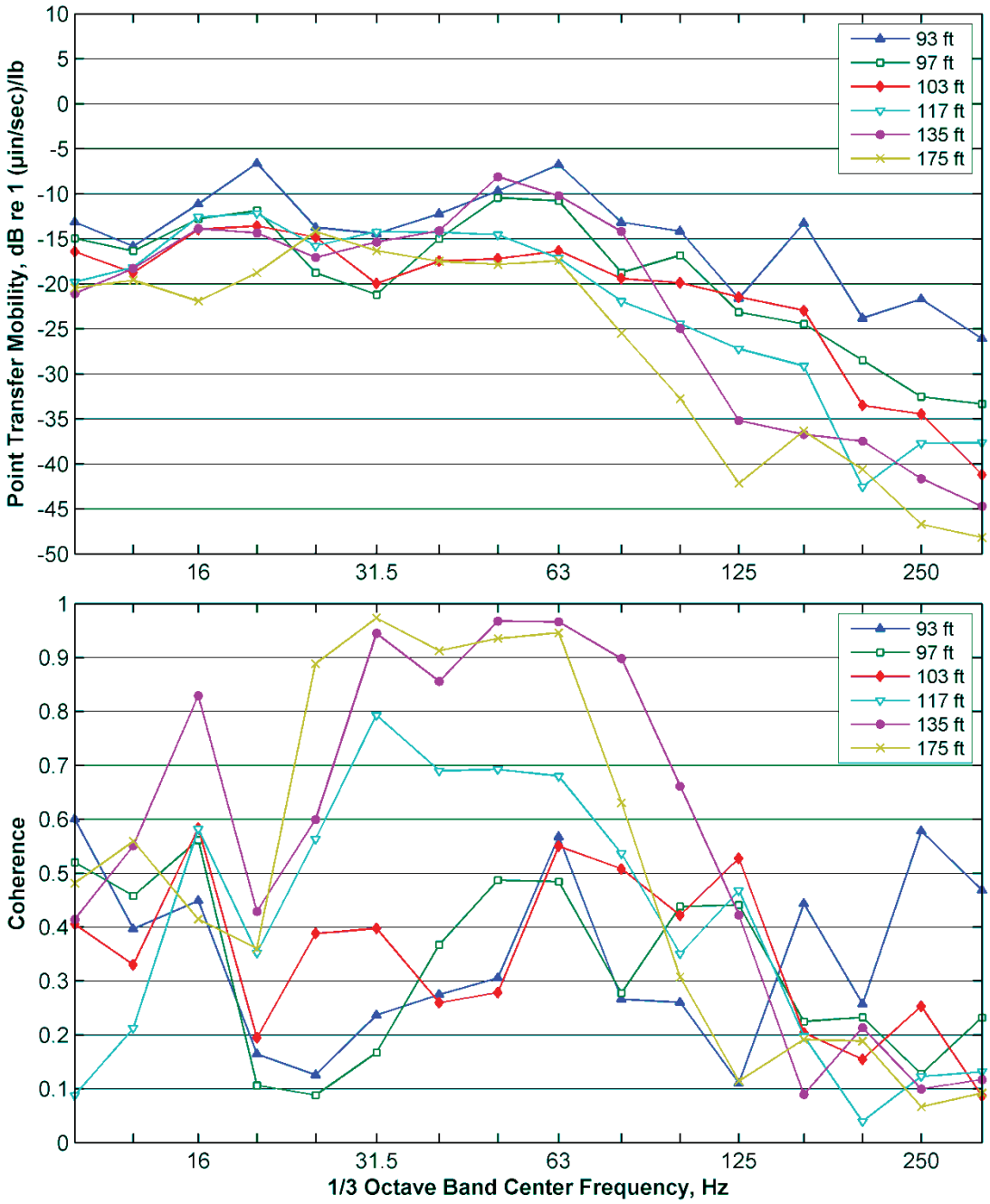

Figure 45: G-176. Measured PSTM at Depth of 90 ft

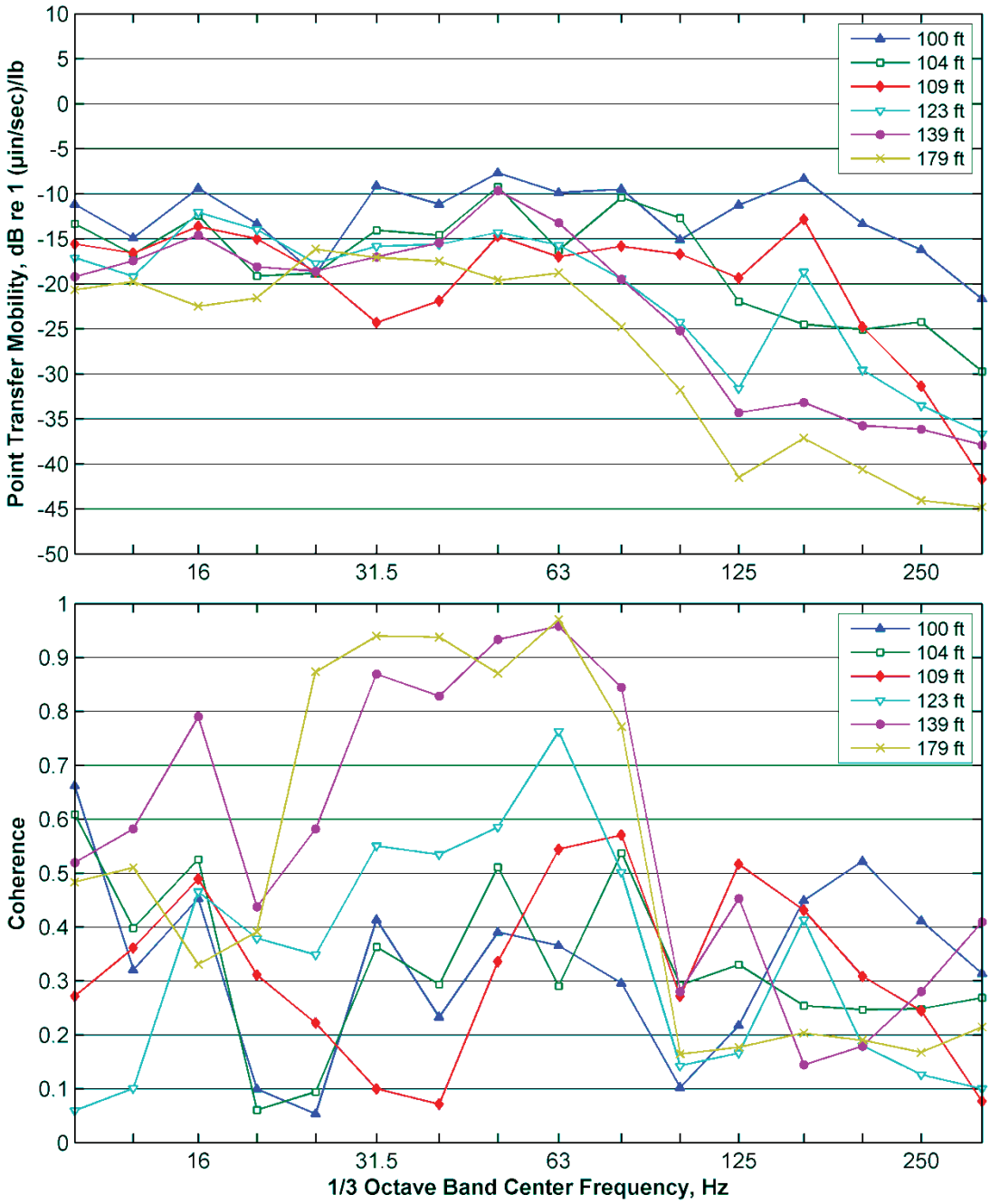

Figure 46: G-176. Measured PSTM at Depth of 97 ft

Table 13: G-176. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	31.59	-3.38	-4.21	**63**	10.72	5.56	-2.87
12.5	13.52	4.89	-3.77	**80**	42.13	-9.76	-4.01
16	55.83	-14.66	-3.80	**100**	86.38	-36.51	-2.72
20	49.82	-11.52	-3.94	**125**	132.40	-63.62	-1.64
25	9.69	5.05	-2.37	**160**	112.05	-52.11	-2.05
31.5	9.09	2.94	-1.21	**200**	78.81	-37.72	-2.66
40	13.48	5.35	-3.58	**250**	90.46	-45.66	-2.31
50	10.54	4.85	-2.22	**315**	62.95	-33.10	-2.88

