Appendix A

Laboratory Compressive Strength Data

Properties of set # 1

Curing Time: (3 Days) **Frequency (20Hz)**

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,3}$, t_0	11.625	7.70E-05	150974	28.26	43891	4787497	1553.121		
$S_{2,3}$, t_0	11.688	7.90E-05	147943	28.26	52609	4597197	1861.605	4733979	1858.15
$S_{3,3}$, t_0	11.813	7.80E-05	151442	28.26	61034	4817242	2159.728		
$S_{1,3}$, t_1	11.75	7.60E-05	154605	28.26	61293	5020565	2168.9		
$S_{2,3}$, t_1	11.813	7.70E-05	153409	28.26	59231	4943178	2095.932	4899967	2051.28
$S_{3,3}$, t_1	11.563	7.70E-05	150162	28.26	53384	4736157	1889.019		
$S_{1,3}$, t_2	11.688	7.70E-05	151786	28.26	61793	4839114	2186.599		
$S_{2,3}$, t_2	11.688	7.80E-05	149840	28.26	57636	4715830	2039.507	4832707	2098.39
$S_{3,3}$, t_2	11.813	7.70E-05	153409	28.26	58472	4943178	2069.062		
$S_{1,3}$, t_3	11.438	7.80E-05	146635	28.26	53916	4516241	1907.839		
$S_{2,3}$, t_3	11.625	7.90E-05	147152	28.26	69388	4548161	2455.338	4537521	2413.91
$S_{3,3}$, t_3	11.625	7.90E-05	147152	28.26	81348	4548161	2878.539		
$S_{1,3}$, t_4	11.5	7.90E-05	145570	28.26	69672	4450877	2465.393		
$S_{2,3}$, t_4	11.5	7.90E-05	145570	28.26	72235	4450877	2556.093	4501376	2645.66
$S_{3,3}$, t_4	11.25	7.60E-05	148026	28.26	82392	4602374	2915.499		
$S_{1,3}$, t_{24}	11.5	8.00E-05	143750	28.26	40816	4340300	1444.314		
$S_{2,3}$, t_{24}	11.25	7.70E-05	146104	28.26	65875	4483608	2331.04	4356789	1934.26
$S_{3,3}$, t_{24}	11.375	8.00E-05	142188	28.26	57295	4246459	2027.414		

Properties of set # 1

Curing Time: (7 Days) Frequency (20Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,7}$, t_0	11.75	7.60E-05	154605.3	28.26	81442.56	5020565	2881.9		
$S_{2,7}$, t_0	12	7.70E-05	155844.2	28.26	85619.52	5101350	3029.71	5074421	2919.97
$S_{3,7}$, t_0	12	7.70E-05	155844.2	28.26	80493.12	5101350	2848.31		
$S_{1,7}$, t_1	11.75	7.60E-05	154605.3	28.26	77170.56	5020565	2730.73		
$S_{2,7}$, t_1	11.688	7.50E-05	155833.3	28.26	85144.32	5100641	3012.89	5030864	2634.45
$S_{3,7}$, t_1	12	7.80E-05	153846.2	28.26	61033.92	4971384	2159.73		
$S_{1,7}$, t_2	11.5	7.70E-05	149350.6	28.26	80303.04	4685094	2841.58		
$S_{2,7}$, t_2	11.813	7.80E-05	151442.3	28.26	83530.56	4817242	2955.79	4749407	2820.31
$S_{3,7}$, t_2	11.875	7.90E-05	150316.5	28.26	75272.64	4745884	2663.58		
$S_{1,7}$, t_3	11.75	7.70E-05	152597.4	28.26	90080.64	4891008	3187.57		
$S_{2,7}$, t_3	11.75	7.80E-05	150641	28.26	92548.8	4766401	3274.9	4883176	3287.18
$S_{3,7}$, t_3	11.563	7.50E-05	154166.7	28.26	96057.6	4992120	3399.07		
$S_{1,7}$, t_4	11.5	7.60E-05	151315.8	28.26	101654.4	4809197	3597.11		
$S_{2,7}$, t_4	11.75	7.70E-05	152597.4	28.26	87991.68	4891008	3113.65	4879500	3372.21
$S_{3,7}$, t_4	11.5	7.50E-05	153333.3	28.26	96249.6	4938297	3405.86		
$S_{1,7}$, t_{24}	11.75	7.90E-05	148734.2	28.26	90935.04	4646496	3217.8		
$S_{2,7}$, t_{24}	11.625	7.70E-05	150974	28.26	82392	4787497	2915.5	4782769	3068.89
$S_{3,7}$, t_{24}	11.625	7.60E-05	152960.5	28.26	86853.12	4914313	3073.36		

Properties of set # 1

Curing Time: (28 Days)   Frequency (20Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f_c (psi)	AVG (E)	AVG (f_c)
$S_{1,28}$, t_0	11.875	7.20E-05	164930.6	28.26	97372.8	5713553	3445.61	5434927	3452.67
$S_{2,28}$, t_0	11.75	7.40E-05	158783.8	28.26	99379.2	5295614	3516.6		
$S_{3,28}$, t_0	11.75	7.40E-05	158783.8	28.26	95965.44	5295614	3395.8		
$S_{1,28}$, t_1	11.875	7.50E-05	158333.3	28.26	100704	5265611	3563.48	5247378	3819.96
$S_{2,28}$, t_1	11.938	7.50E-05	159166.7	28.26	99571.2	5321184	3523.4		
$S_{3,28}$, t_1	11.75	7.50E-05	156666.7	28.26	123580.8	5155339	4372.99		
$S_{1,28}$, t_2	11.813	7.50E-05	157500	28.26	124060.8	5210329	4389.98	5342701	4512.05
$S_{2,28}$, t_2	11.875	7.40E-05	160473	28.26	136780.8	5408886	4840.08		
$S_{3,28}$, t_2	11.875	7.40E-05	160473	28.26	121689.6	5408886	4306.07		
$S_{1,28}$, t_3	11.813	7.50E-05	157500	28.26	96249.6	5210329	3405.86	5229339	3237.93
$S_{2,28}$, t_3	11.938	7.60E-05	157072.4	28.26	83720.64	5182074	2962.51		
$S_{3,28}$, t_3	11.75	7.40E-05	158783.8	28.26	94541.76	5295614	3345.43		
$S_{1,28}$, t_4	11.938	7.70E-05	155032.5	28.26	95016	5048349	3362.21	5102342	3518.94
$S_{2,28}$, t_4	11.938	7.70E-05	155032.5	28.26	118080	5048349	4178.34		
$S_{3,28}$, t_4	11.813	7.50E-05	157500	28.26	85239.36	5210329	3016.25		
$S_{1,28}$, t_{24}	11.75	7.60E-05	154605.3	28.26	117321.6	5020565	4151.51	5183929	4462.68
$S_{2,28}$, t_{24}	11.875	7.50E-05	158333.3	28.26	125289.6	5265611	4433.46		
$S_{3,28}$, t_{24}	11.875	7.50E-05	158333.3	28.26	135734.4	5265611	4803.06		

Properties of set # 1

Curing Time: (14 Days)   Frequency (20Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,14}, t_0$	11.688	7.50E-05	155833.3	28.26	90269.76	5100641	3194.26		
$S_{2,14}, t_0$	11.813	7.50E-05	157500	28.26	87043.2	5210329	3080.08	5137204	3074.47
$S_{3,14}, t_0$	11.688	7.50E-05	155833.3	28.26	83340.48	5100641	2949.08		
$S_{1,14}, t_1$	11.938	7.70E-05	155032.5	28.26	95965.44	5048349	3395.8		
$S_{2,14}, t_1$	11.938	7.70E-05	155032.5	28.26	100233.6	5048349	3546.84	5139294	3768.59
$S_{3,14}, t_1$	11.938	7.50E-05	159166.7	28.26	123302.4	5321184	4363.14		
$S_{1,14}, t_2$	11.938	7.50E-05	159166.7	28.26	112195.2	5321184	3970.11		
$S_{2,14}, t_2$	12	7.50E-05	160000	28.26	118550.4	5377049	4194.99	5331283	4261.12
$S_{3,14}, t_2$	11.75	7.40E-05	158783.8	28.26	130512	5295614	4618.26		
$S_{1,14}, t_3$	11.875	7.60E-05	156250	28.26	73819.2	5127954	2612.14		
$S_{2,14}, t_3$	11.875	7.70E-05	154220.8	28.26	93213.12	4995625	3298.41	5048048	2945.37
$S_{3,14}, t_3$	11.75	7.60E-05	154605.3	28.26	82676.16	5020565	2925.55		
$S_{1,14}, t_4$	11.938	7.70E-05	155032.5	28.26	93592.32	5048349	3311.83		
$S_{2,14}, t_4$	11.875	7.60E-05	156250	28.26	84860.16	5127954	3002.84	5074884	3048.73
$S_{3,14}, t_4$	11.938	7.70E-05	155032.5	28.26	80018.88	5048349	2831.52		
$S_{1,14}, t_{24}$	11.875	7.40E-05	160473	28.26	88371.84	5408886	3127.1		
$S_{2,14}, t_{24}$	11.5	7.40E-05	155405.4	28.26	73658.88	5072666	2606.47	5159059	2868.46
$S_{3,14}, t_{24}$	11.875	7.70E-05	154220.8	28.26	81157.44	4995625	2871.81		

Properties of set # 2

Curing Time: (3 Days) Frequency (40Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,3}$, t_0	11.438	7.70E-05	148539	28.26	74703	4634307	2643.431		
$S_{2,3}$, t_0	11.5	7.60E-05	151316	28.26	84480	4809197	2989.384	4776090	2922.21
$S_{3,3}$, t_0	11.438	7.50E-05	152500	28.26	88562	4884766	3133.826		
$S_{1,3}$, t_1	11.813	7.90E-05	149525	28.26	88562	4696059	3133.826		
$S_{2,3}$, t_1	11.75	7.90E-05	148734	28.26	71191	4646496	2519.134	4630239	2698.28
$S_{3,3}$, t_1	11.625	7.90E-05	147152	28.26	69008	4548161	2441.885		
$S_{1,3}$, t_2	11.625	7.80E-05	149038	28.26	91314	4665528	3231.219		
$S_{2,3}$, t_2	11.625	7.70E-05	150974	28.26	90650	4787497	3207.711	4645337	3187.56
$S_{3,3}$, t_2	11.688	8.00E-05	146094	28.26	88277	4482985	3123.737		
$S_{1,3}$, t_3	11.688	8.00E-05	146094	28.26	79544	4482985	2814.709		
$S_{2,3}$, t_3	11.75	8.10E-05	145062	28.26	71760	4419873	2539.278	4483673	2793.44
$S_{3,3}$, t_3	11.625	7.90E-05	147152	28.26	85524	4548161	3026.344		
$S_{1,3}$, t_4	11.75	8.10E-05	145062	28.26	85429	4419873	3022.981		
$S_{2,3}$, t_4	11.688	8.00E-05	146094	28.26	82771	4482985	2928.917	4516451	2954.68
$S_{3,3}$, t_4	11.75	7.90E-05	148734	28.26	82297	4646496	2912.136		
$S_{1,3}$, t_{24}	11.75	8.00E-05	146875	28.26	54922	4531060	1943.439		
$S_{2,3}$, t_{24}	11.875	8.10E-05	146605	28.26	78120	4514413	2764.331	4557817	2516.45
$S_{3,3}$, t_{24}	11.875	8.00E-05	148438	28.26	80303	4627978	2841.58		

Properties of set # 2

Curing Time: (7 Days) Frequency (40Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,7}$, t_0	11.5	7.60E-05	151315.8	28.26	81632.64	4809197	2888.63		
$S_{2,7}$, t_0	11.5	7.70E-05	149350.6	28.26	56345.28	4685094	1993.82	4743483	2445.86
$S_{3,7}$, t_0	11.563	7.70E-05	150162.3	28.26	69382.08	4736157	2455.13		
$S_{1,7}$, t_1	11.688	7.60E-05	153782.9	28.26	104793.6	4967297	3708.2		
$S_{2,7}$, t_1	11.688	7.50E-05	155833.3	28.26	69292.8	5100641	2451.97	4944780	3274.85
$S_{3,7}$, t_1	11.75	7.80E-05	150641	28.26	103555.2	4766401	3664.37		
$S_{1,7}$, t_2	11.75	7.70E-05	152597.4	28.26	86663.04	4891008	3066.63		
$S_{2,7}$, t_2	11.563	7.80E-05	148237.2	28.26	98236.8	4615496	3476.18	4717667	3112.46
$S_{3,7}$, t_2	11.75	7.90E-05	148734.2	28.26	78974.4	4646496	2794.56		
$S_{1,7}$, t_3	11.688	7.70E-05	151785.7	28.26	90269.76	4839114	3194.26		
$S_{2,7}$, t_3	11.688	7.80E-05	149839.7	28.26	90459.84	4715830	3200.99	4885195	3224.49
$S_{3,7}$, t_3	11.688	7.50E-05	155833.3	28.26	92642.88	5100641	3278.23		
$S_{1,7}$, t_4	11.75	7.60E-05	154605.3	28.26	79259.52	5020565	2804.65		
$S_{2,7}$, t_4	11.75	7.70E-05	152597.4	28.26	81821.76	4891008	2895.32	5022304	2964.74
$S_{3,7}$, t_4	11.75	7.50E-05	156666.7	28.26	90269.76	5155339	3194.26		
$S_{1,7}$, t_{24}	11.813	7.90E-05	149525.3	28.26	65780.16	4696059	2327.68		
$S_{2,7}$, t_{24}	11.813	7.70E-05	153409.1	28.26	64166.4	4943178	2270.57	4886601	2567.28
$S_{3,7}$, t_{24}	11.75	7.60E-05	154605.3	28.26	87707.52	5020565	3103.59		

Properties of set # 2

Curing Time; (14 Days)　　　　Frequency (40Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,14}$, t_0	11.25	6.90E-05	163043.5	28.26	87707.52	5583557	3103.59		
$S_{2,14}$, t_0	11.5	7.00E-05	164285.7	28.26	76886.4	5668963	2720.68	5528232	2611.85
$S_{3,14}$, t_0	11.313	7.10E-05	159331	28.26	56838.72	5332177	2011.28		
$S_{1,14}$, t_1	11.375	7.00E-05	162500	28.26	85808.64	5546395	3036.4		
$S_{2,14}$, t_1	11.313	7.00E-05	161607.1	28.26	90840	5485613	3214.44	5580111	3014.01
$S_{3,14}$, t_1	11.375	6.90E-05	164855.1	28.26	78879.36	5708325	2791.2		
$S_{1,14}$, t_2	11.75	7.40E-05	158783.8	28.26	99136.32	5295614	3508.01		
$S_{2,14}$, t_2	11.375	7.20E-05	157986.1	28.26	71190.72	5242541	2519.13	5298850	3266.29
$S_{3,14}$, t_2	11.5	7.20E-05	159722.2	28.26	106588.8	5358395	3771.72		
$S_{1,14}$, t_3	11.75	7.40E-05	158783.8	28.26	88751.04	5295614	3140.52		
$S_{2,14}$, t_3	11.75	7.40E-05	158783.8	28.26	86853.12	5295614	3073.36	5276885	2918.84
$S_{3,14}$, t_3	11.688	7.40E-05	157939.2	28.26	71855.04	5239428	2542.64		
$S_{1,14}$, t_4	11.875	7.40E-05	160473	28.26	94067.52	5408886	3328.65		
$S_{2,14}$, t_4	11.688	7.40E-05	157939.2	28.26	79543.68	5239428	2814.71	5286214	3063.89
$S_{3,14}$, t_4	11.813	7.50E-05	157500	28.26	86145.6	5210329	3048.32		
$S_{1,14}$, t_{24}	11.75	7.50E-05	156666.7	28.26	93592.32	5155339	3311.83		
$S_{2,14}$, t_{24}	11.75	7.50E-05	156666.7	28.26	87991.68	5155339	3113.65	5155339	3296.14
$S_{3,14}$, t_{24}	11.75	7.50E-05	156666.7	28.26	97862.4	5155339	3462.93		

Properties of set # 2

Curing Time: (28 Days) Frequency (40Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f_c (psi)	AVG (E)	AVG (f_c)
$S_{1,28}$, t_0	11.313	7.00E-05	161607.1	28.26	67774.08	5485613	2398.23	5342377	2406.62
$S_{2,28}$, t_0	11.625	7.30E-05	159246.6	28.26	0	5326529	0		
$S_{3,28}$, t_0	11.188	7.10E-05	157570.4	28.26	68248.32	5214990	2415.01		
$S_{1,28}$, t_1	11.438	6.90E-05	165760.9	28.26	0	5771226	0	5758220	3043.13
$S_{2,28}$, t_1	11.5	6.90E-05	166666.7	28.26	82866.24	5834472	2932.28		
$S_{3,28}$, t_1	11.5	7.00E-05	164285.7	28.26	89131.2	5668963	3153.97		
$S_{1,28}$, t_2	11.688	7.30E-05	160102.7	28.26	93023.04	5383957	3291.69	5403202	3387.33
$S_{2,28}$, t_2	11.75	7.30E-05	160958.9	28.26	0	5441693	0		
$S_{3,28}$, t_2	11.688	7.30E-05	160102.7	28.26	98428.8	5383957	3482.97		
$S_{1,28}$, t_3	11.625	7.30E-05	159246.6	28.26	97286.4	5326529	3442.55	5335367	3536.65
$S_{2,28}$, t_3	11.688	7.30E-05	160102.7	28.26	102604.8	5383957	3630.74		
$S_{3,28}$, t_3	11.75	7.40E-05	158783.8	28.26	0	5295614	0		
$S_{1,28}$, t_4	11.688	7.30E-05	160102.7	28.26	85144.32	5383957	3012.89	5374374	3429.33
$S_{2,28}$, t_4	11.813	7.30E-05	161815.1	28.26	0	5499738	0		
$S_{3,28}$, t_4	11.688	7.40E-05	157939.2	28.26	108681.6	5239428	3845.77		
$S_{1,28}$, t_{24}	11.688	7.30E-05	160102.7	28.26	98236.8	5383957	3476.18	5343891	3263.01
$S_{2,28}$, t_{24}	11.75	7.40E-05	158783.8	28.26	86188.8	5295614	3049.85		
$S_{3,28}$, t_{24}	11.813	7.40E-05	159628.4	28.26	0	5352100	0		

Properties of set # 3

Curing Time: (3 Days) Frequency (10Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f'_c (psi)	AVG (E)	AVG (f'_c)
$S_{1,3}$, t_0	11.5	7.00E-05	164286	28.26	80873	5668983	2861.758		
$S_{2,3}$, t_0	11.5	7.10E-05	161972	28.26	74988	5510399	2653.486	5616109	2922.2
$S_{3,3}$, t_0	11.5	7.00E-05	164286	28.26	91884	5668983	3251.363		
$S_{1,3}$, t_1	11.563	7.10E-05	162852	28.26	79924	5570457	2828.161		
$S_{2,3}$, t_1	11.5	7.00E-05	164286	28.26	103939	5668963	3677.962	5643657	3422.66
$S_{3,3}$, t_1	11.688	7.10E-05	164613	28.26	106310	5691551	3761.868		
$S_{1,3}$, t_2	11.563	7.00E-05	165179	28.26	84765	5730750	2999.473		
$S_{2,3}$, t_2	11.563	7.10E-05	162852	28.26	102230	5570457	3617.495	5644016	3338.68
$S_{3,3}$, t_2	11.625	7.10E-05	163732	28.26	96058	5630841	3399.066		
$S_{1,3}$, t_3	11.688	7.30E-05	160103	28.26	57996	5383957	2052.246		
$S_{2,3}$, t_3	11.625	7.20E-05	161458	28.26	90555	5475515	3204.348	5414476	2933.34
$S_{3,3}$, t_3	11.688	7.30E-05	160103	28.26	100138	5383957	3543.439		
$S_{1,3}$, t_4	11.625	7.30E-05	159247	28.26	76886	5326529	2720.679		
$S_{2,3}$, t_4	11.5	7.30E-05	157534	28.26	75273	5212595	2663.575	5318640	2794.58
$S_{3,3}$, t_4	11.563	7.20E-05	160590	28.26	84765	5416797	2999.473		
$S_{1,3}$, t_{24}	11.625	7.20E-05	161458	28.26	100522	5475515	3557.028		
$S_{2,3}$, t_{24}	11.625	7.30E-05	159247	28.26	82676	5326529	2925.554	5414579	3218.9
$S_{3,3}$, t_{24}	11.75	7.30E-05	160959	28.26	89700	5441693	3174.115		

Properties of set # 3

Curing Time: (7 Days)   Frequency (10Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f_c (psi)	AVG (E)	AVG (f_c)
$S_{1,7}$, t_0	11.5	6.90E-05	166666.7	28.26	105734.4	5834472	3741.49		
$S_{2,7}$, t_0	11.563	7.00E-05	165178.6	28.26	103363.2	5730750	3657.58	5765324	3780.78
$S_{3,7}$, t_0	11.563	7.00E-05	165178.6	28.26	111436.8	5730750	3943.27		
$S_{1,7}$, t_1	11.563	7.20E-05	160590.3	28.26	94161.6	5416797	3331.97		
$S_{2,7}$, t_1	11.563	7.10E-05	162852.1	28.26	98428.8	5570457	3482.97	5552073	3645.41
$S_{3,7}$, t_1	11.5	7.00E-05	164285.7	28.26	116467.2	5668963	4121.27		
$S_{1,7}$, t_2	11.5	7.00E-05	164285.7	28.26	91978.56	5668963	3254.73		
$S_{2,7}$, t_2	11.563	7.10E-05	162852.1	28.26	106022.4	5570457	3751.68	5623421	3649.89
$S_{3,7}$, t_2	11.625	7.10E-05	163732.4	28.26	111436.8	5630841	3943.27		
$S_{1,7}$, t_3	11.5	7.10E-05	161971.8	28.26	63882.24	5510399	2260.52		
$S_{2,7}$, t_3	11.5	7.10E-05	161971.8	28.26	106022.4	5510399	3751.68	5530418	3298.33
$S_{3,7}$, t_3	11.563	7.10E-05	162852.1	28.26	109728	5570457	3882.8		
$S_{1,7}$, t_4	11.625	7.30E-05	159246.6	28.26	78879.36	5326529	2791.2		
$S_{2,7}$, t_4	11.75	7.50E-05	156666.7	28.26	83815.68	5155339	2965.88	5269465	3165.17
$S_{3,7}$, t_4	11.625	7.30E-05	159246.6	28.26	105648	5326529	3738.43		
$S_{1,7}$, t_{24}	11.75	7.30E-05	160958.9	28.26	103171.2	5441693	3650.79		
$S_{2,7}$, t_{24}	11.75	7.30E-05	160958.9	28.26	87138.24	5441693	3083.45	5393000	3572.53
$S_{3,7}$, t_{24}	11.75	7.40E-05	158783.8	28.26	112569.6	5295614	3983.35		

Properties of set # 3

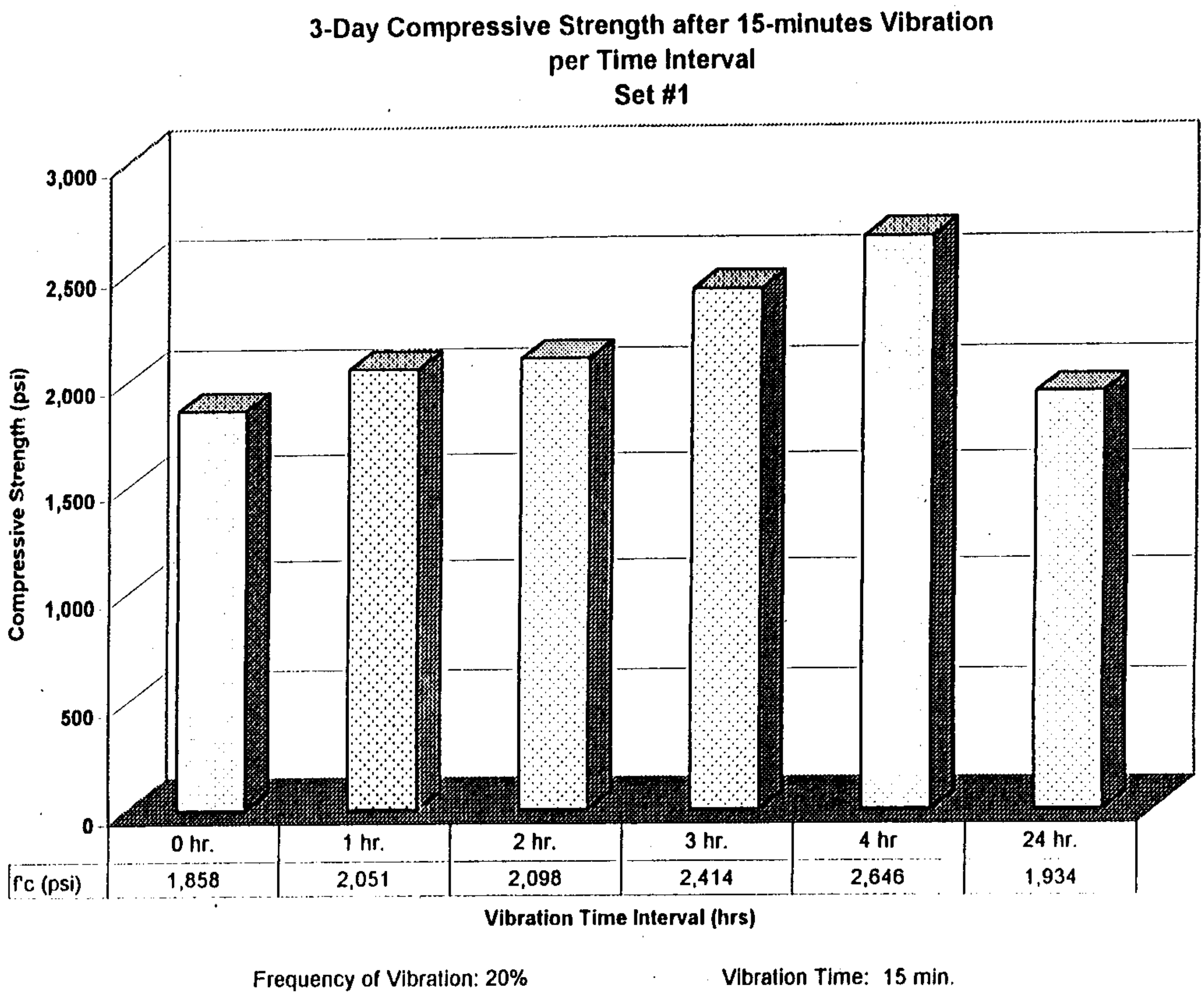
Curing Time: (14 Days)   Frequency (10Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f_c (psi)	AVG (E)	AVG (f_c)
$S_{1,14}, t_0$	11.625	6.90E-05	168478.3	28.26	107539.2	5961998	3805.35		
$S_{2,14}, t_0$	11.563	6.90E-05	167572.5	28.26	128803.2	5898062	4557.79	5919374	3990.15
$S_{3,14}, t_0$	11.563	6.90E-05	167572.5	28.26	101942.4	5898062	3607.3		
$S_{1,14}, t_1$	11.5	6.90E-05	166666.7	28.26	92737.92	5834472	3281.6		
$S_{2,14}, t_1$	11.625	7.00E-05	166071.4	28.26	121113.6	5792872	4285.69	5820605	3726
$S_{3,14}, t_1$	11.5	6.90E-05	166666.7	28.26	102038.4	5834472	3610.7		
$S_{1,14}, t_2$	11.5	6.90E-05	166666.7	28.26	106972.8	5834472	3785.31		
$S_{2,14}, t_2$	11.688	7.00E-05	166964.3	28.26	91314.24	5855328	3231.22	5806850	3770.8
$S_{3,14}, t_2$	11.563	7.00E-05	165178.6	28.26	121401.6	5730750	4295.88		
$S_{1,14}, t_3$	11.75	7.10E-05	165493	28.26	87043.2	5752586	3080.08		
$S_{2,14}, t_3$	11.688	7.00E-05	166964.3	28.26	111811.2	5855328	3956.52	5800262	3402.45
$S_{3,14}, t_3$	11.625	7.00E-05	166071.4	28.26	89605.44	5792872	3170.75		
$S_{1,14}, t_4$	11.813	7.20E-05	164062.5	28.26	94541.76	5653569	3345.43		
$S_{2,14}, t_4$	11.625	7.10E-05	163732.4	28.26	111532.8	5630841	3946.67	5699452	3486.49
$S_{3,14}, t_4$	11.813	7.10E-05	166373.2	28.26	89510.4	5813946	3167.39		
$S_{1,14}, t_{24}$	11.75	7.10E-05	165493	28.26	126144	5752586	4463.69		
$S_{2,14}, t_{24}$	11.688	7.20E-05	162326.4	28.26	96912	5534550	3429.3	5627012	4033.86
$S_{3,14}, t_{24}$	11.75	7.20E-05	163194.4	28.26	118934.4	5593901	4208.58		

Properties of set # 3

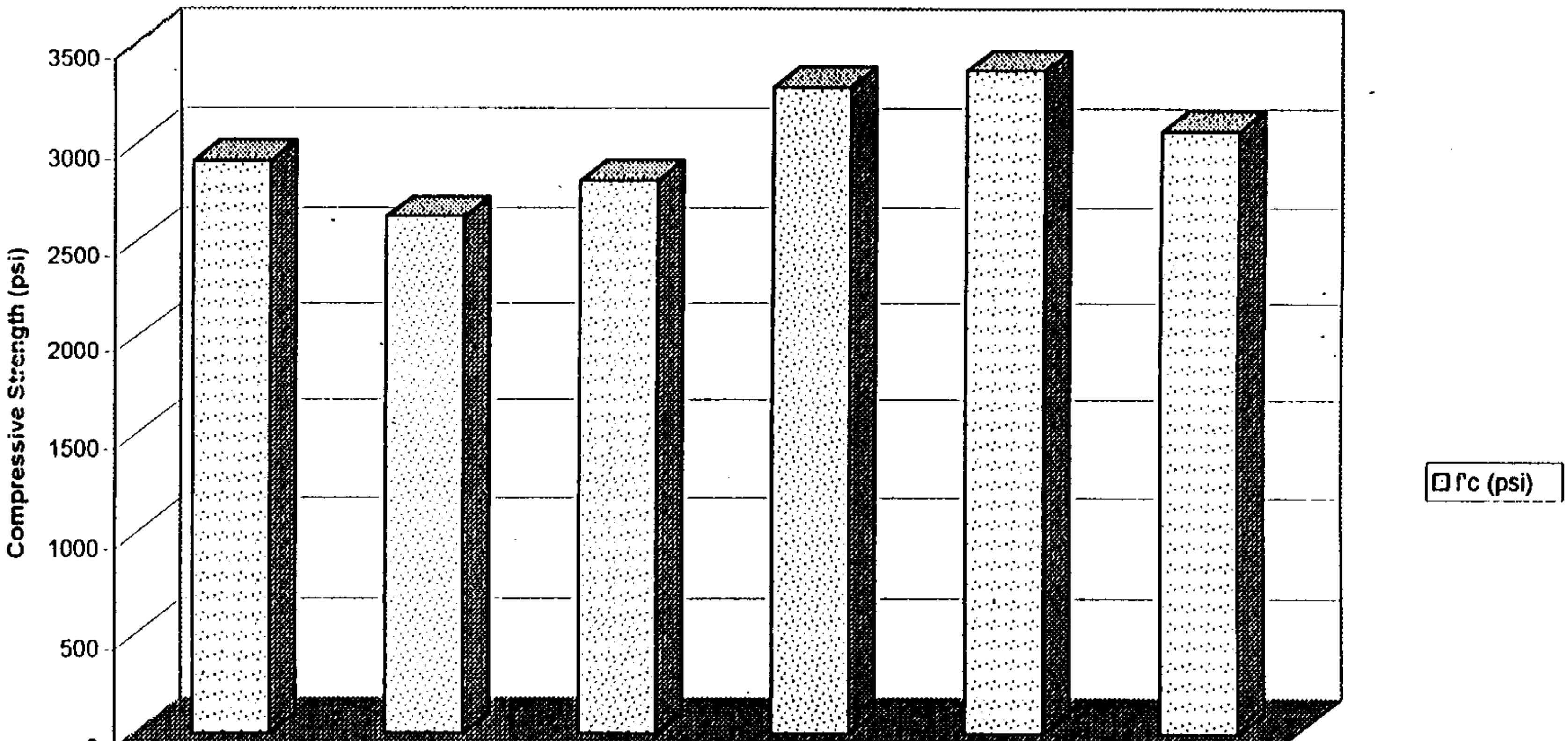
Curring : (28 Days) Frequency (10Hz)

Sample	Height (in)	Time (s)	Velocity (in/s)	Area (in^2)	Force (lb)	E (psi)	f_c (psi)	AVG (E)	AVG (f_c)
$S_{1,28}$, t_0	11.625	6.70E-05	173507.5	28.26	0	6323250	0	6359164	4151
$S_{2,28}$, t_0	11.563	6.60E-05	175189.4	28.26	108489.6	6446436	3838.98		
$S_{3,28}$, t_0	11.438	6.60E-05	173295.5	28.26	126124.8	6307807	4463.01		
$S_{1,28}$, t_1	11.625	6.80E-05	170955.9	28.26	84099.84	6138640	2975.93	6280172	3400.83
$S_{2,28}$, t_1	11.563	6.70E-05	172574.6	28.26	108115.2	6255441	3825.73		
$S_{3,28}$, t_1	11.563	6.60E-05	175189.4	28.26	0	6446436	0		
$S_{1,28}$, t_2	11.75	6.80E-05	172794.1	28.26	97104	6271363	3436.09	6328680	3395.8
$S_{2,28}$, t_2	11.688	6.70E-05	174440.3	28.26	94826.88	6391425	3355.52		
$S_{3,28}$, t_2	11.625	6.70E-05	173507.5	28.26	0	6323250	0		
$S_{1,28}$, t_3	11.688	6.80E-05	171875	28.26	0	6204824	0	6160701	4849.94
$S_{2,28}$, t_3	11.625	6.80E-05	170955.9	28.26	133641.6	6138640	4729		
$S_{3,28}$, t_3	11.625	6.80E-05	170955.9	28.26	140476.8	6138640	4970.37		
$S_{1,28}$, t_4	11.625	6.80E-05	170955.9	28.26	117417.6	6138640	4154.9	6048721	3667.87
$S_{2,28}$, t_4	11.813	7.00E-05	168750	28.26	0	5981245	0		
$S_{3,28}$, t_4	11.688	6.90E-05	169384.1	28.26	89890.56	6026277	3180.84		
$S_{1,28}$, t_{24}	11.813	7.00E-05	168750	28.26	96912	5981245	3429.3	6119434	3822.34
$S_{2,28}$, t_{24}	11.875	6.90E-05	172101.4	28.26	119126.4	6221185	4215.37		
$S_{3,28}$, t_{24}	11.813	6.90E-05	171195.7	28.26	0	6155871	0		



3-Day Compressive Strength after 15-minutes Vibration
per Time Interval
Set #1
Compressive Strength (psi)
3,000
2,500
2,000
1,500
1,000
500
0
f'c (psi)
0 hr.
1,858
1 hr.
2,051
2 hr.
2,098
3 hr.
2,414
4 hr
2,646
24 hr.
1,934
Vibration Time Interval (hrs)
Frequency of Vibration: 20%
Vibration Time: 15 min.

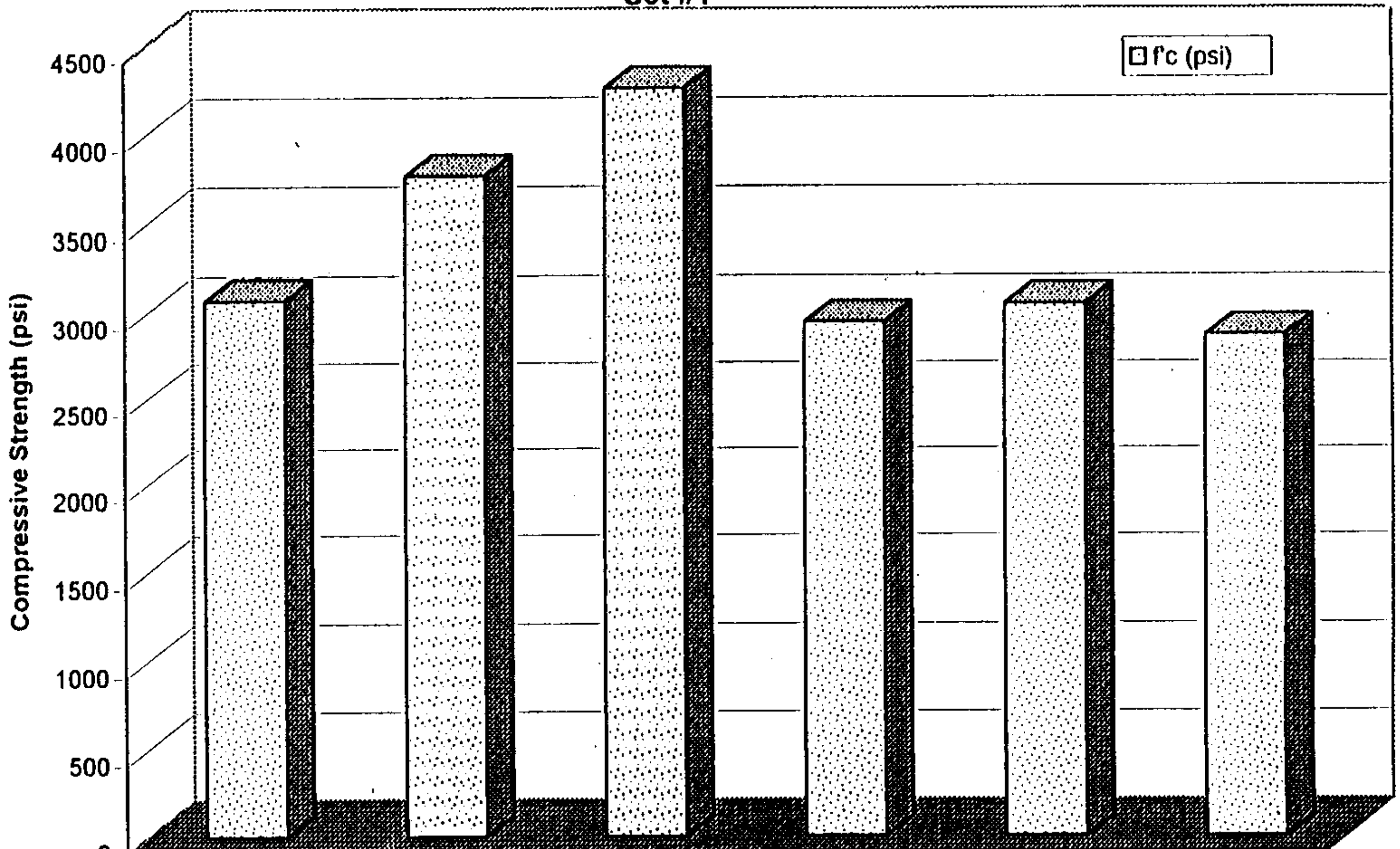
7-Day Compressive Strength after 15-minutes Vibration per Time Interval Set #1



	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	2920	2634	2820	3287	3372	3069

Frequency of Vibration: 20%   Vibration Time: 15 min.

14-Days Compressive Strength after 15-minutes Vibration per Time Interval
Set #1

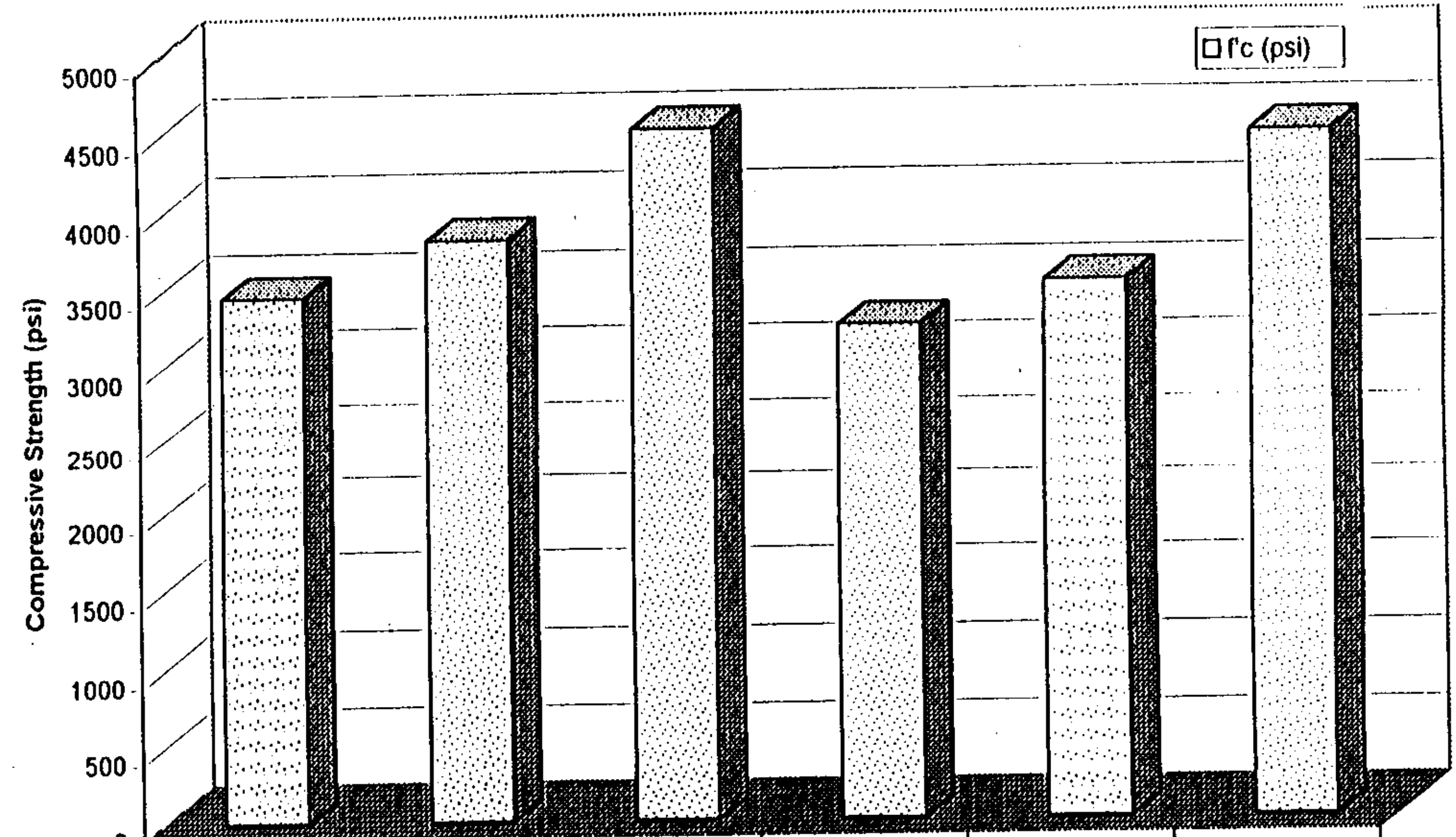


	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	3074	3769	4261	2945	3049	2868

Vibration Time Interval (hrs)

Frequency of Vibration: 20% Vibration Time: 15 min.

28-Day Compressive Strength after 15-minutes Vibration per Time Interval
Set #1

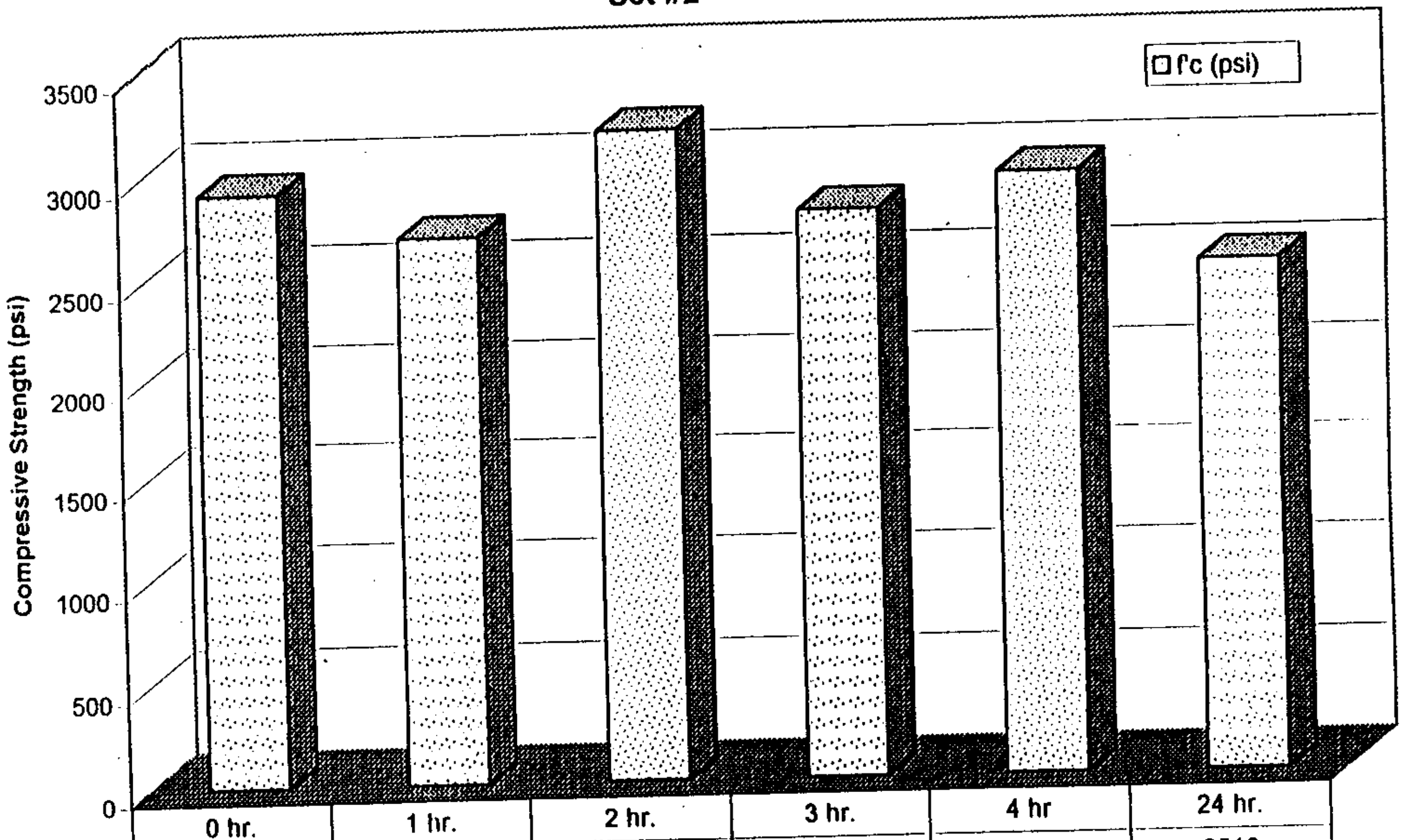


	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	3453	3820	4512	3238	3519	4463

Vibration Time Interval (hrs)

Frequency of Vibration: 20%   Vibration Time: 15 min.