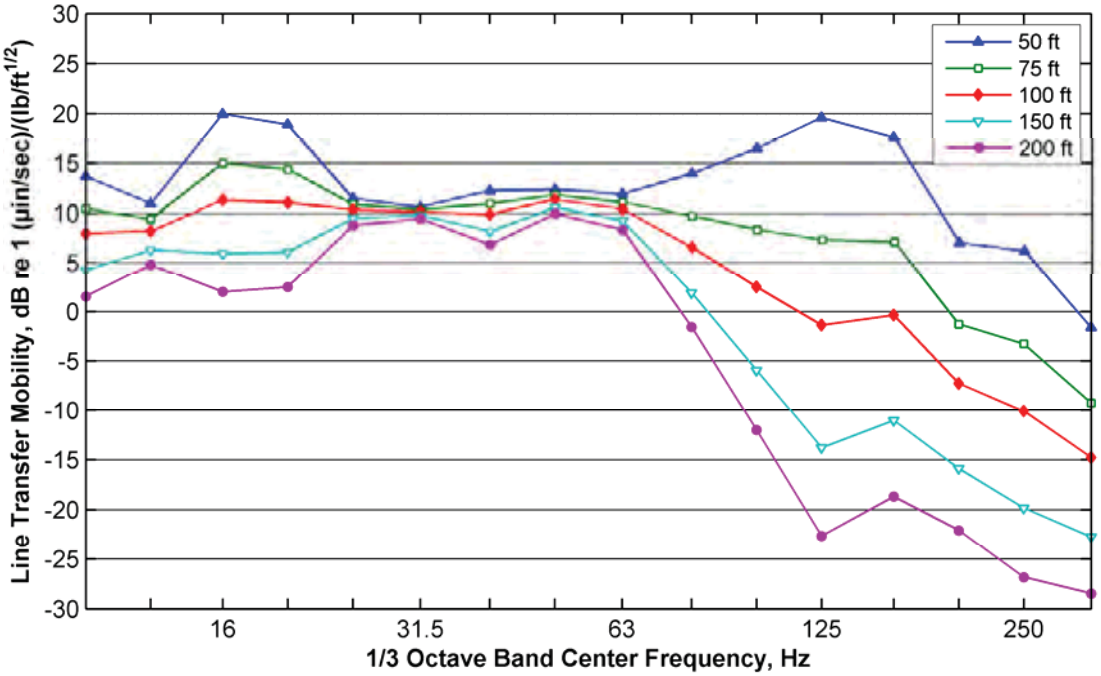

Figure 47: G-176. Best Fit LSTM

3.11 Site G-178

3.11.1 Site Description

Testing was performed on 17 and18 Jan 2011, at test depths of 65, 75, and 85 feet. This site was located on Wilshire Boulevard between Manning and Westholme in Westwood. The nearest vibration-sensitive receiver to this borehole is NV-50, the apartment building at 10655 Wilshire Boulevard. The line of accelerometers was located along the Wilshire Boulevard median on a downward slope at distances of 25, 37, 50, 75, 100, and 150 feet from the borehole with an offset of 3 feet. The measurements were performed at depths of 65, 75, and 85 ft. The measurements were affected by the vibration from continuous vehicular traffic on Wilshire Boulevard. Observations from the measurements results are:

- At the 65 ft depth, 100 impact hits were recorded with approximately 2 feet of drill string advancement. Force levels ranged from 8k to 12k lbs.
- At 75 feet, 100 impact hits were recorded with no perceptible load cell advancement. Force levels were 20k to 25k lbs.
- At 85 feet, two sets of 100 impact hits were recorded. The first set showed force levels from 14k to 18k lbs, with 15k to 22k lbs for the second set.

3.11.2 Results for G-178

- The PSTM was dominated by energy below 80 Hz.
- The PSTM showed higher attenuation rates above 100 Hz.
- Coherence was very poor below 31.5 Hz, which may be attributable to background vibration from Wilshire traffic.
- The LSTM has the smallest decrease with distance in the low frequency ranges where coherence is also the lowest and progressively greater decay rates above 31 Hz. This site had the highest decrease with distance at high frequencies of any borehole test, dropping 60 dB from 50 ft to 200 ft.