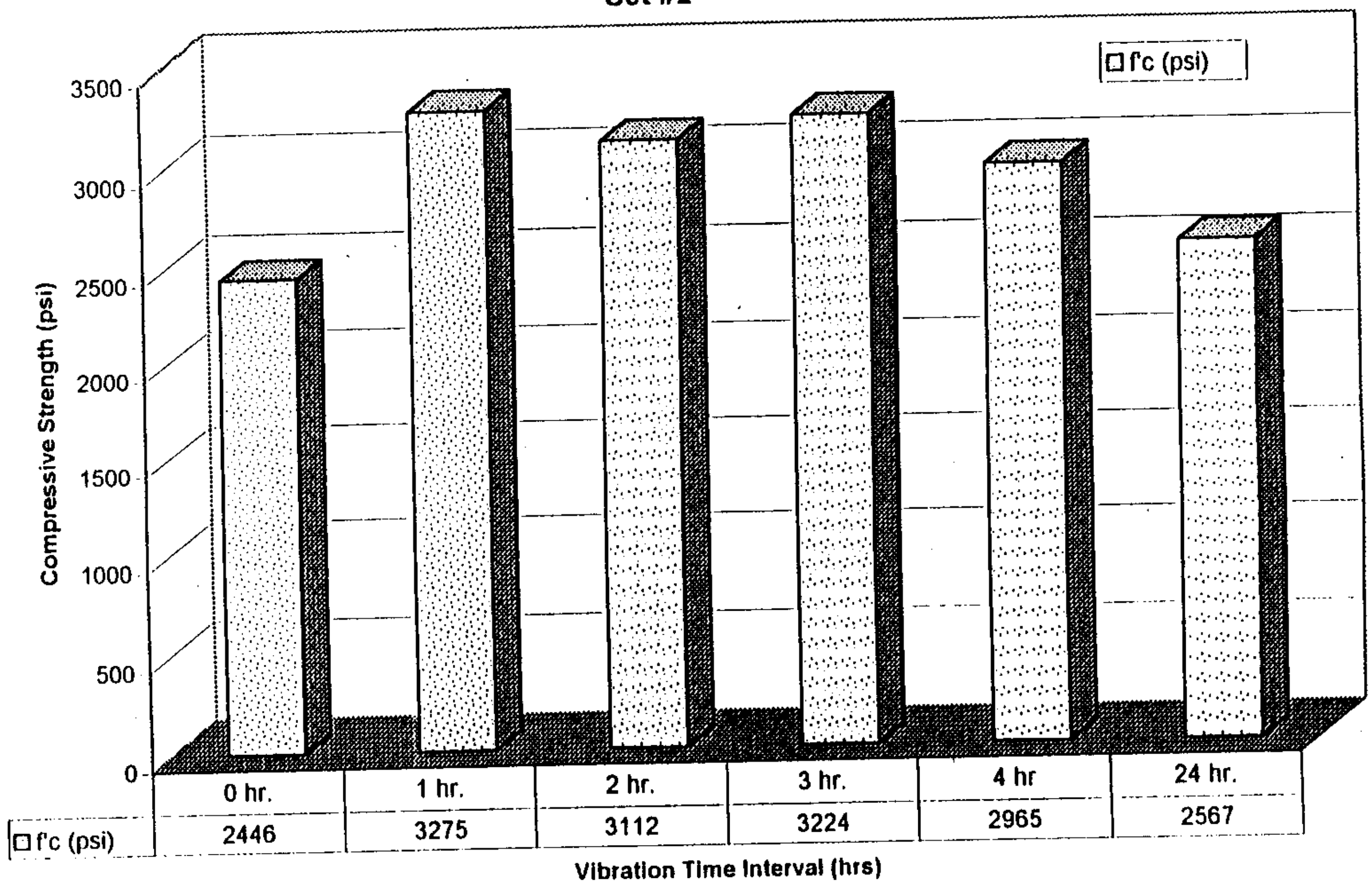
3-Day Compressive Strength after 15-minutes Vibration per Time Interval Set #2



	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	2922	2698	3188	2793	2955	2516

Frequency of Vibration: 40% Vibration Time: 15 min.

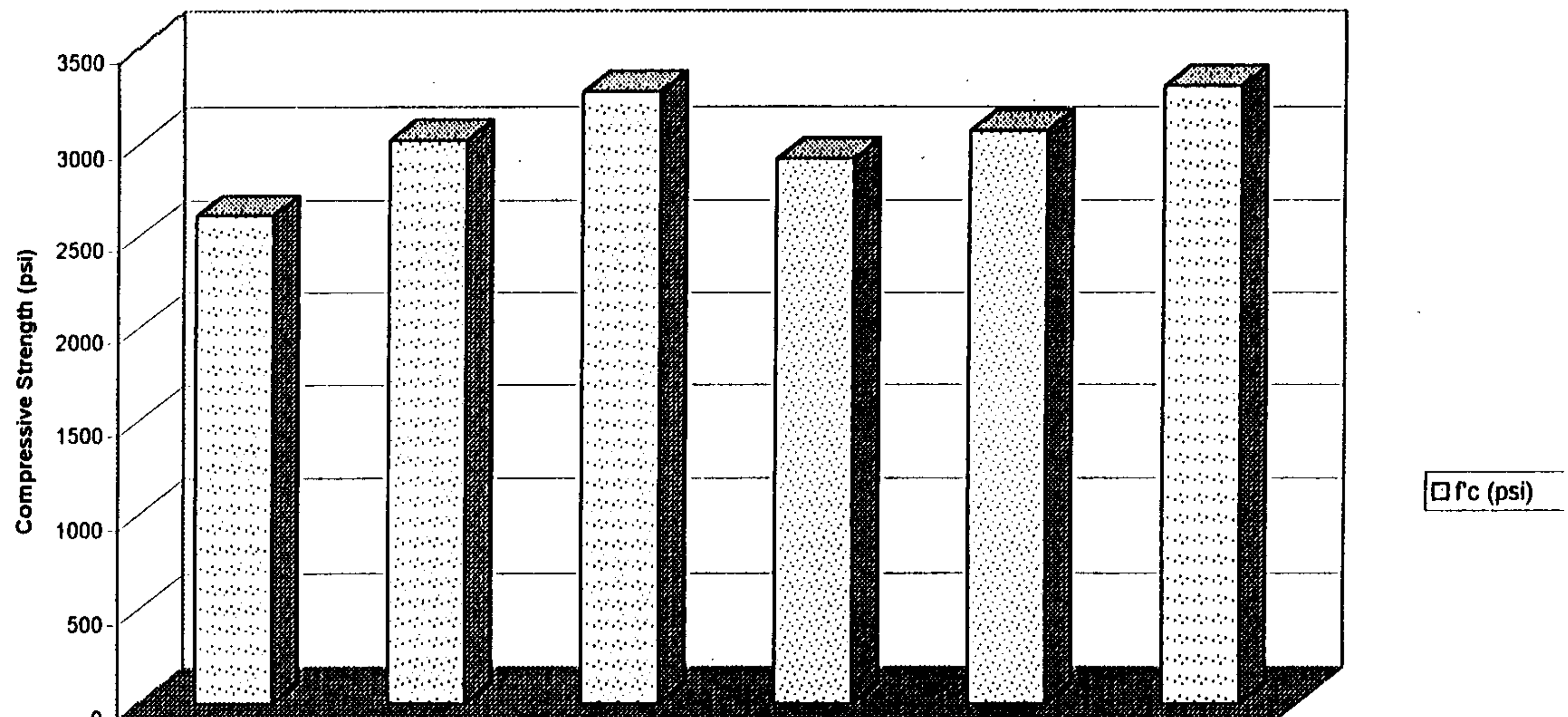
7-Day Compressive Strength after 15-minutes Vibration per Time Interval Set #2



Frequency of vibration: 40%

Vibration Time: 15 min.

14-Day Copmressive Strength after 15-minutes Vibration per Time Interval
Set #2

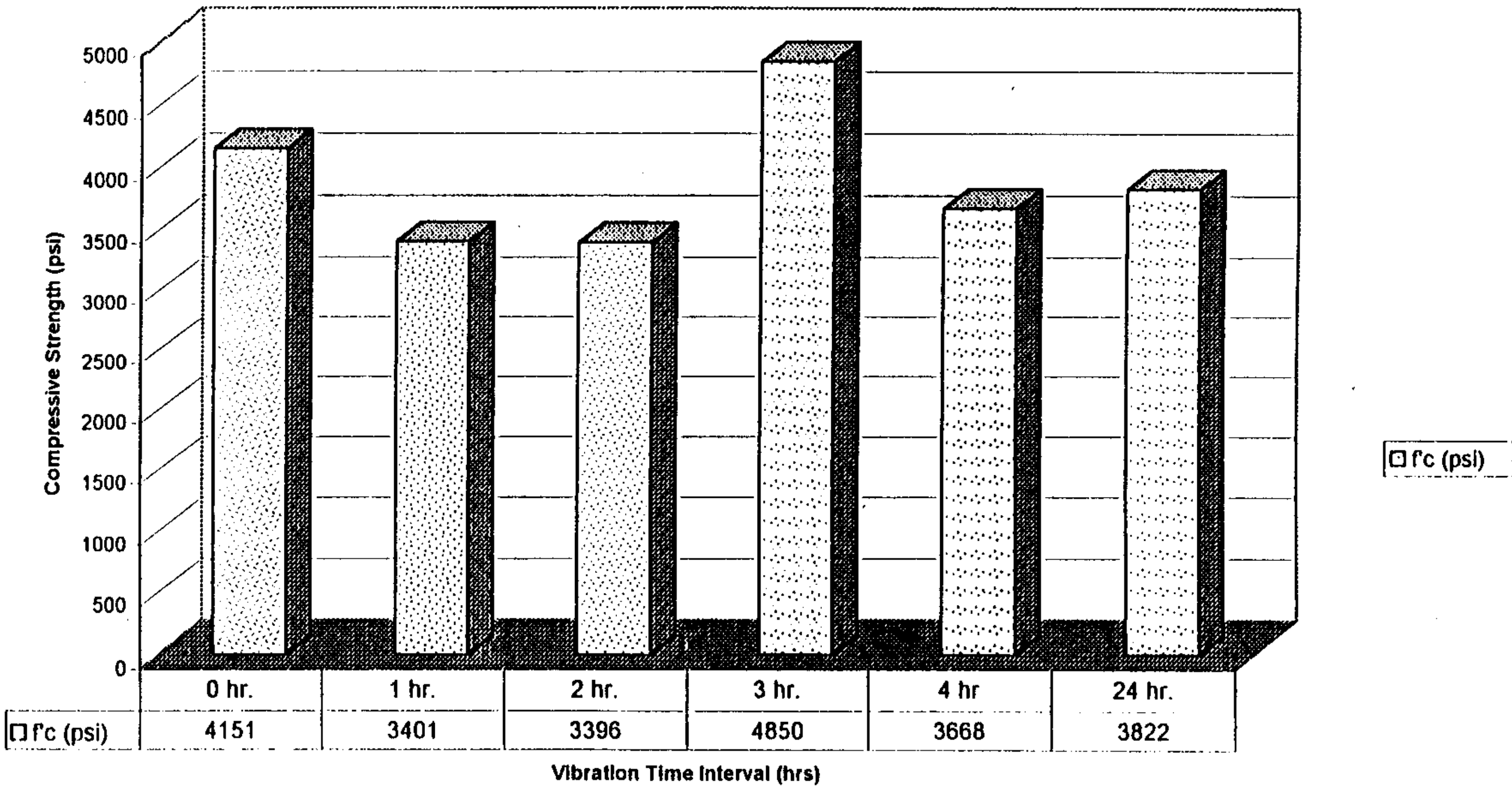


	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	2612	3014	3266	2919	3064	3296

Vibration Time Interval (hrs)

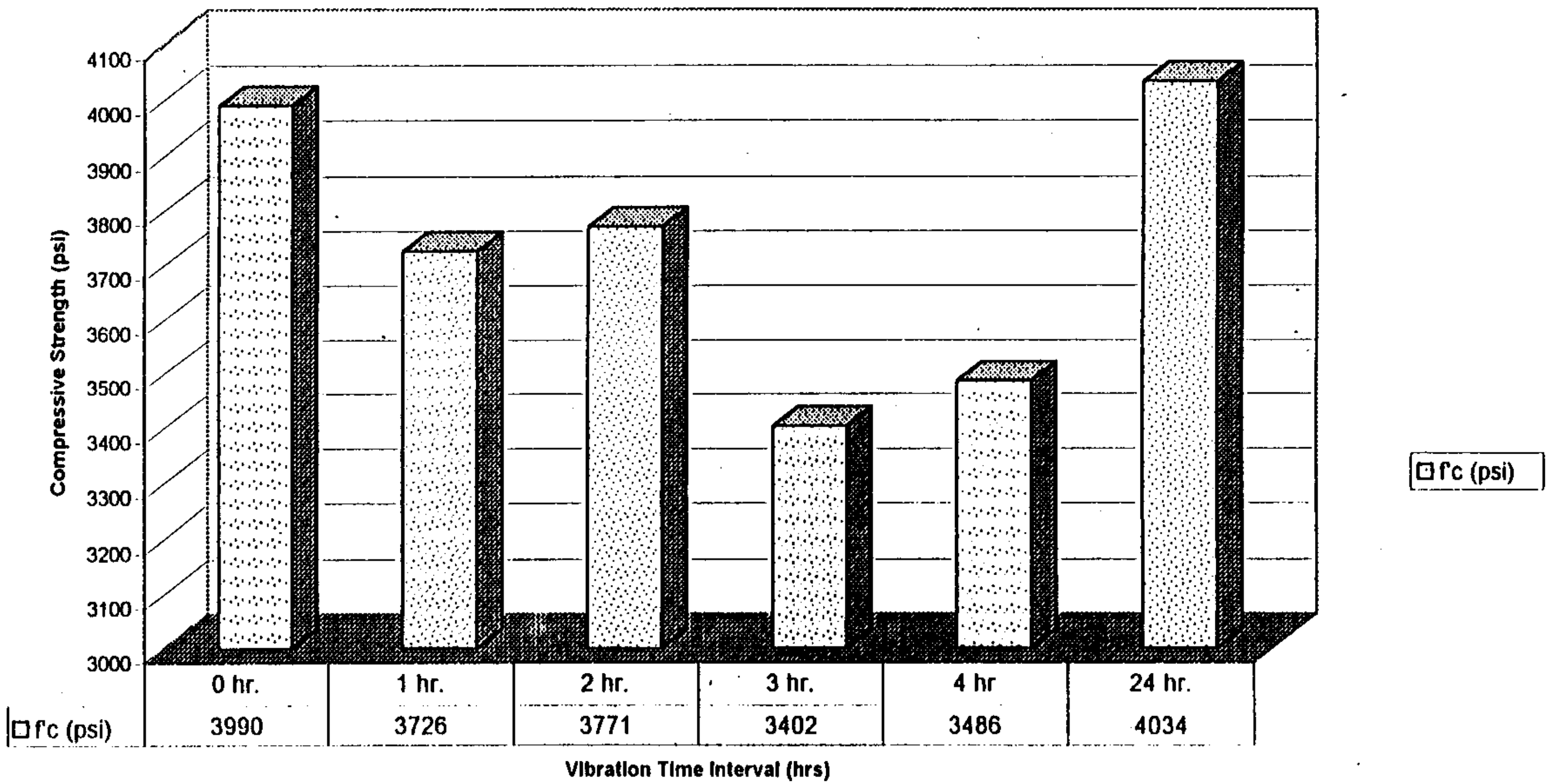
Frequency of Vibration: 40% , Vibration Time: 15 min.

28-Day Compressive Strength after 15-minutes Vibration per Time Interval
Set #3



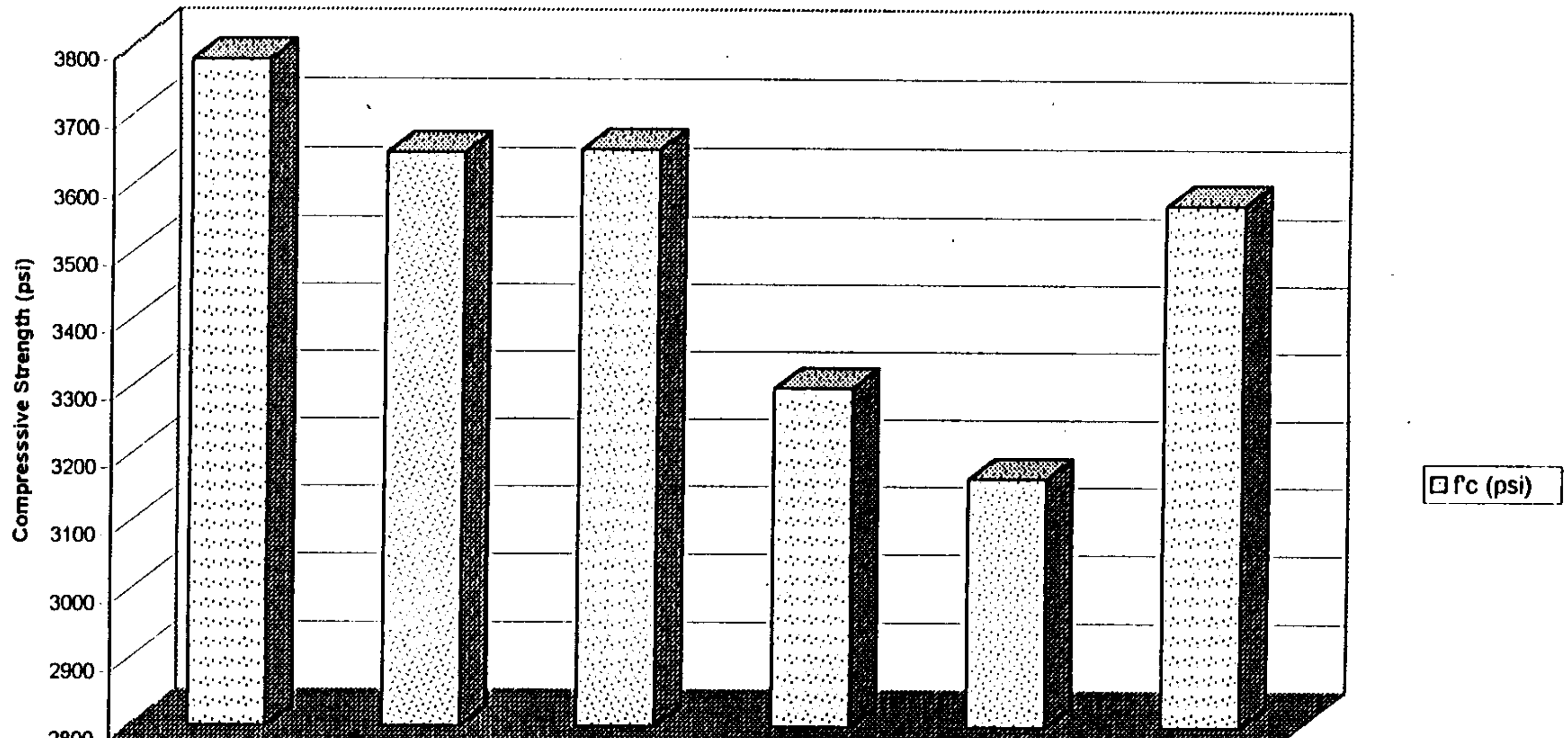
Frequency of Vibration: 10% Vibration Time: 15 min.

14-Day Compressive Strength after 15-minutes Vibration per Time Interval Set #3



Frequency of Vibration: 10%   Vibration Time: 15 min.

7-Day Compressive Strength after 15-minutes Vibration per Time Interval
Set #3

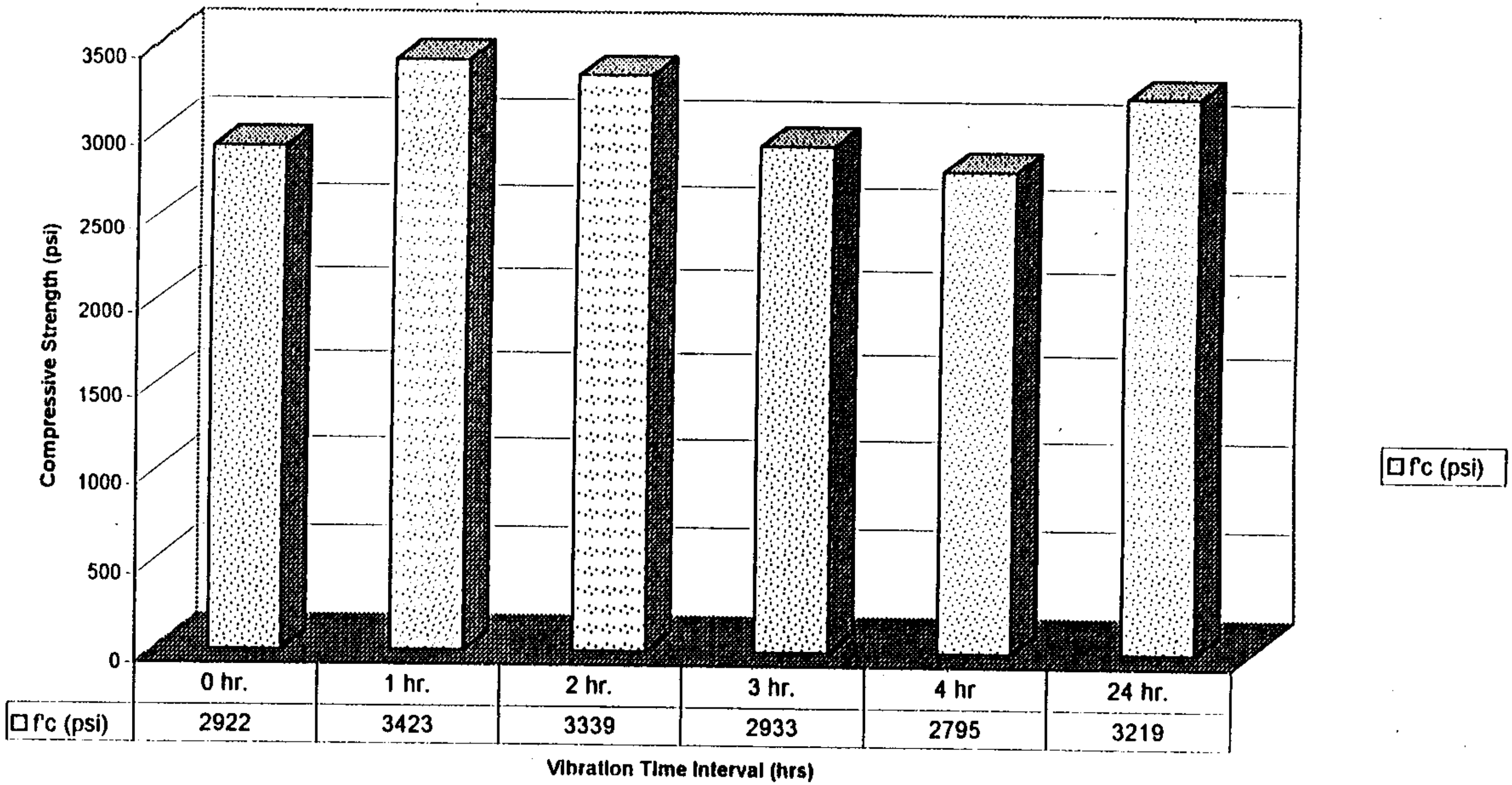


	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
f'c (psi)	3781	3645	3650	3298	3165	3573

Vibration Time Interval (hrs)

Frequency of Vibration: 10%   Vibration Time: 15 min.

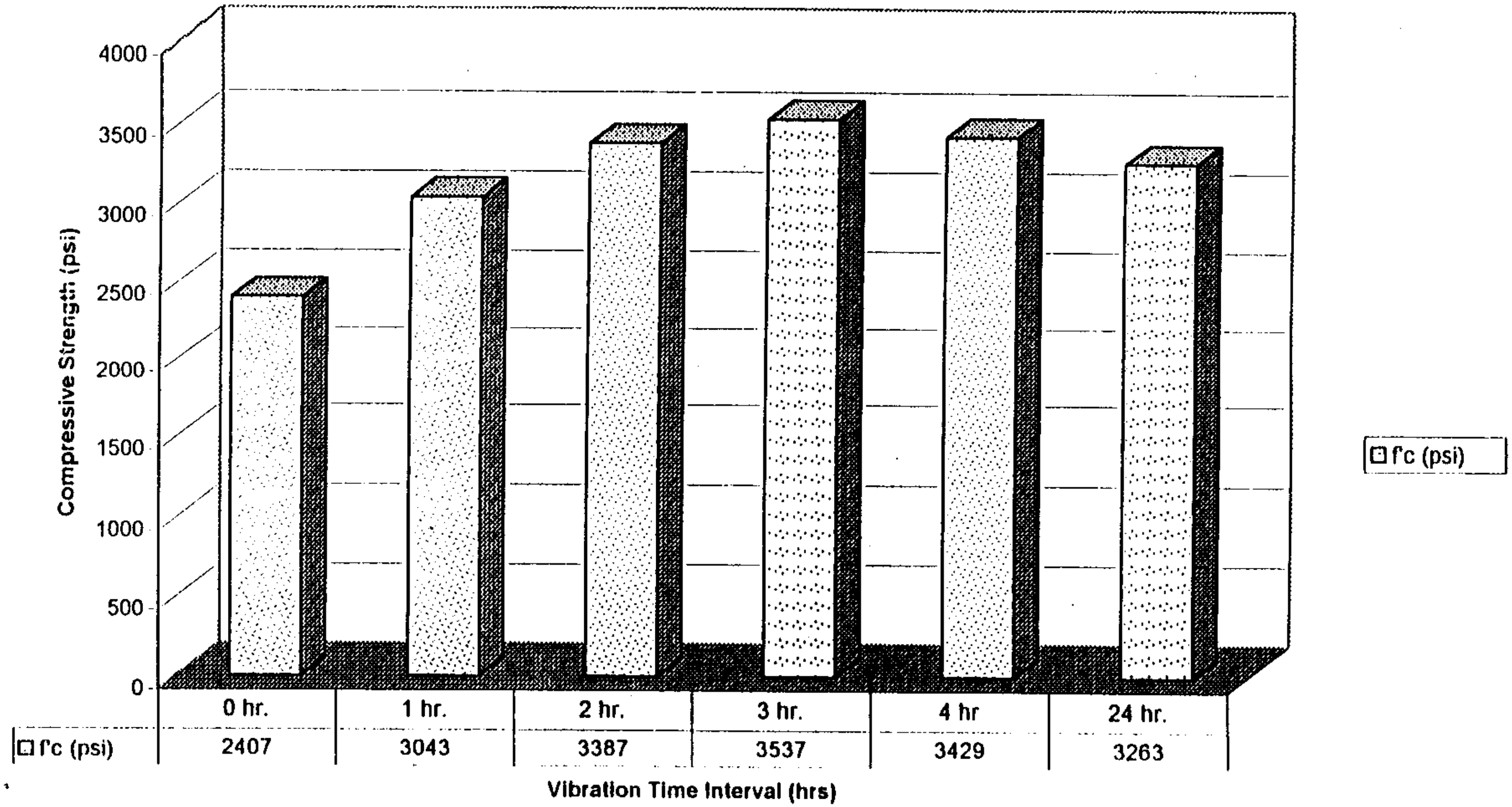
3-Day Compressive Strength after 15-minutes Vibration per Time Interval
Set #3



	0 hr.	1 hr.	2 hr.	3 hr.	4 hr	24 hr.
□ f'c (psi)	2922	3423	3339	2933	2795	3219

Frequency of Vibration: 10%   Vibration Time: 15 min.

28-Day Compressive Strength after 15-minutes Vibration per Time Interval Set #2



Frequency of Vibration: 40%   Vibration Time: 15 min

APPENDIX B

STANDARD PENETRATION TESTS

DELRAY BEACH

FDOT, District IV

FIELD BORING LOG

SHEET 1 OF 3

PROJECT NO. FAU Research NAME ______ COUNTY Palm Beach Co DISTRICT 4

LOCATION ______ TOWNSHIP — RANGE — SECTION ______

ROAD NUMBER I-95 @ Linton SURFACE ELEVATION ______

EQUIPMENT TYPE CME-75 RIG NO. DOT 26696 BORING NO. B-1

DATE STARTED 3/4/98 COMPLETED 3/4/98 DRILLED BY Laninck, Lewis, Bennett

LOGGED BY [illegible] BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, Stemflight Auger

CASED, UNCASED, DRILLING MUD

WATER TABLE: 0 HR. 7.6' 24 HRS. ______ HRS. ______

SPT No 4 Automatic hammer.

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE

SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE

TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	CON.	NO. TYPE	REC. (%)	TESTS	REMARKS
	1	1, 2, 2	Light to dark Tan fine sand		1	50		
	2	3, 4, 6	Tan fine sand.		2	60		
	3, 4	4, 4, 6			3	70		
	5	4, 3, 4			4	70		
	6, 7	3, 2, 2			5	70		
	8	2, 2, 2			6	70		
	9, 10	2, 2, 2			7	70		
	11	3, 4, 4			8	70		
	12, 13	3, 4, 7	Dark to light Tan fine sand		9	70		
	14	3, 5, 4	Light Tan fine sand		10	60		
	15, 16	4, 4, 4			11	60		
	17							
	18, 19	2, 1, 3	Light gray fine sand		12	50		
	20							

FIELD BORING LOG

SHEET 2 OF 3

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. B-1
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, ______ CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS ______

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE

SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE

TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	21	4 5 7	Light Gray fine sand		13	40		
	22							
	23	3 4 4	" " " "		14	40		
	24							
	25	2 2 2	" " " "		15	40		
	26							
	27							
	28	2 2 2	" " " "		16	40		
	29							
	30	1	light gray fine sand with cemented sand and shell fragments.		17	30		*Advanced 12" under weight of hammer
	31	1						
	32							
	33	4 4 5	" " "		18	40		
	34							
	35	5 4 4	" " "		19	30		
	36							
	37							
	38	3 3 4	" " "		20	30		
	39							
	40							

RECYCLED PAPER

GRL Goble Rausche Likins and Associates, Inc

FIELD BORING LOG

SHEET 3 OF 3

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______

LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______

ROAD NUMBER ______ SURFACE ELEVATION ______

EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. B-1

DATE STARTED ______ COMPLETED ______ DRILLED BY ______

LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, ______ CASED, UNCASED, DRILLING MUD, ______

WATER TABLE. 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE

SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE

TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
	41	5 5 5	Light gray fine sand with cemented, [illegible] and shell fragments		21	30		
			Boring terminated at 41.5'					

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GRL Goble Rausche Likins and Associates, Inc.

FIELD BORING LOG

SHEET 1 OF —

PROJECT NO. FAD Research NAME ______ COUNTY Palm Beach DISTRICT 4

LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______

ROAD NUMBER I-95 at Lantana Blvd SURFACE ELEVATION ______

EQUIPMENT TYPE CME-75 RIG NO. 24496 BORING NO. B-2

DATE STARTED 3-5-98 COMPLETED 3-5-98 DRILLED BY [illegible]

LOGGED BY Swaminathan BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, ______ CASED, UNCASED, DRILLING MUD

WATER TABLE: 0 HR. 9.3' 24 HRS. ______ HRS. ______

140 lb. CME Automatic hammer

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE

SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE

TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC (%)	TESTS	REMARKS
	0–1	1, 1, 2, 4	Fine tan sand		1	60		
	2	6, 7, 6	" "		2	70		
	3–4	6, 5, 3	" "		3	70		
	5	4, 1	" "		4	60		
	6–7	2, 3	" "		5	60		
	8	2, 2, 1	" "		6	60		
	9–10	2, 3, 3	" "		7	60		
	11	2, 3	" "		8	60		
	12–13	3, 3, 2, 4	" "		9	60		*Turning to lighter tan/grey
	14	3, 3, 2	" "		10	60		
	15–16	2, 1, 1	" "		11	60		
	17							
	18–19	2, 3, 4	" "		12	[illegible]		
	20							

RECYCLED PAPER

GRL Goble Rausche Likins and Associates, Inc

FROM: DISTRICT MATERIALS TO: 4073672789 APR 9. 1998 1:43PM #483 P.6

FIELD BORING LOG

SHEET 2 OF 3

PROJECT NO ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
EQUIPMENT TYPE ______ RIG NO. ______ BORING NO. B-2
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, ______ CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE
SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE
TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	NO. TYPE	REC. (%)	TESTS	REMARKS
	21	5 5 6	Grey fine sand		13	60		
	22							
	23	4 4 3	" "		14	60		
	24							
	25							
	26	3 4 3	" "		15	60		
	27							
	28	3 3 3	" "		16	60		
	29							
	30							
	31	2 2 2	" "		17	60		
	32							
	33	4 3 4	Grey sand with cemented sand fragments (traces of shell)		18	60		
	34							
	35							
	36	4 4 4	"		19	50		
	37							
	38	4 4 4	Grey sand and shell traces of cemented sand		20	50		
	39							
	40							

RECYCLED PAPER

GRL Goble Rausche Likins and Associates, Inc

FIELD BORING LOG

SHEET 3 OF 3

PROJECT NO. ______ NAME ______ COUNTY ______ DISTRICT ______
LOCATION ______ TOWNSHIP ______ RANGE ______ SECTION ______
ROAD NUMBER ______ SURFACE ELEVATION ______
BORING NO. B-2
EQUIPMENT TYPE ______ RIG NO. ______
DATE STARTED ______ COMPLETED ______ DRILLED BY ______
LOGGED BY ______ BORING TYPE: AUGER, WASHED, PERCUSSION, ROTARY, ______ CASED, UNCASED, DRILLING MUD, ______
WATER TABLE: 0 HR. ______ 24 HRS. ______ HRS. ______

SAMPLE CONDITIONS: DISTURBED, GOOD, LOST, CORE SAMPLE
SAMPLE TYPES: A: AUGER; SB: SPLIT BARREL; S: SHELBY TUBE; RC: ROCK CORE ______ SIZE
TESTS: W.C.: WATER CONTENT (%); T: TORVANE (TSF); V: IN-SITU VANE TEST (TSF)

ELEV. (FT.)	DEPTH (FT.)	S.P.T. BLOWS	MATERIAL DESCRIPTION	SAMPLES CON.	SAMPLES NO. TYPE	SAMPLES REC. (%)	TESTS	REMARKS
		5	Gray sand and shell		21	60		
	41	5						
		7						
			Boring ends 41.5'					

APPENDIX C

PEAK PARTICLE VELOCITY Vs. TIME RECORDS

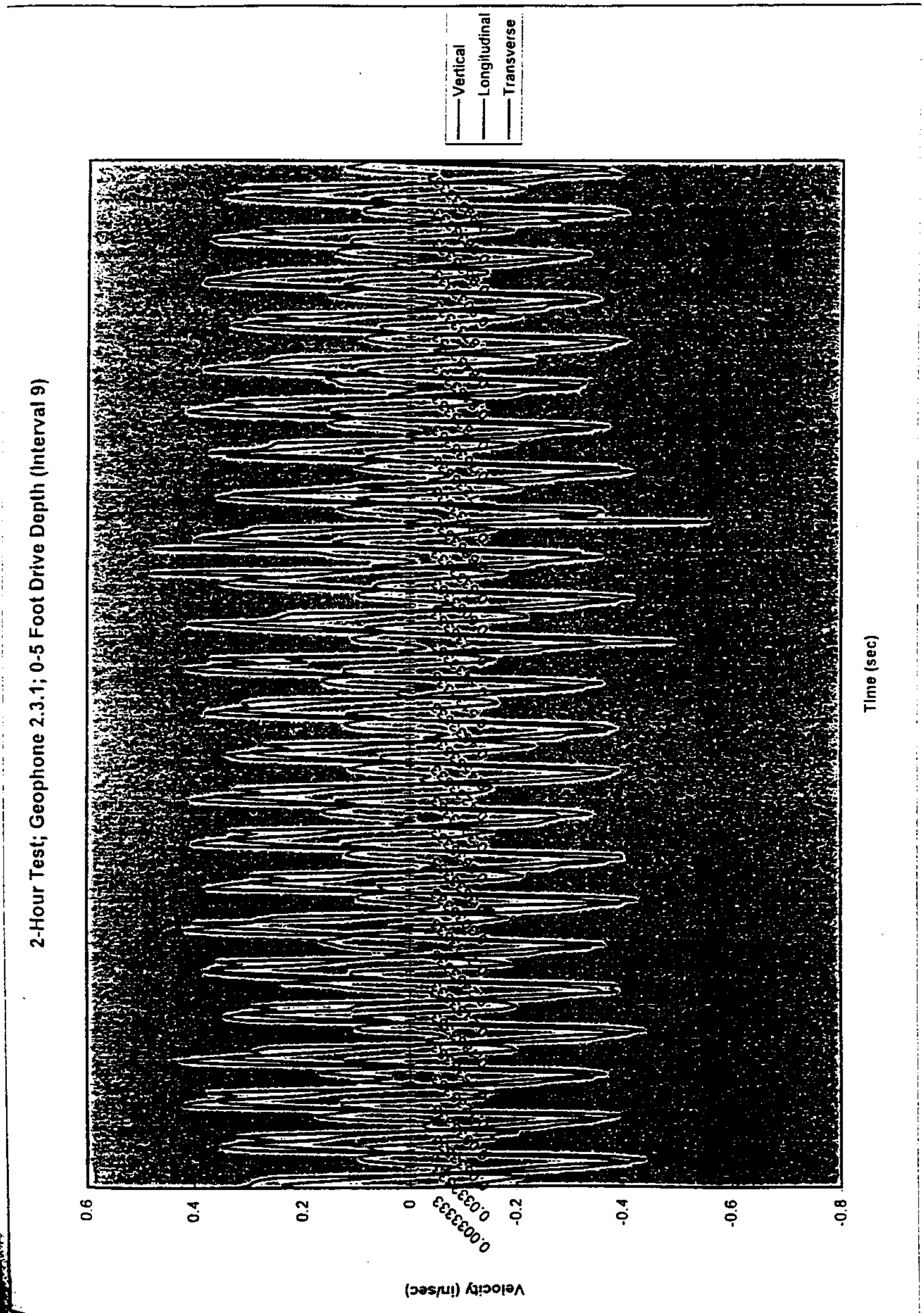
September 98

DELRAY BEACH

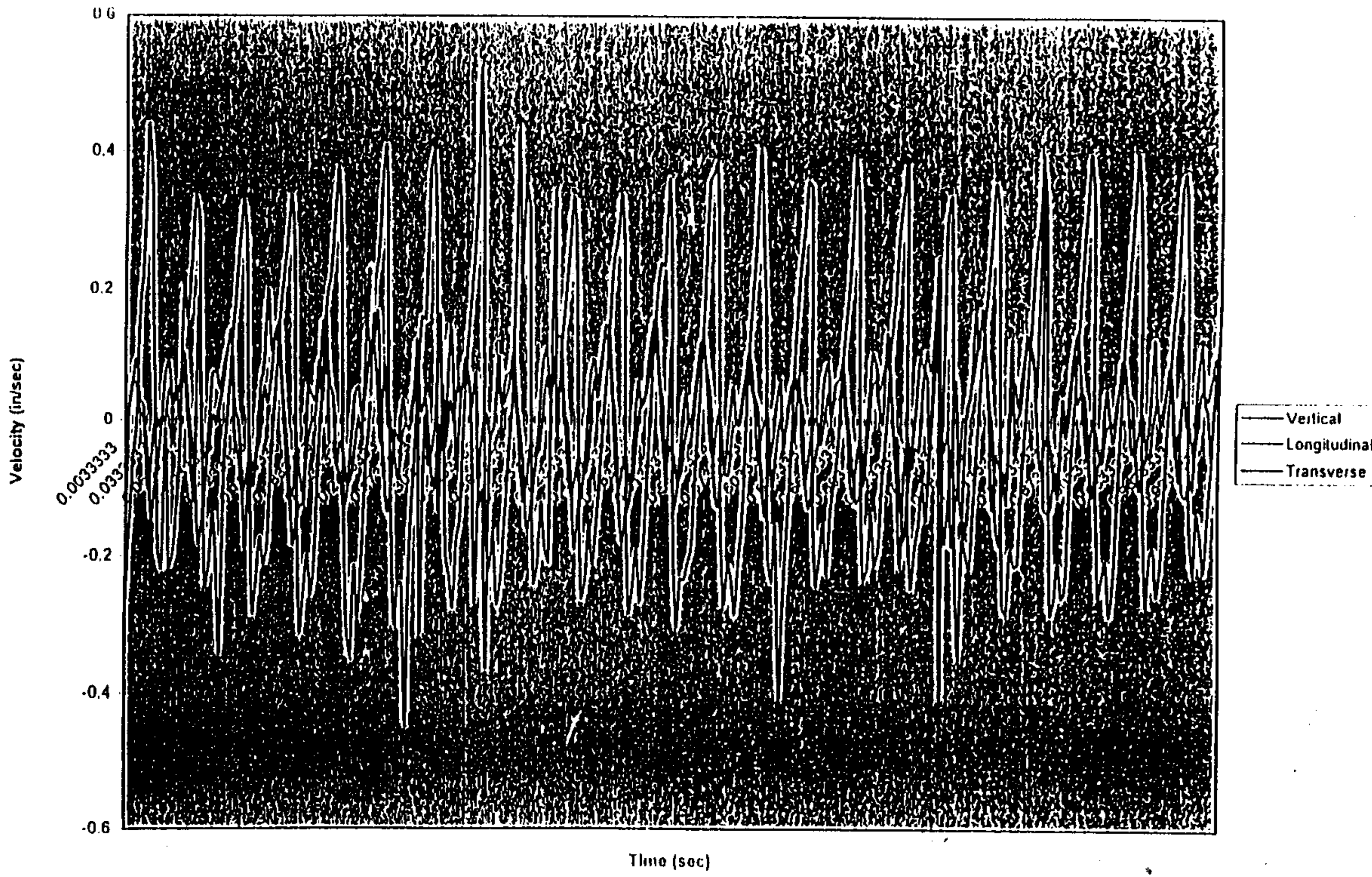
LAW ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

CLEARWATER

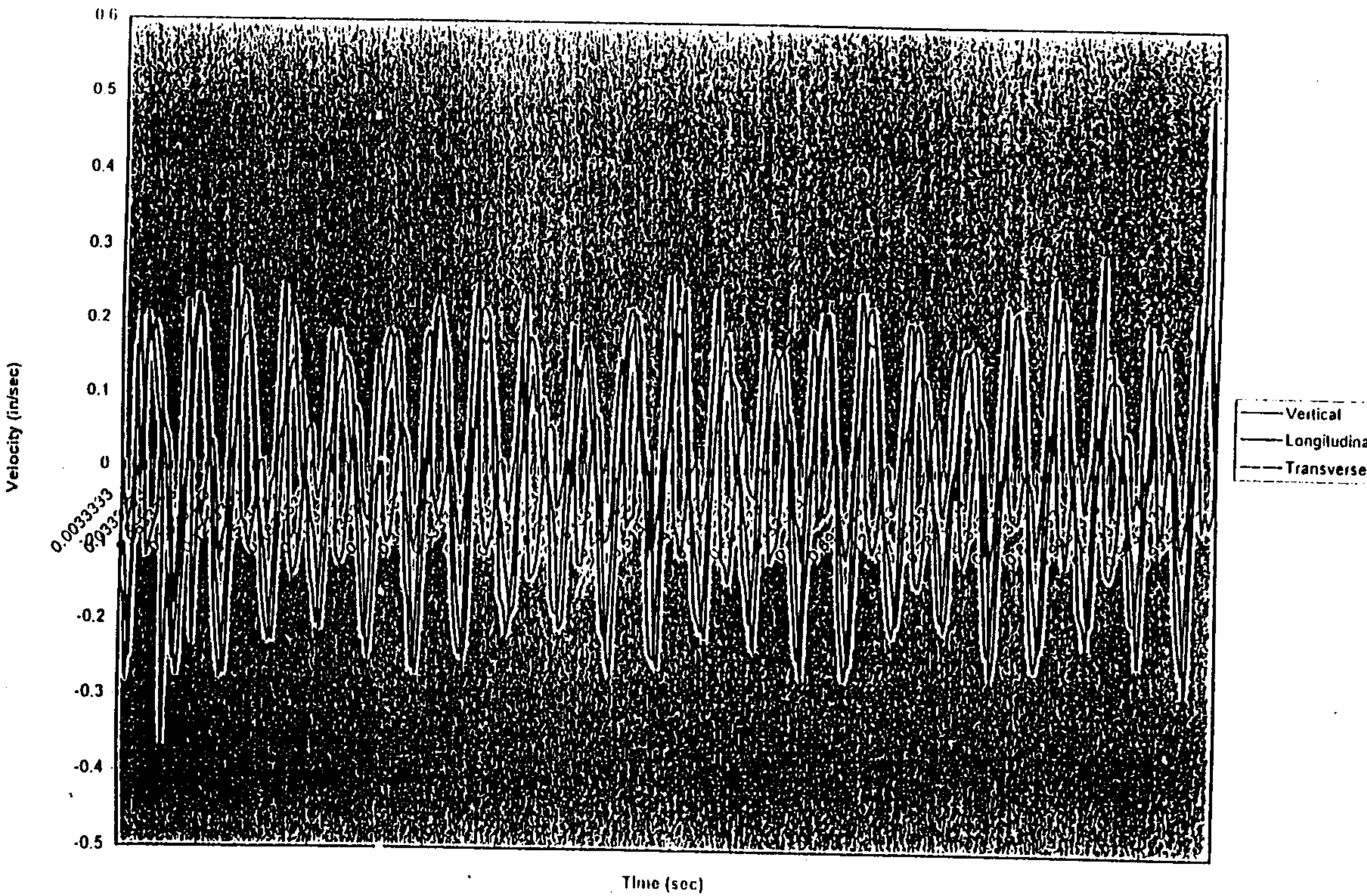
LAW ENGINEERING AND ENVIRONMENTAL SERVICES, INC.