3.11.3 Plots and Tables

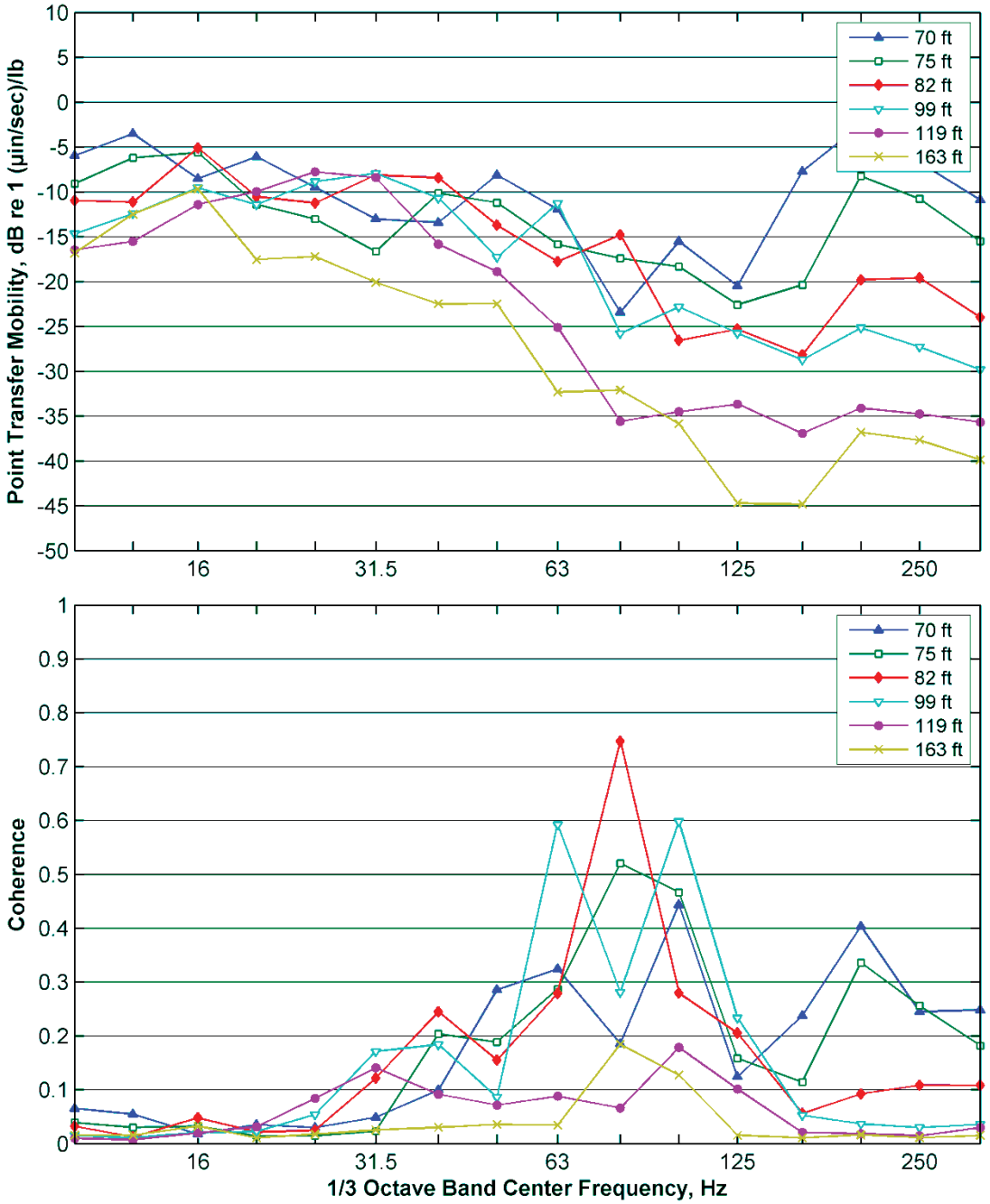

Figure 48: G-178. Measured PSTM at Depth of 65 ft

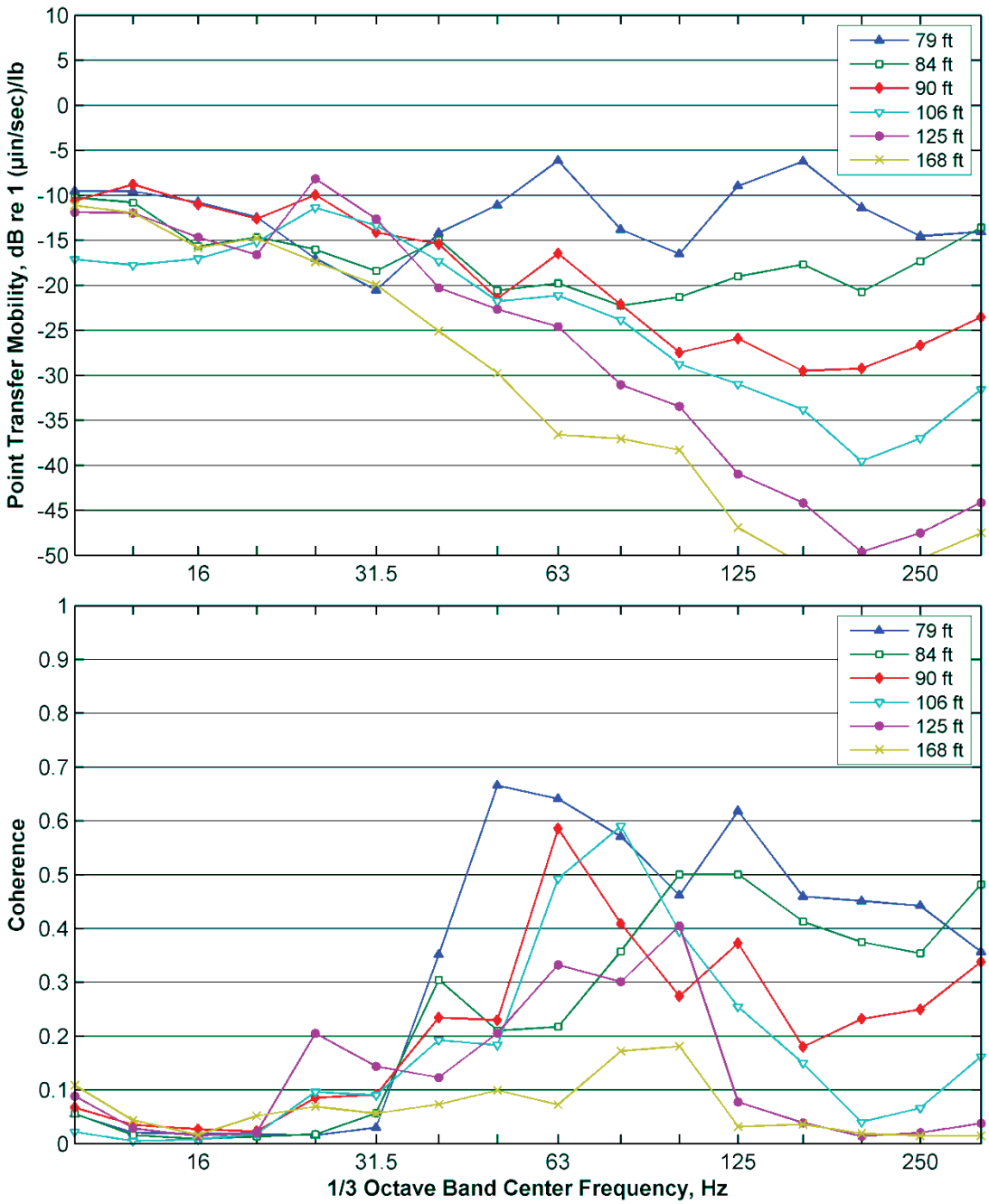

Figure 49: G-178. Measured PSTM at Depth of 75 ft

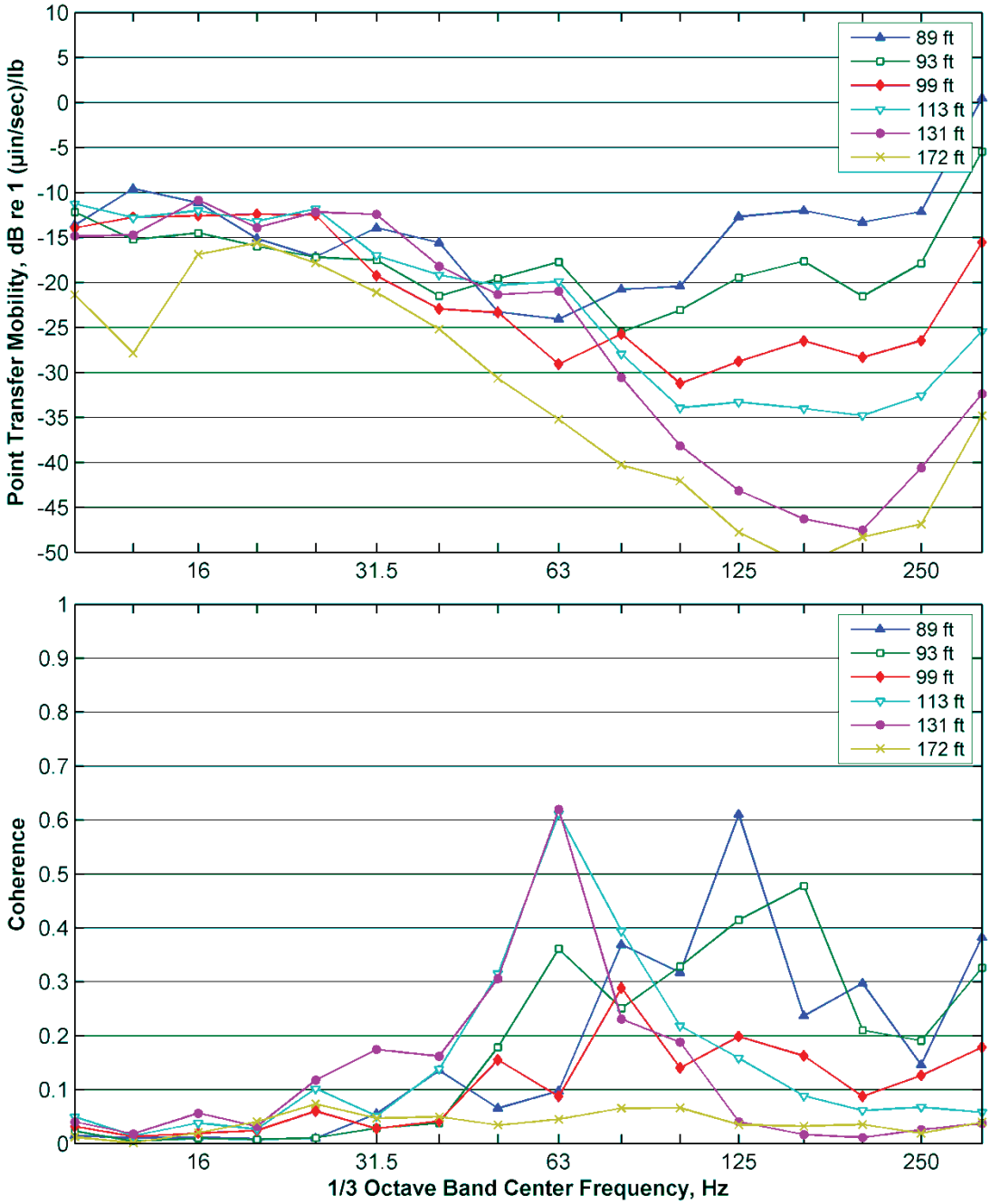

Figure 50: G-178. Measured PSTM at Depth of 85 ft

Table 14: G-178. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	23.06	2.28	-4.14	**63**	81.81	-35.02	-2.79
12.5	35.17	-3.76	-4.20	**80**	73.34	-32.90	-2.89
16	16.54	5.31	-3.60	**100**	88.50	-42.54	-2.45
20	14.48	5.45	-3.51	**125**	141.86	-72.18	-1.38
25	11.55	4.86	-2.23	**160**	184.02	-94.54	-0.86
31.5	10.17	5.55	-2.85	**200**	190.95	-97.73	-0.80