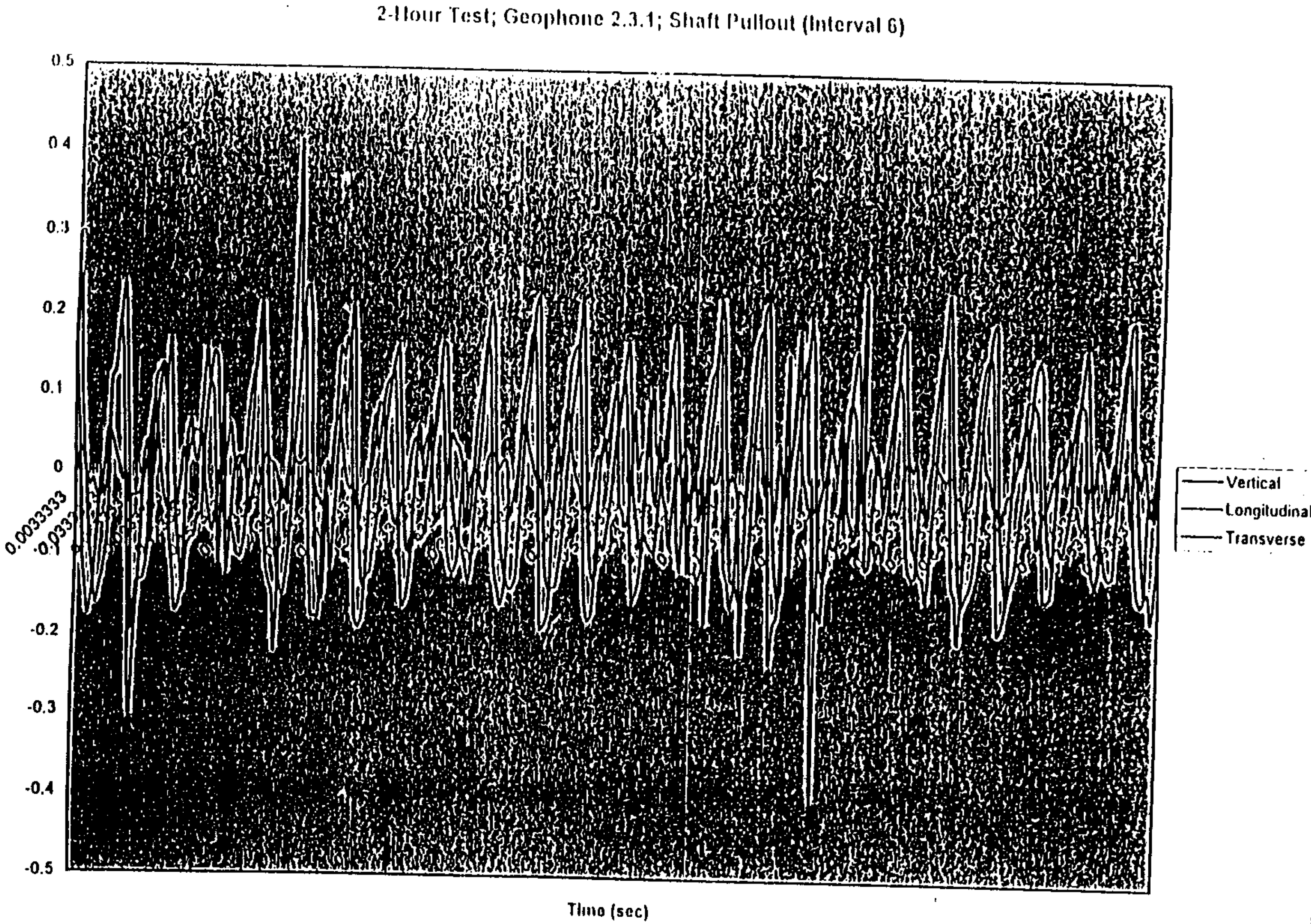

2-Hour Test; Geophone 2.3.1; 0-5 Foot Drive Depth (Interval 9)
Vertical
Longitudinal
Transverse
Velocity (in/sec)
Time (sec)
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0.0033333

2-Hour Test; Geophone 2.3.1; 5-10 Foot Drive Depth (Interval 8)

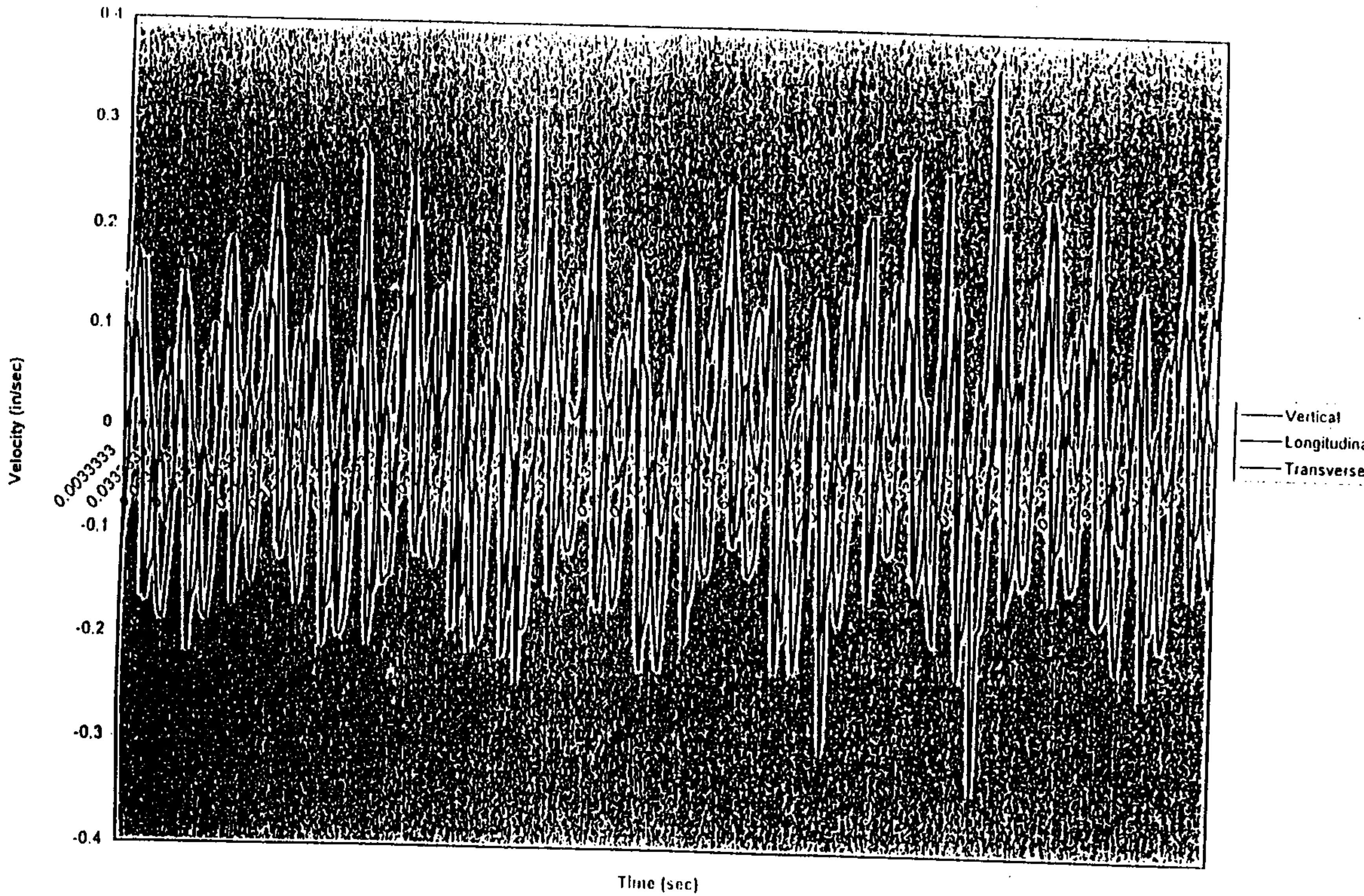


2-Hour Test; Geophone 2.3.1; 10-15 Foot Drive Depth (Interval 11)

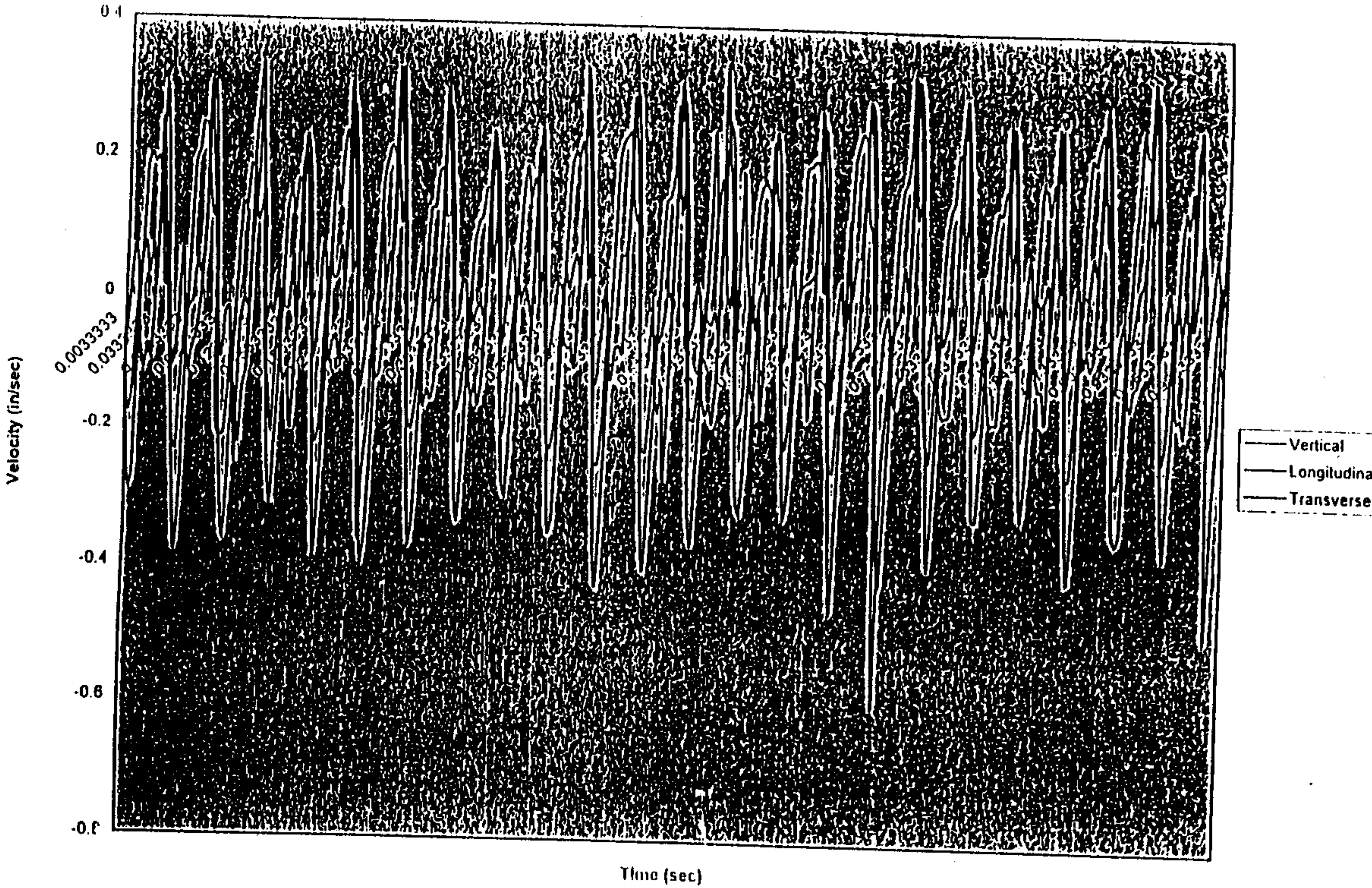



2-Hour Test; Geophone 2.3.1; Shaft Pullout (Interval 6)
0.5
0.4
0.3
0.2
0.1
0
0.0033333
-0.0333
-0.2
-0.3
-0.4
-0.5
Velocity (in/sec)
Time (sec)
Vertical
Longitudinal
Transverse

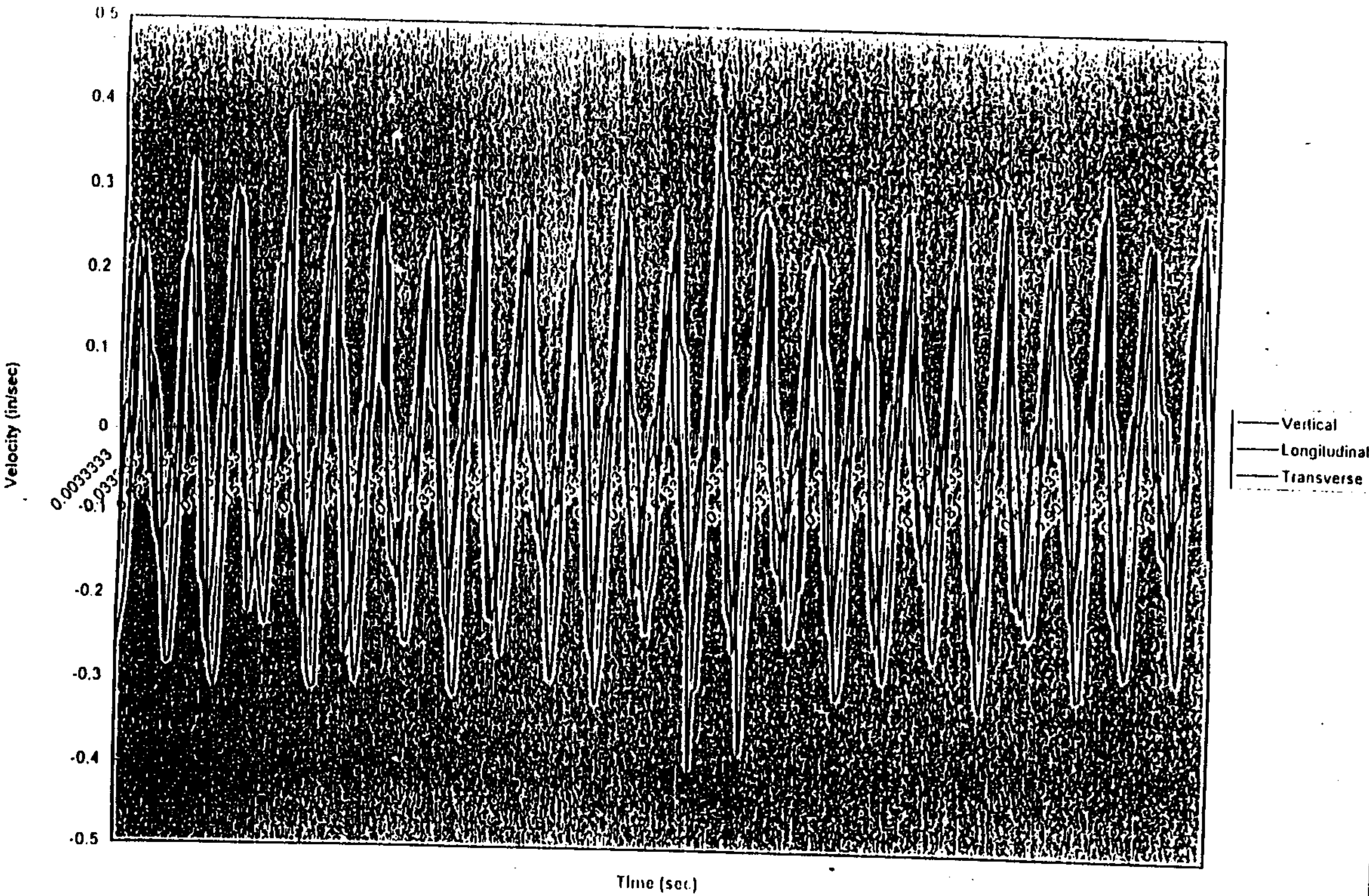
2-Hour Test; Geophone 2.3.2; 0-5 Foot Drive Depth (Interval 10)



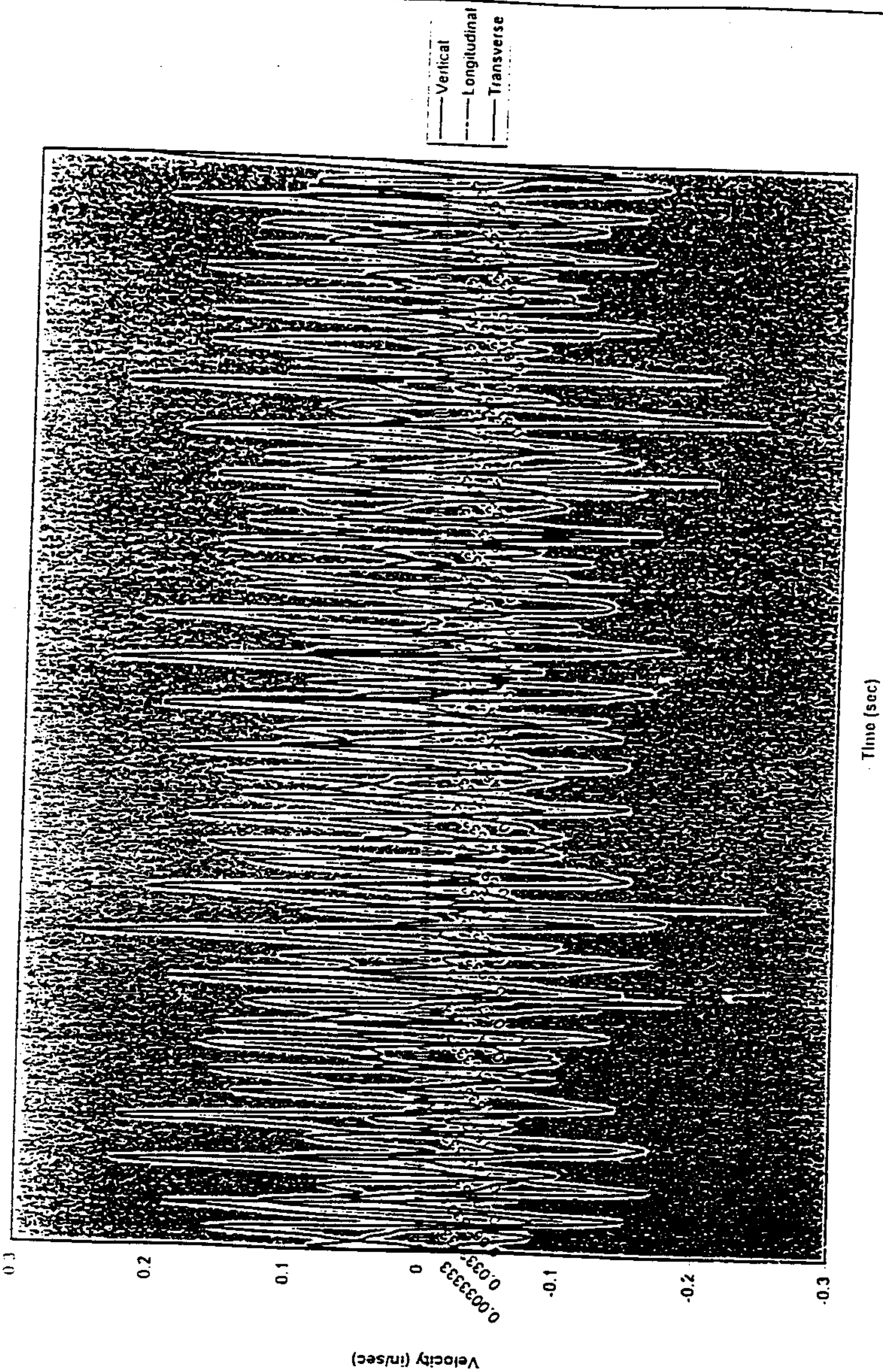
2-Hour Test; Geophone 2.3.2; 5-10 Foot Drive Depth (Interval 5)

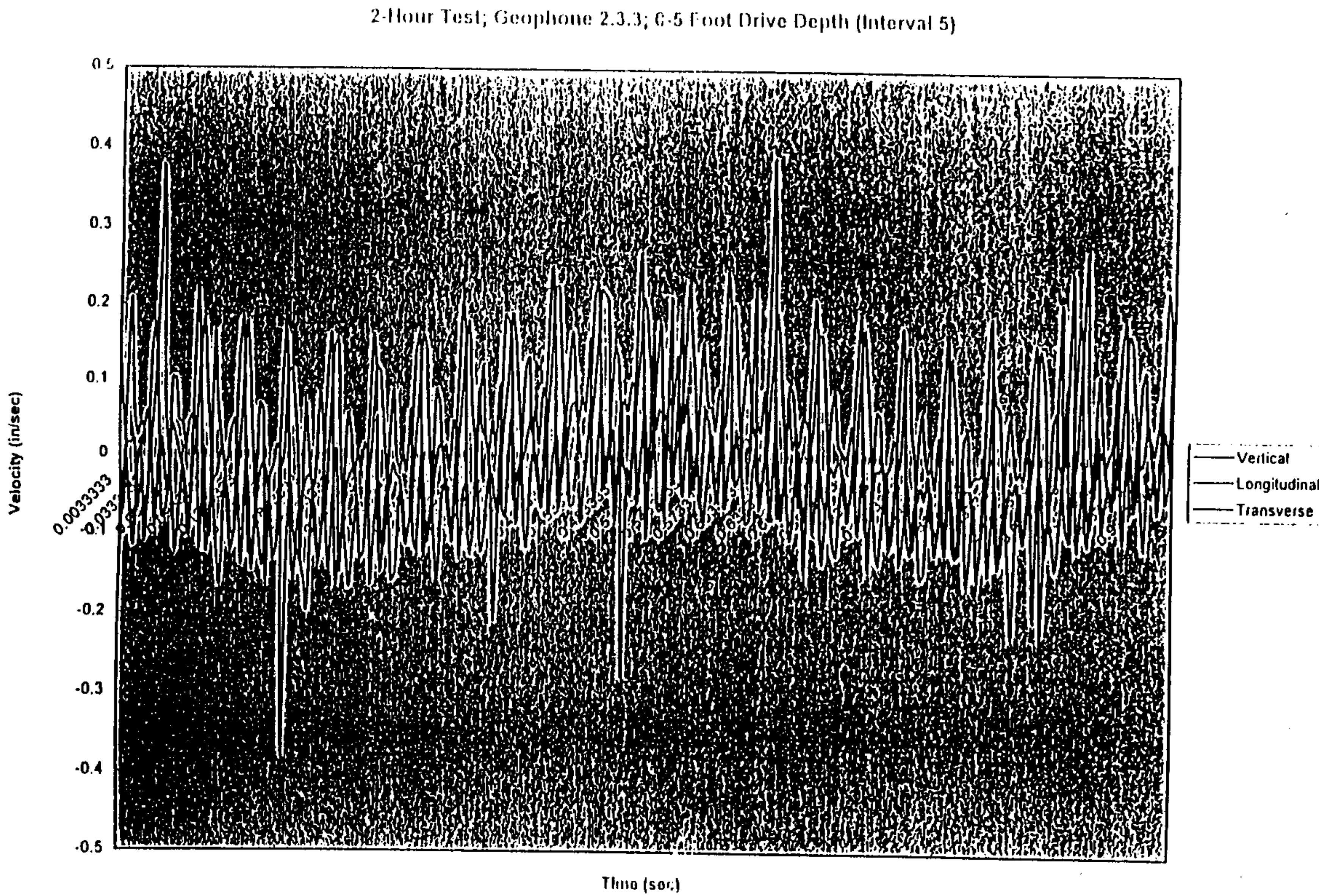


2-Hour Test; Geophone 2.3.2; 10-15 Foot Drive Depth (Interval 12)



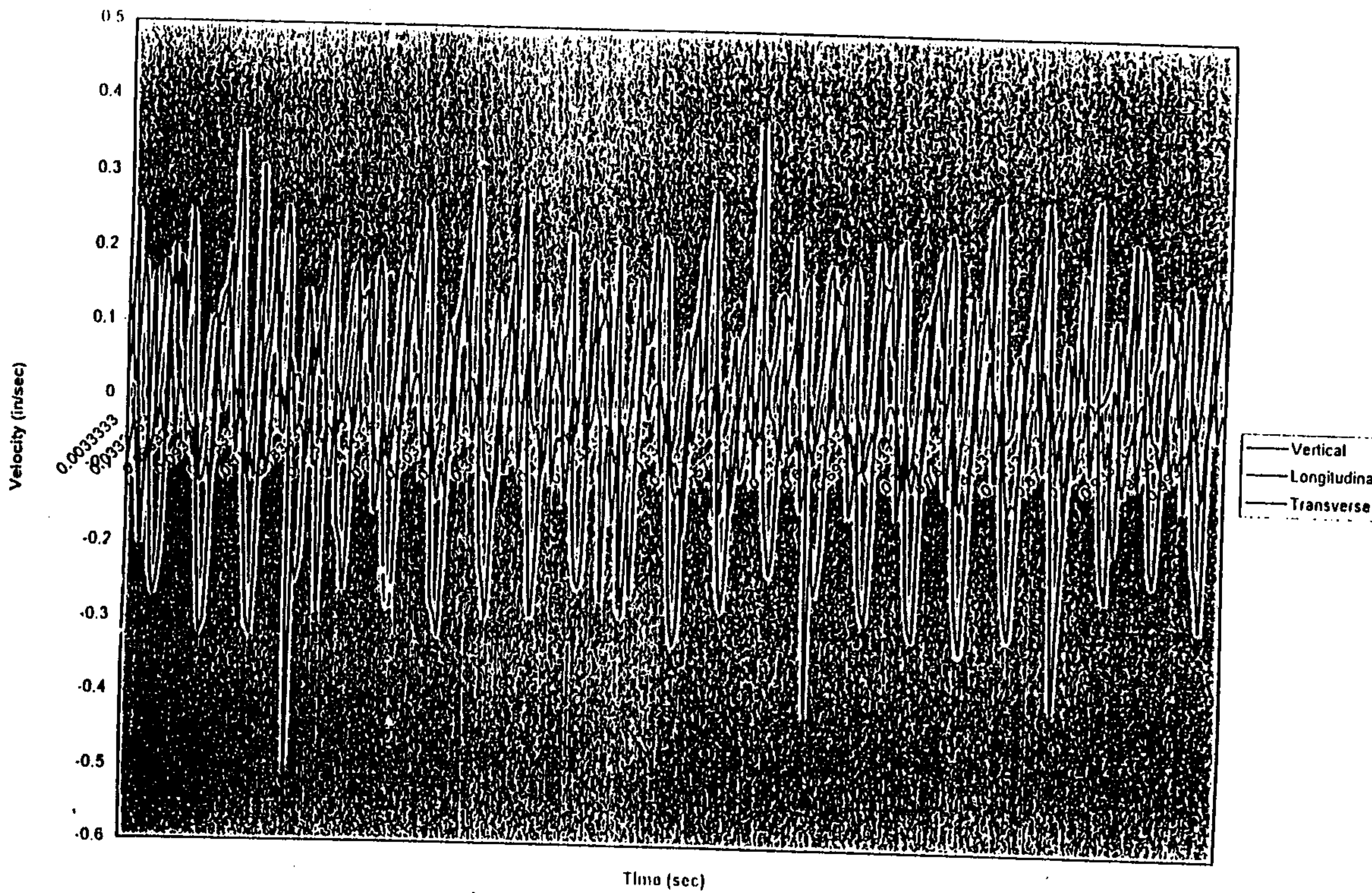
2-Hour Test; Geophone 2.3.2; Shaft Pullout (Interval 7)



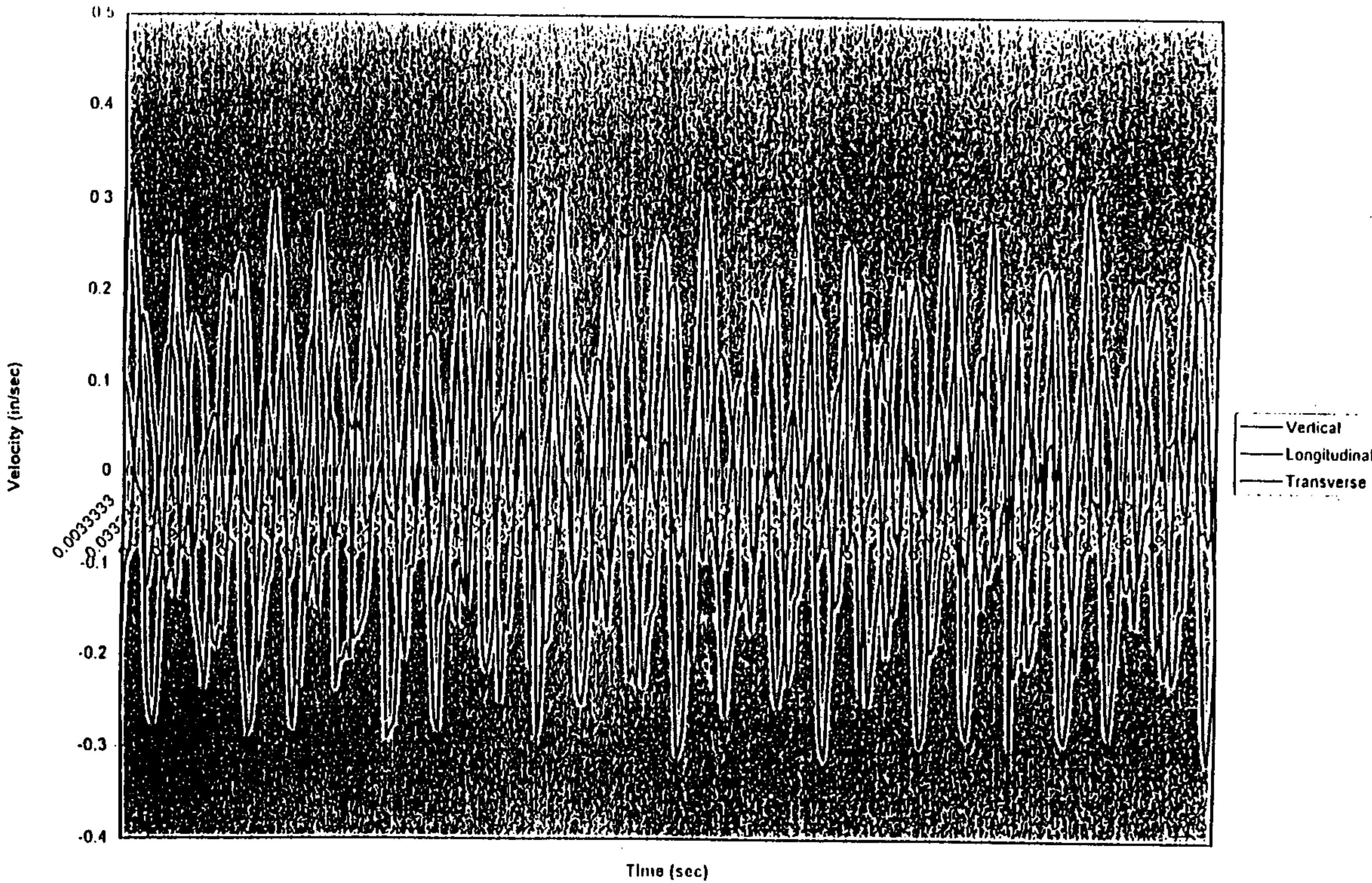


2-Hour Test; Geophone 2.3.3; 0-5 Foot Drive Depth (Interval 5)
0.5
0.4
0.3
0.2
0.1
0
0.0033333
-0.1
-0.2
-0.3
-0.4
-0.5
Velocity (in/sec)
Time (sec)
Vertical
Longitudinal
Transverse

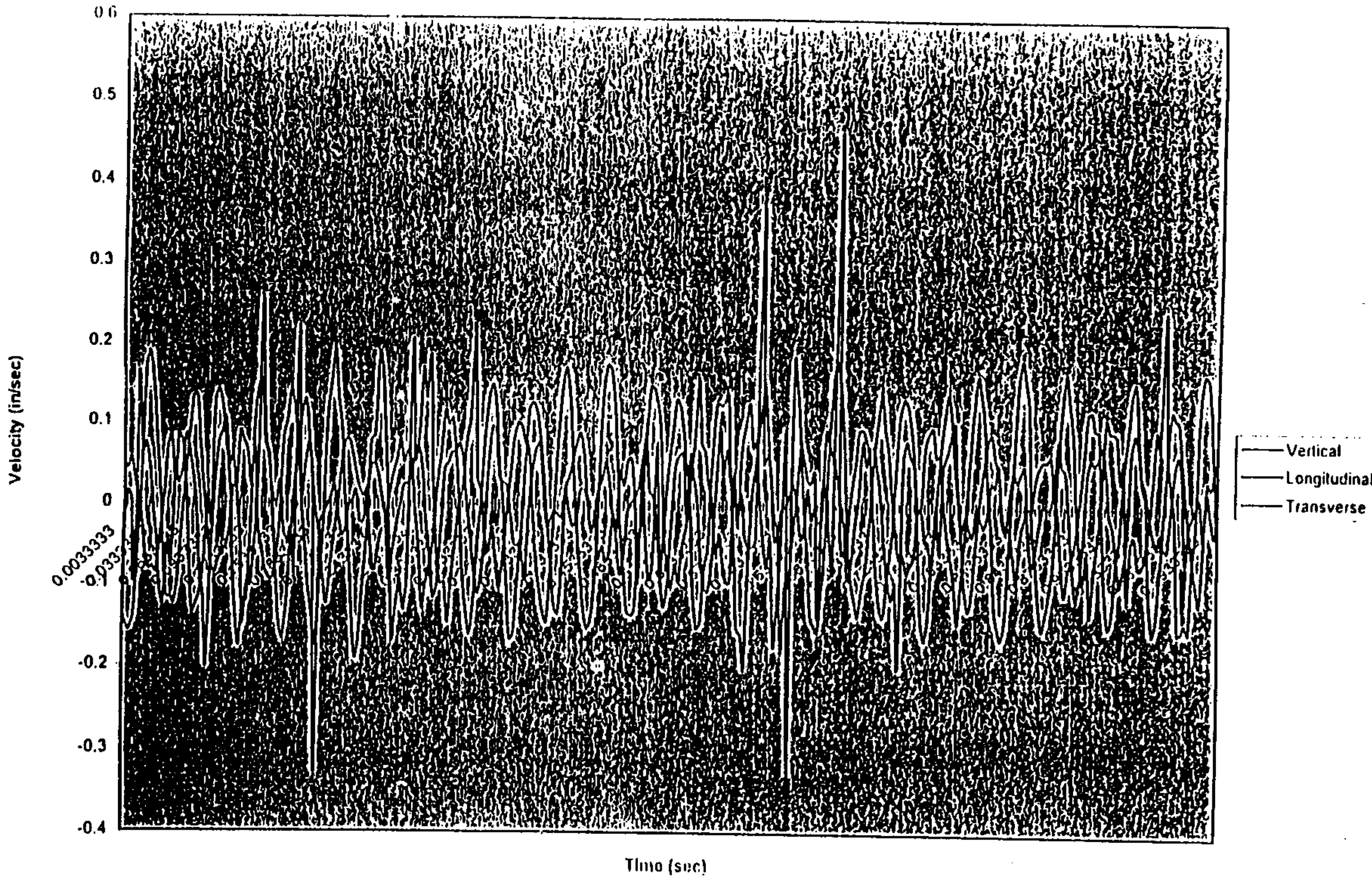
2-Hour Test; Geophone 2.3.3; 5-10 Foot Drive Depth (Interval 5)



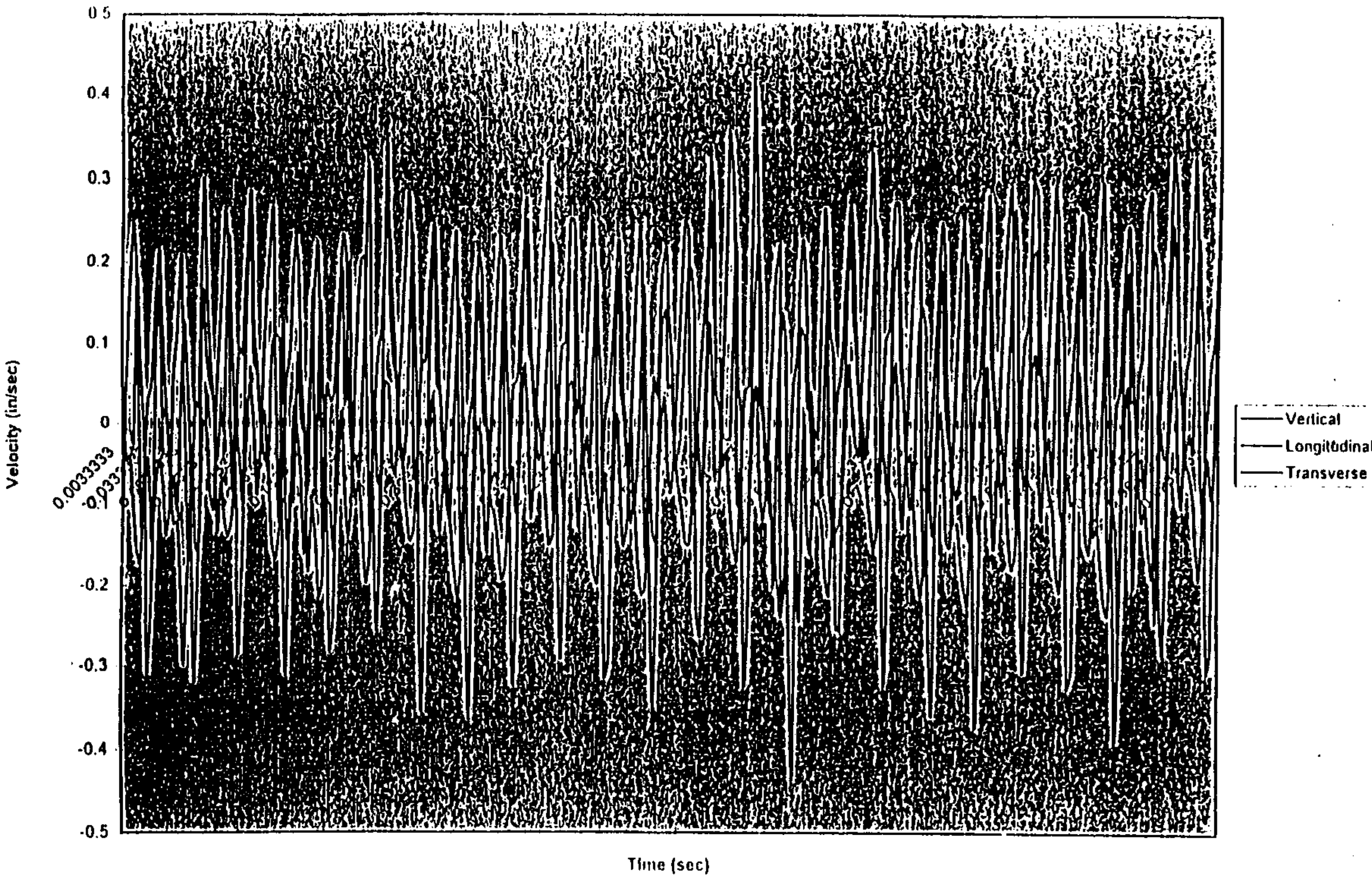
2-Hour Test; Geophone 2.3.3; 10-15 Foot Drive Depth (Interval 11)



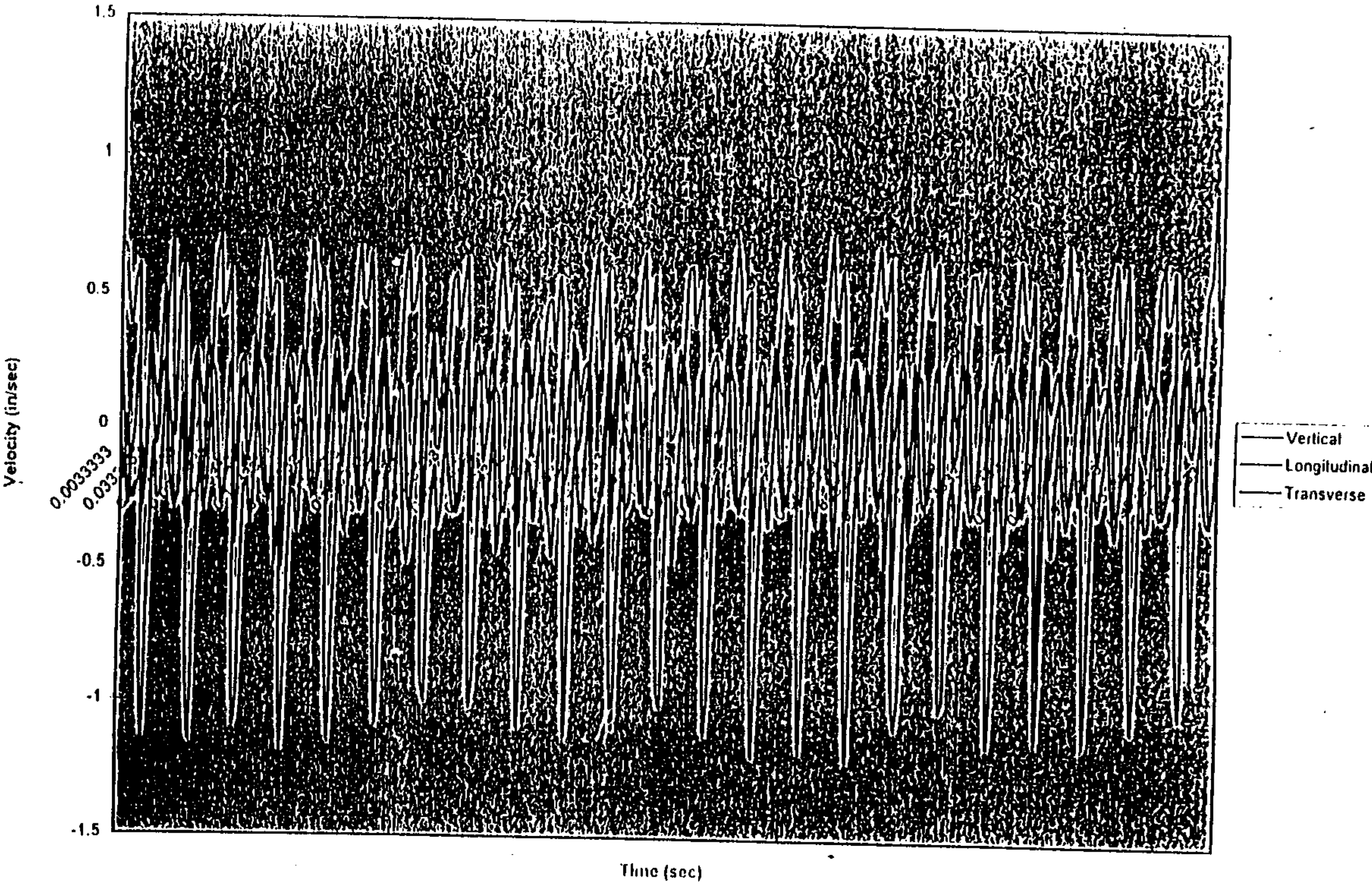
2-Hour Test; Geophone 2.3.3; Shaft Pullout (Interval 7)