40	36.67	-7.20	-4.11	**250**	175.47	-89.21	-0.97
50	49.25	-15.72	-3.75	**315**	149.05	-73.43	-1.34

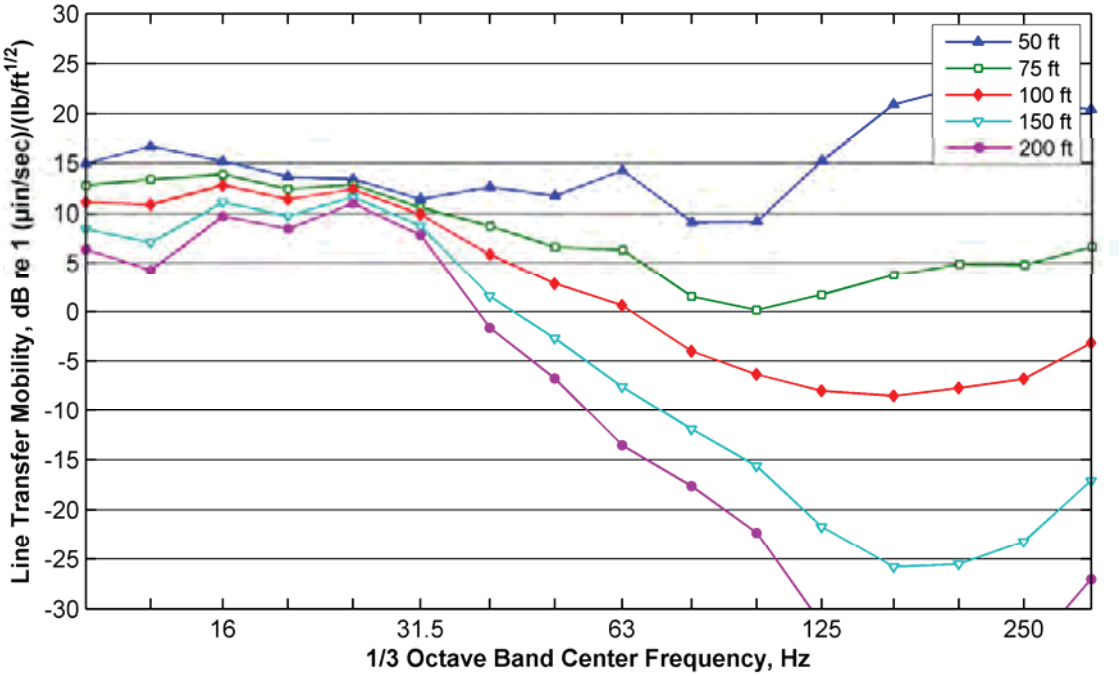

Figure 51: G-178. Best Fit LSTM

3.12 Site G-203

3.12.1 Site Description

This site was located in the West parking lot of the VA Medical Center at 11301 Wilshire Boulevard. Testing was performed on 3 May 2011, at test depths of 55, 65 and 75 feet. The accelerometers were located along South Moreno Drive at distances of 25, 37, 50, 75, 100, and 150 feet from the borehole location. The line of accelerometers extended northward from the borehole with an offset of 8 feet. Additional observations from the measurements results are:

- At the 55 ft depth, 100 hits were recorded but the amount of load cell advancement was not noted. The drill crew supervisor reported mostly sandy conditions at 55 feet with thin layering above consisting of silty sand and some clay. Typical test forces ranged from 8k to 11k lbs.
- At the 65 ft depth, 100 impact hits were recorded with no perceptible load cell advancement. No force data were obtained at this test depth as the load cell failed after the second impact.
- At the 75 ft test depth, 100 impact hits were recorded. No force data were obtained at this test depth.