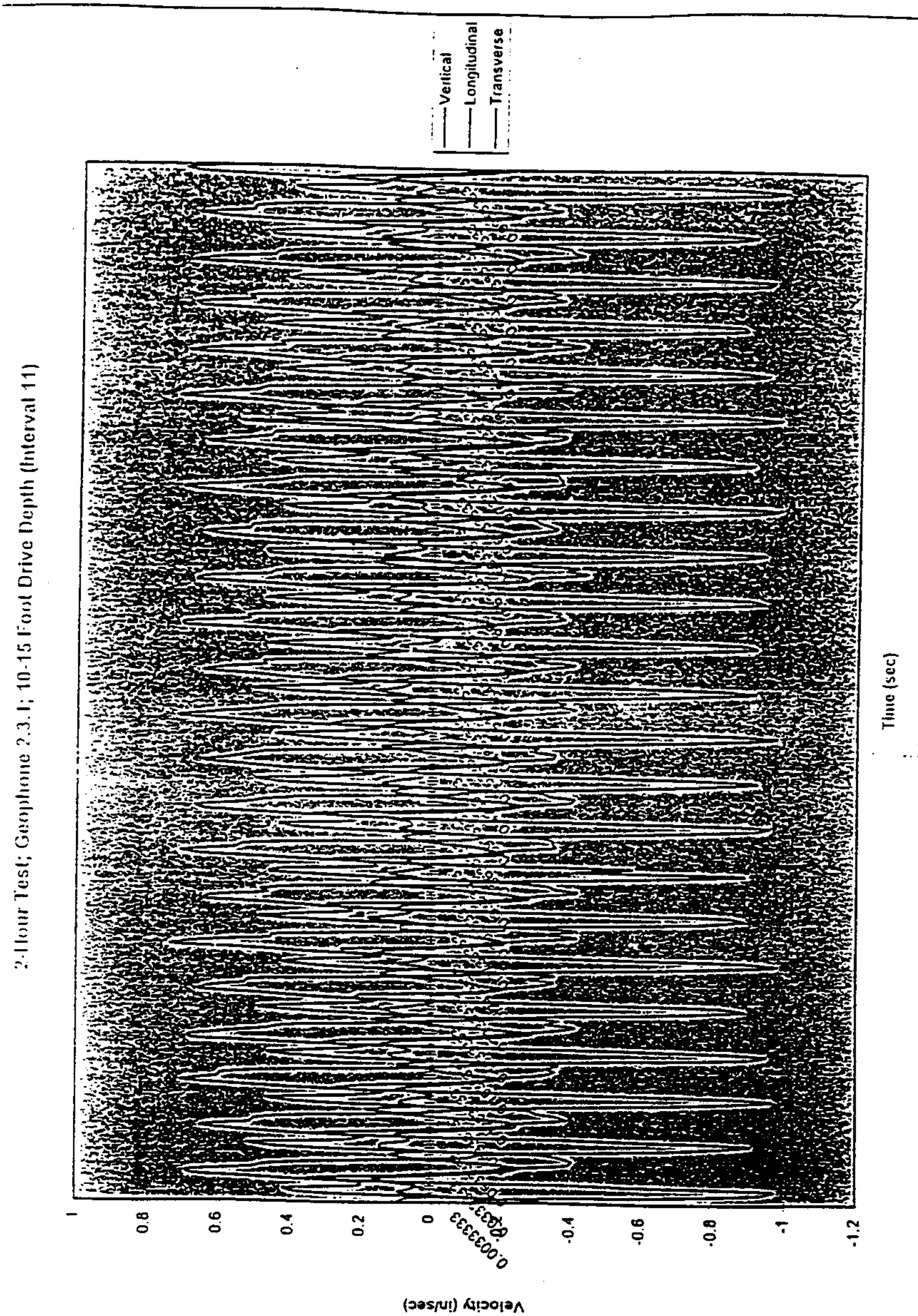


2-Hour Test; Geophone 2.3.1; 0-5 Foot Drive Depth (Interval 9)

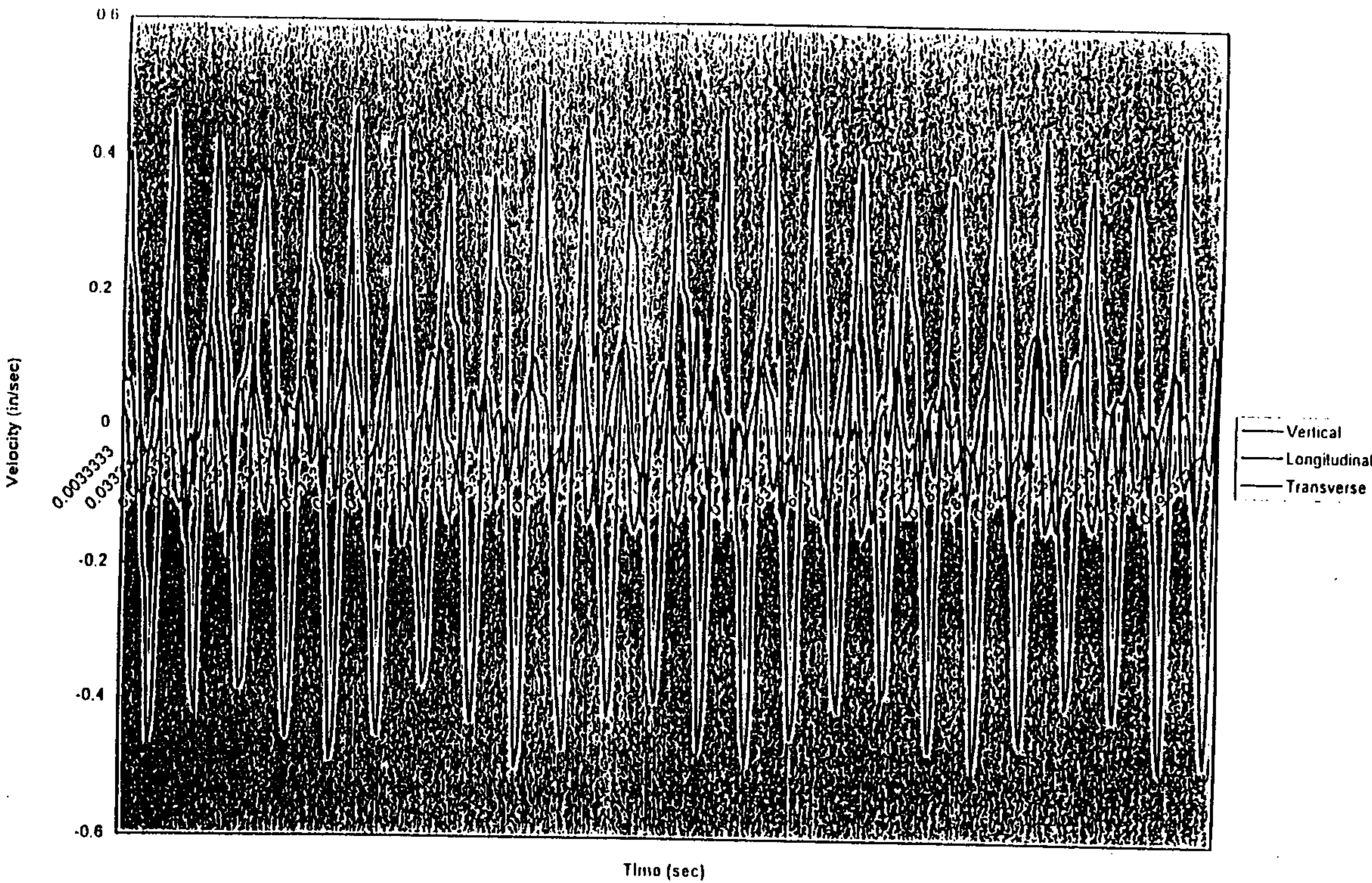


2-Hour Test; Geophone 2.3.1; 5-10 Foot Drive Depth (Interval 9)

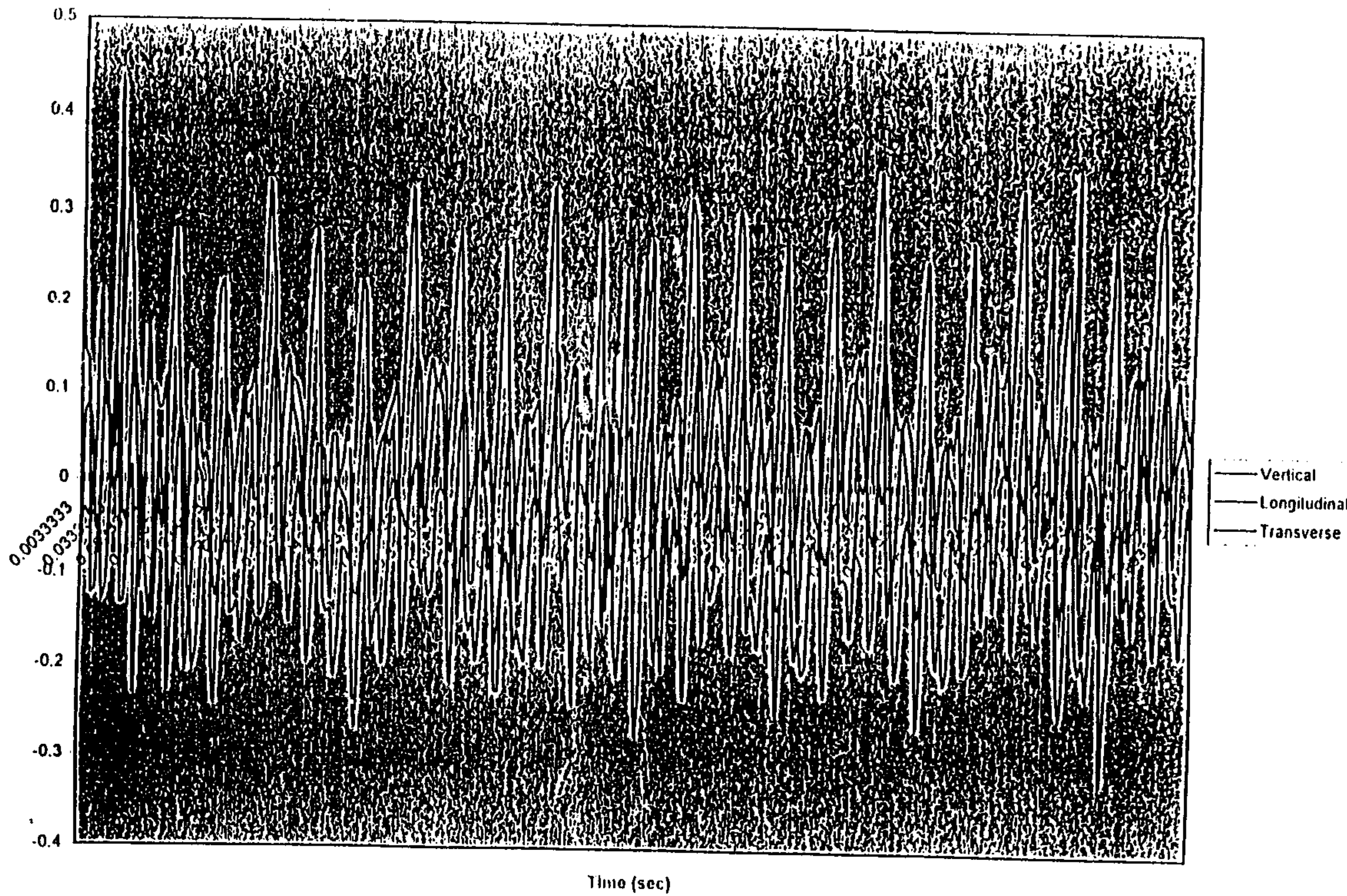



24 Hour Test; Geophone 2.3.1; 10-15 Foot Drive Depth (Interval 11)
Vertical
Longitudinal
Transverse
Time (sec)
Velocity (in/sec)
1
0.8
0.6
0.4
0.2
0
-0.0033333
-0.4
-0.6
-0.8
-1
-1.2

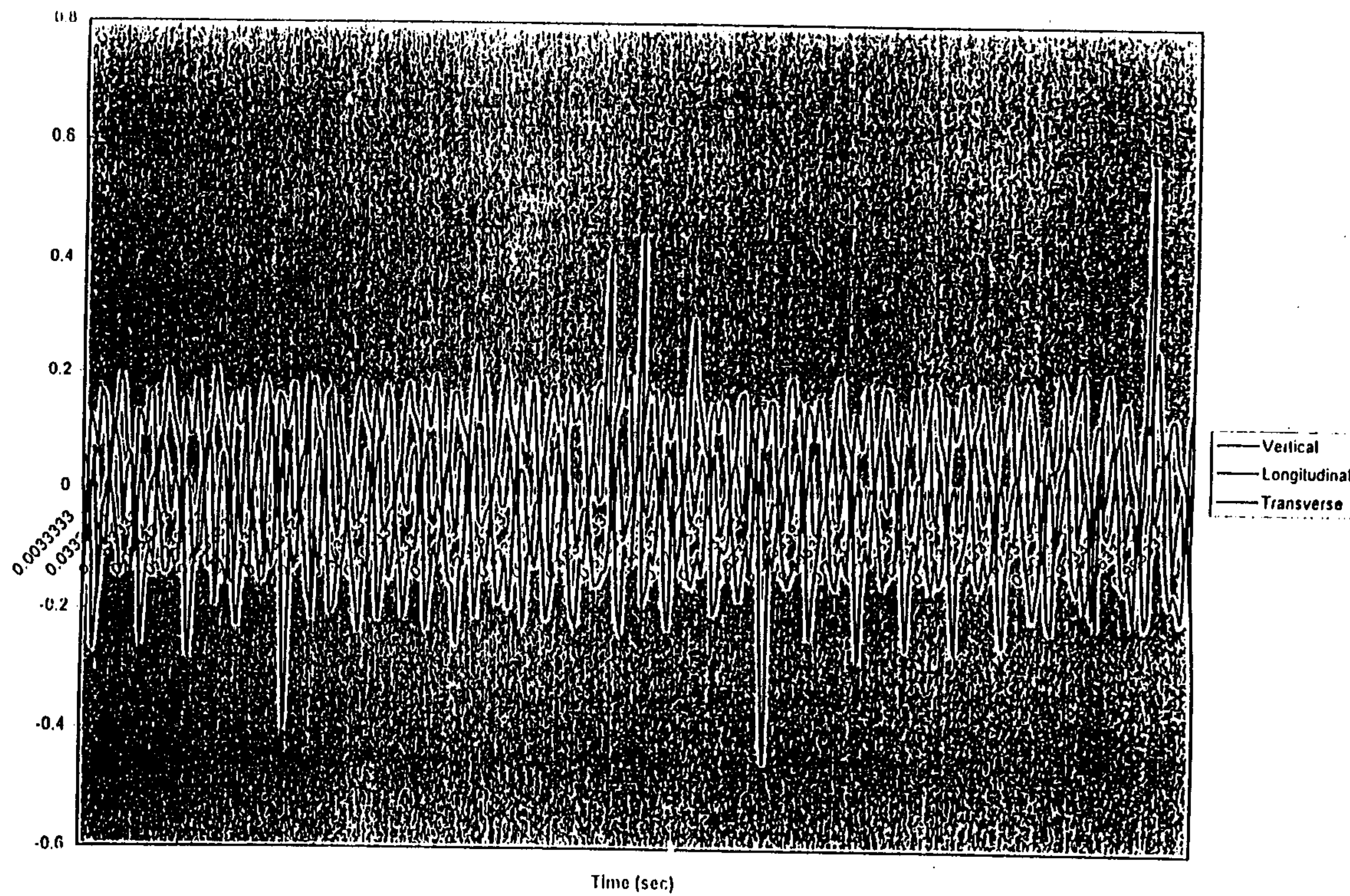
2-Hour Test; Geophone 2.3.1; Shaft Pullout (Interval 7)



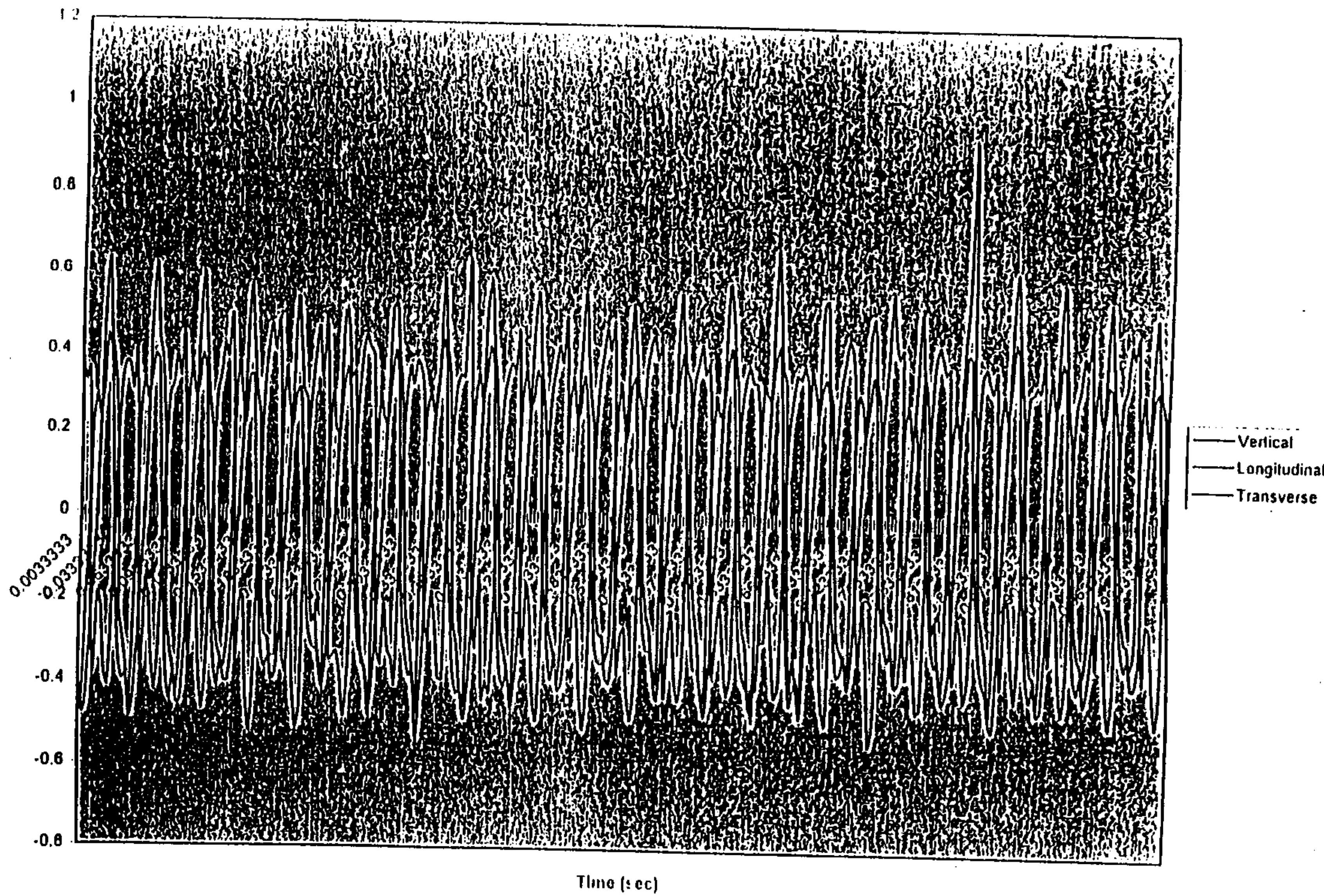
2-Hour Test; Geophone 2.3.2; 0-5 Foot Drive Depth (Interval 9)



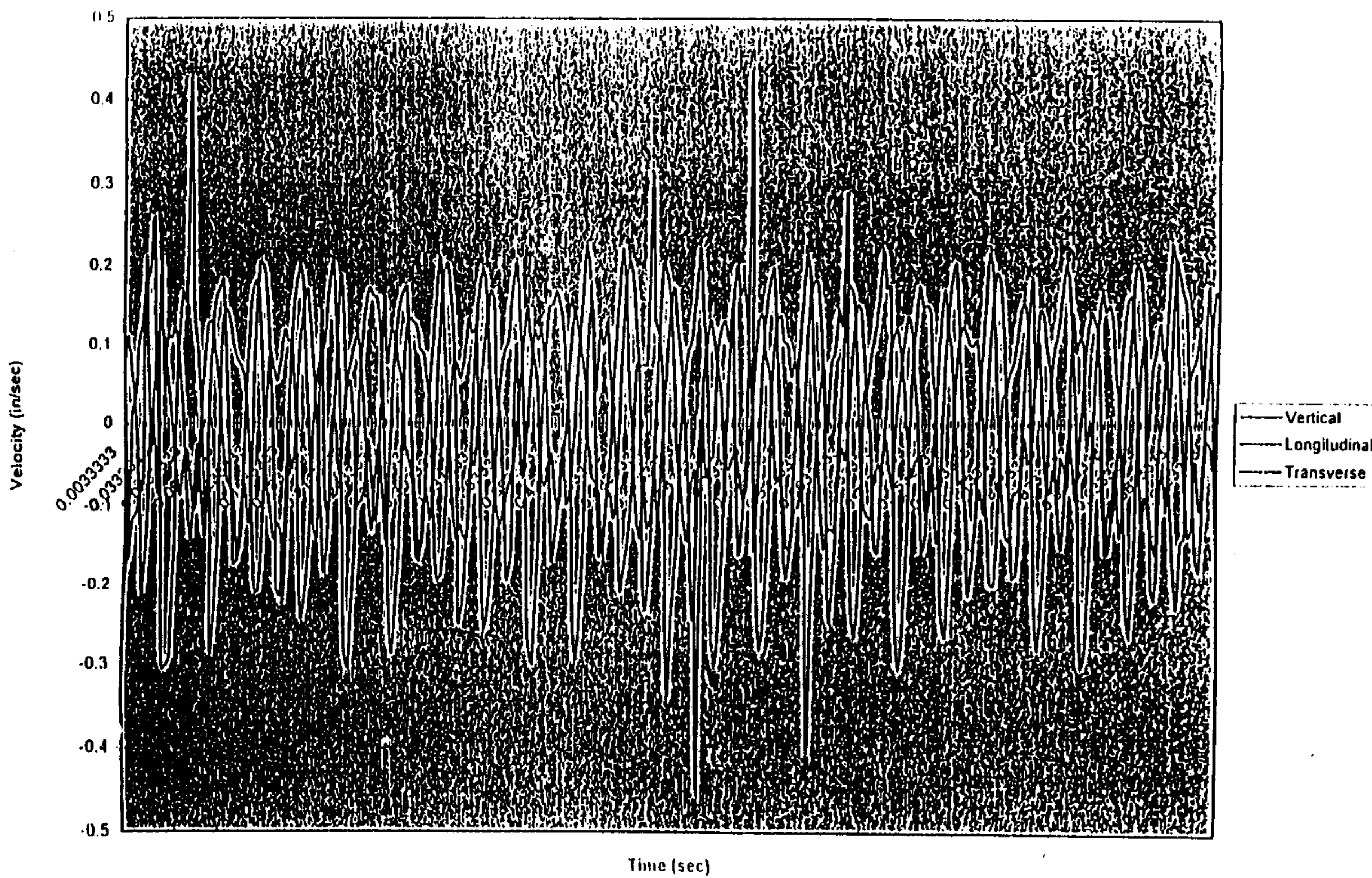
Hour Test; Geophone 2.3.2; 5-10 Foot Drive Depth (Interval 9)