3.12.2 Results for G-203

- Coherence was generally good from 20 to 120 Hz even though peak force levels were low-to-average for these tests. Interference from traffic vibration noise was minimal during the 55 foot test.
- The best fit LSTM suggests there is virtually no change in LSTM with distance in the 25 Hz band but nearly 50 dB decrease from 50 to 200 ft in the higher frequency bands. These anomalies are likely to be an artifact of having only six data points for estimating LSTM. The coherences are high in the 25 Hz band and not unreasonably low at higher frequencies.

3.12.3 Plots and Tables

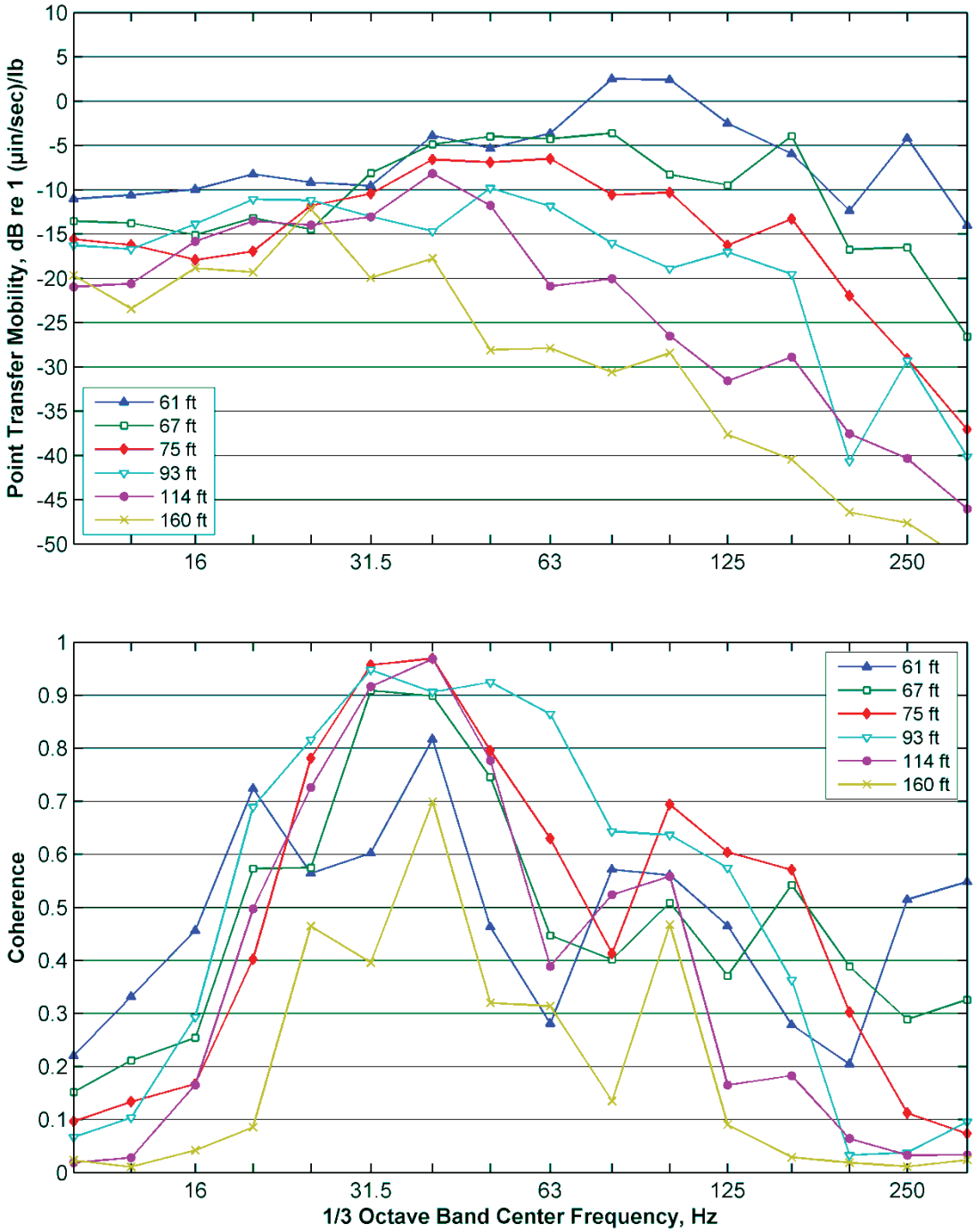

Figure 52: G-203. Measured PSTM at Depth of 55 ft

Table 15: G-203. Coefficients for Best Fit LSTM							
Freq. (Hz)	**A**	**B**	**C**	**Freq. (Hz)**	**A**	**B**	**C**
10	18.23	2.33	-4.14	**63**	100.03	-42.53	-2.45
12.5	28.52	-3.57	-4.21	**80**	123.89	-56.38	-1.89
16	11.20	5.54	-3.43	**100**	115.04	-52.49	-2.03
20	15.63	4.62	-3.85	**125**	133.82	-65.28	-1.58
25	12.64	2.79	-1.14	**160**	147.62	-72.67	-1.36
31.5	27.93	-0.74	-4.23	**200**	126.79	-67.04	-1.53
40	39.40	-5.45	-4.16	**250**	148.87	-78.37	-1.21
50	81.19	-30.78	-3.00	**315**	113.11	-63.15	-1.65

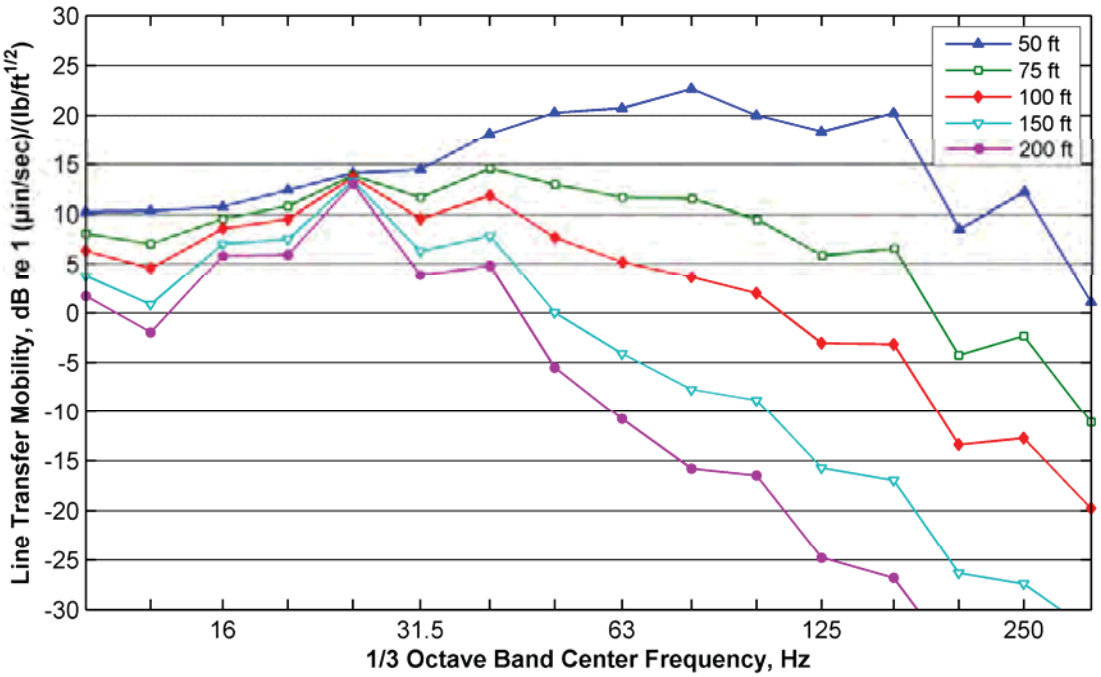

Figure 53: G-203. Best Fit LSTM

APPENDIX A: PHOTOGRAPHS OF TEST SITES

Figure 54: G-106 Wilshire/Arden.

View looking west. Accelerometers placed along the row of small traffic cones, directly in-line with the borehole.

Figure 55: G-124 Wilshire/Fairfax

View looking west. Accelerometers along the edge of the median.

Figure 56: G-134 Wilshire/Hamel

View looking east. Accelerometers placed near small traffic cones.

Figure 57: G-152 Santa Monica/Wilshire.

View looking east towards Wilshire Boulevard. Accelerometers placed approximately one lane from traffic. Borehole is only a few feet from accelerometer line.

Figure 58: G-164 Moreno/Young.

View looking northwest, education center bldg is to the right. Accelerometers were in a line extending to the southeast between the trucks.

Figure 59: G-165 Beverly Hills High School.

View looking toward the north.

Figure 60: G-166 Beverly Hills High School.

View looking south, along the west edge of the school's Lacrosse field.

Figure 61: G-173 Fox Hills/Missouri.

View of Missouri Ave looking east (left photo). Accelerometer line runs parallel to white stop line, south along Fox Hills sidewalk.

Figure 62: G-178 Wilshire/Manning.

View looking west along Wilshire blvd.