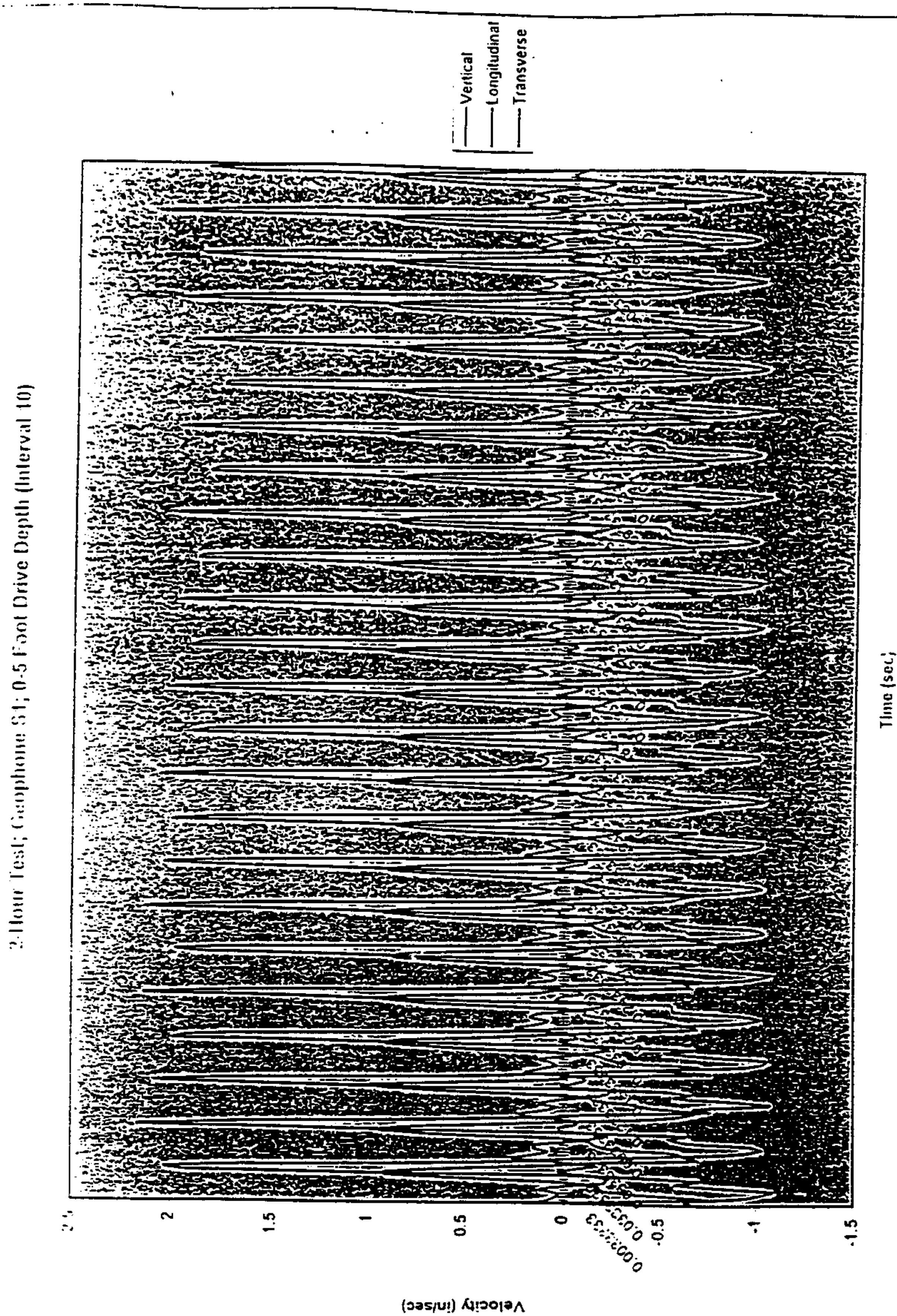


2-Hour Test; Geophone 2.3.2; 10-15 Foot Drive Depth (Interval 10)

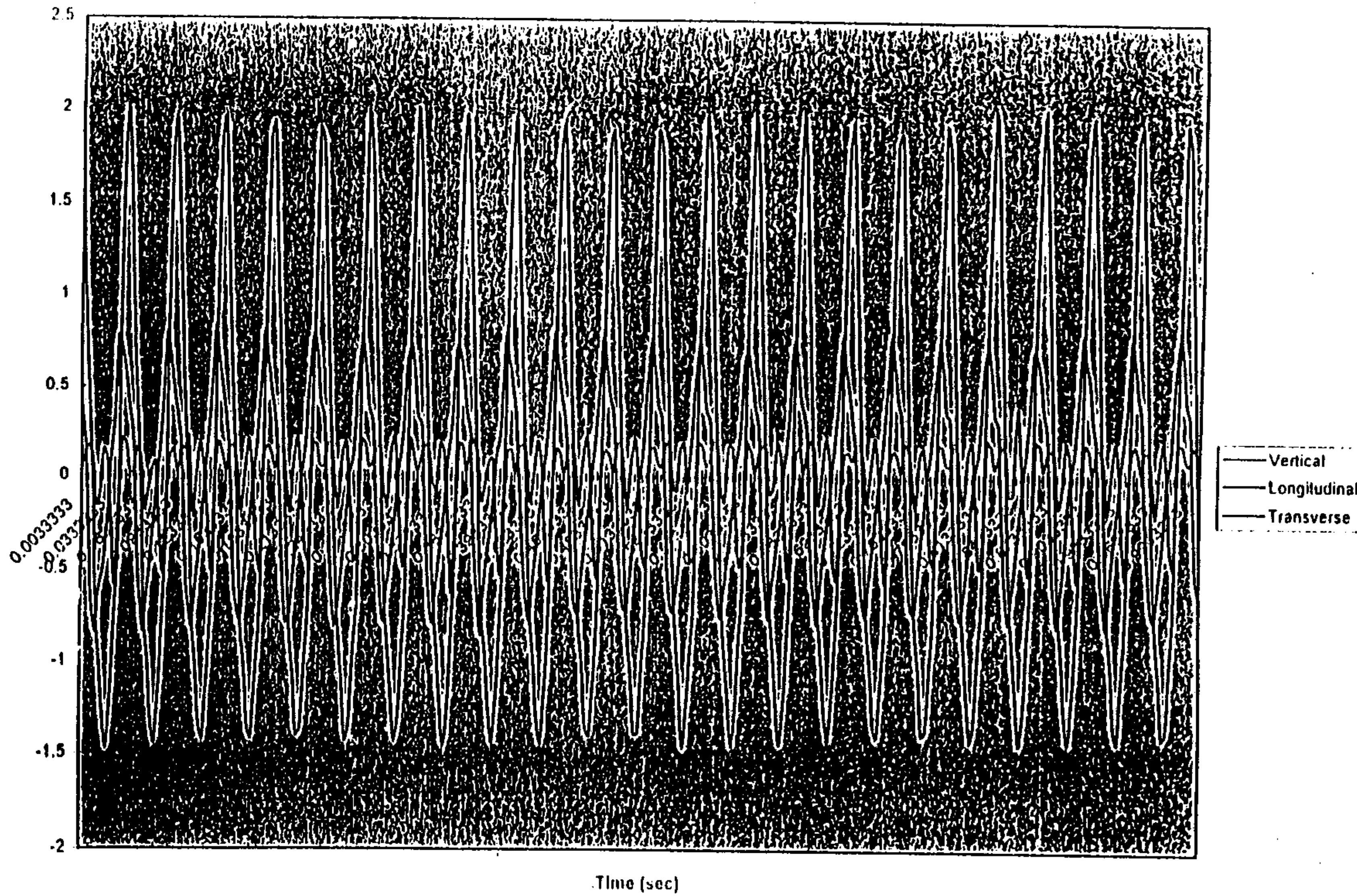


2-Hour Test; Geophone 2.3.2; Shaft Pullout (Interval 7)

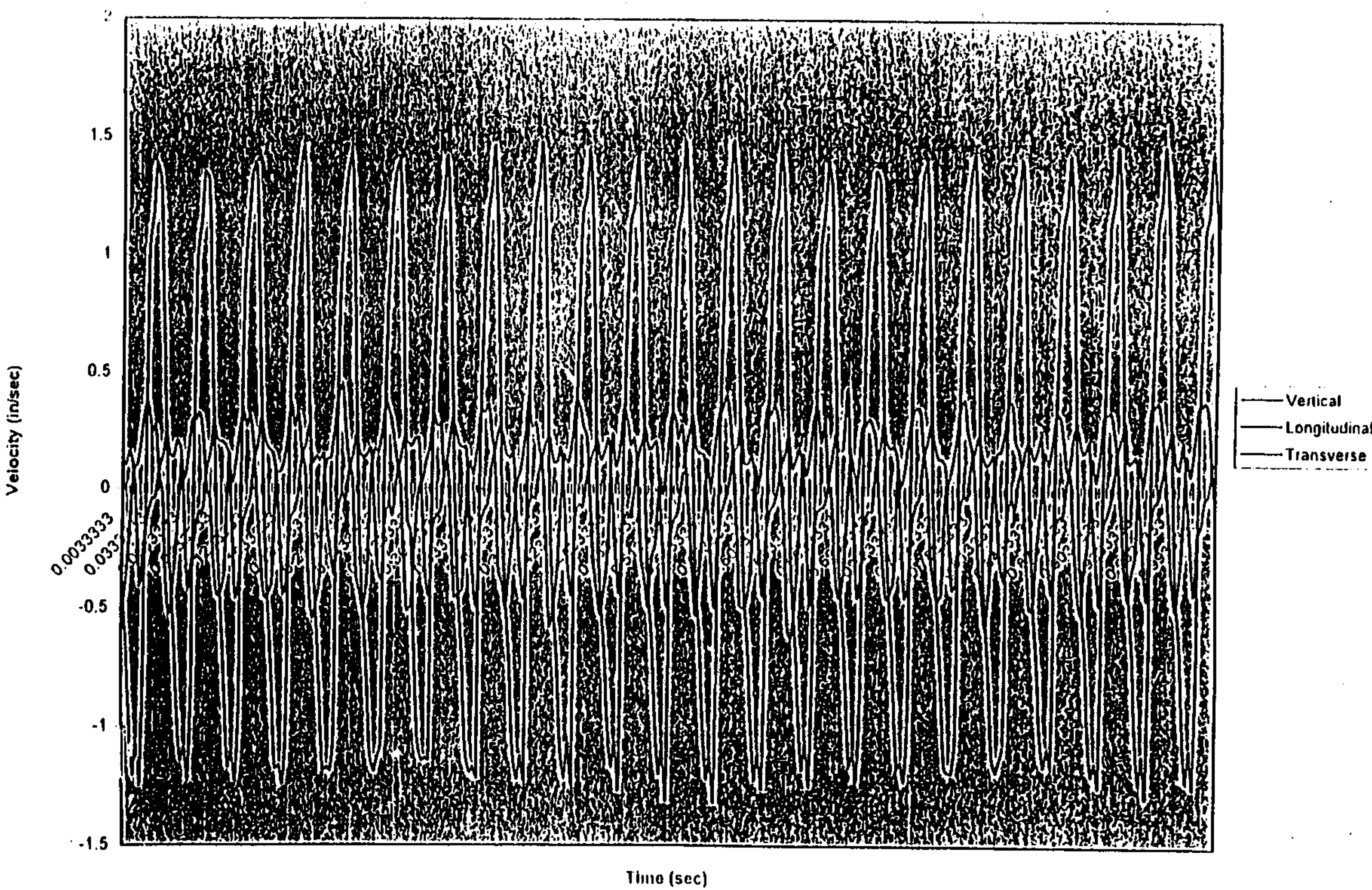



2 Hour Test; Geophone S1; 0-5 Foot Drive Depth (Interval 10)
Vertical
Longitudinal
Transverse
Velocity (in/sec)
Time (sec)
2
1.5
1
0.5
0
-0.5
-1
-1.5

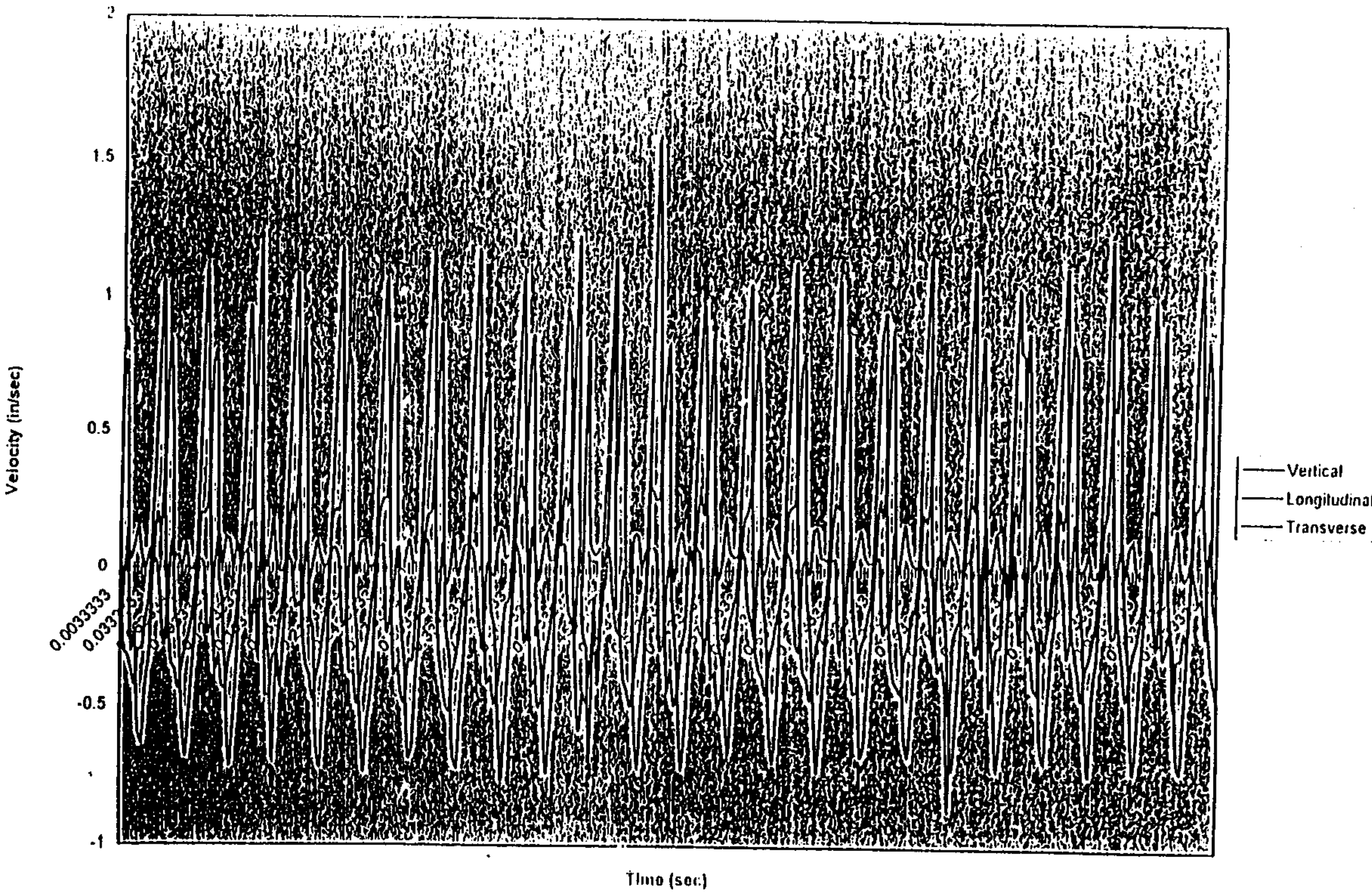
2-Hour Test; Geophone S1; 5-10 Foot Drive Depth (Interval 9)



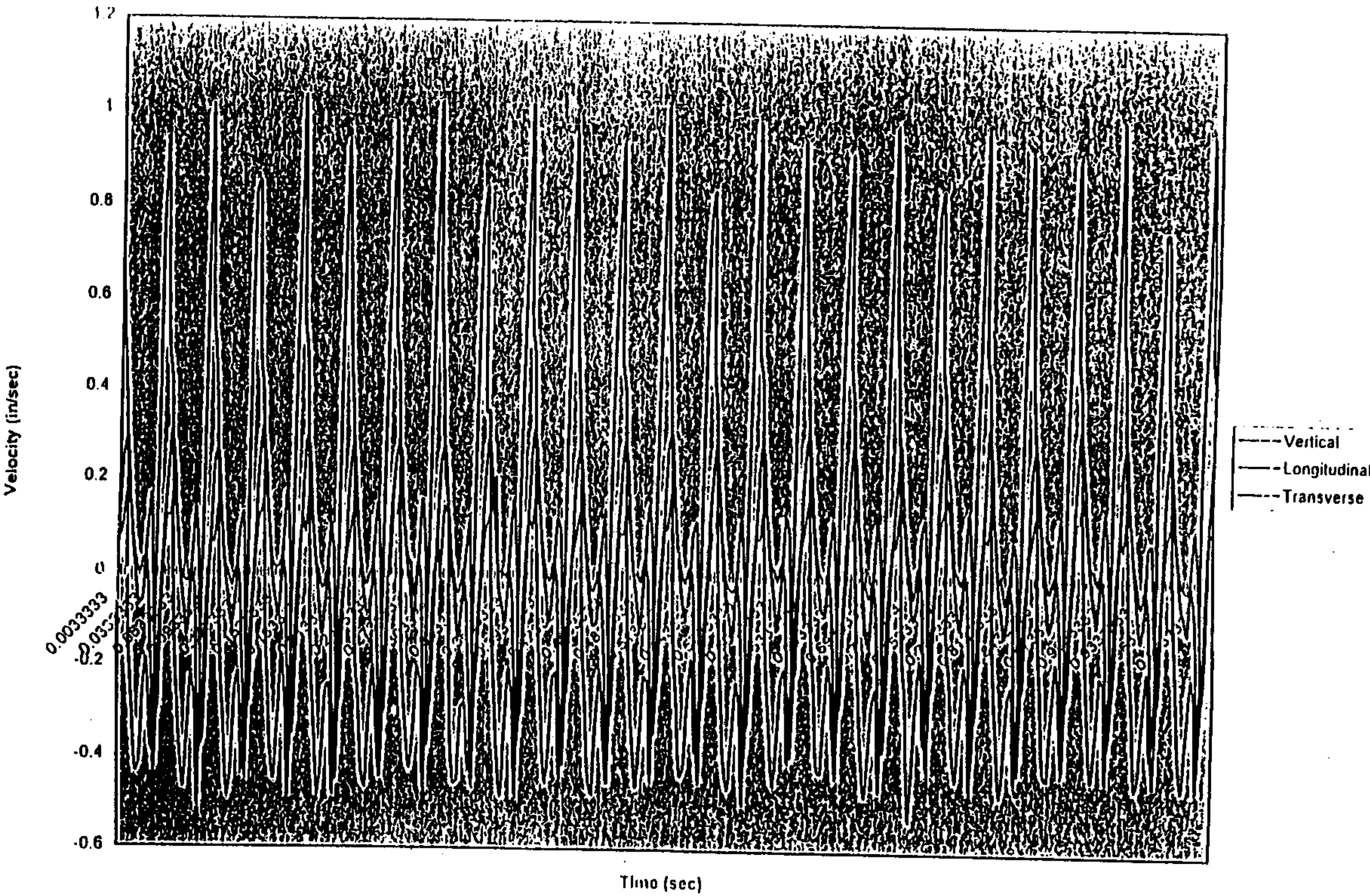
2-Hour Test; Geophone S1; 10-15 Foot Drive Depth (Interval 10)



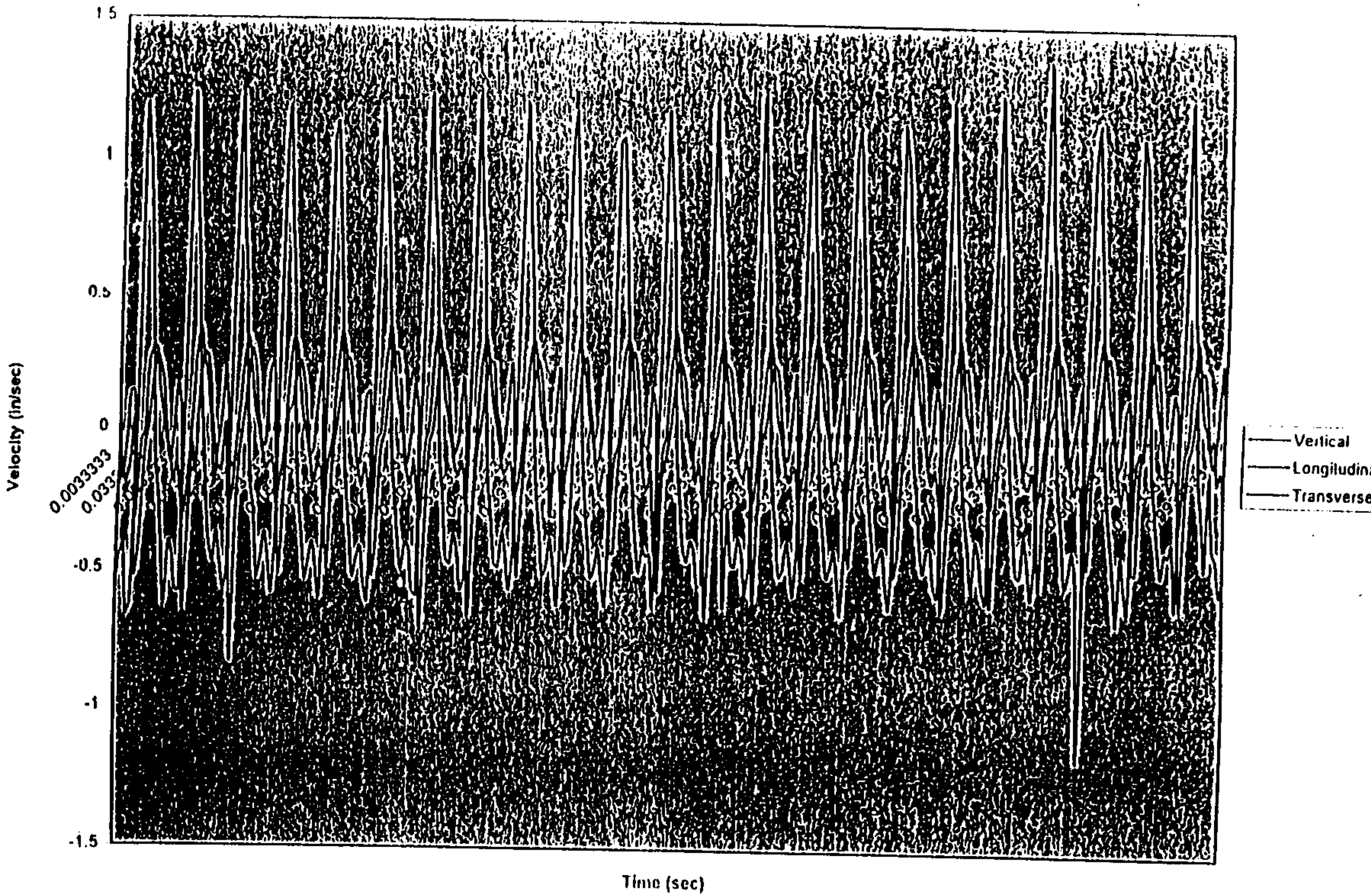
2-Hour Test; Geophone S4; Shaft Pullout (Interval 10)



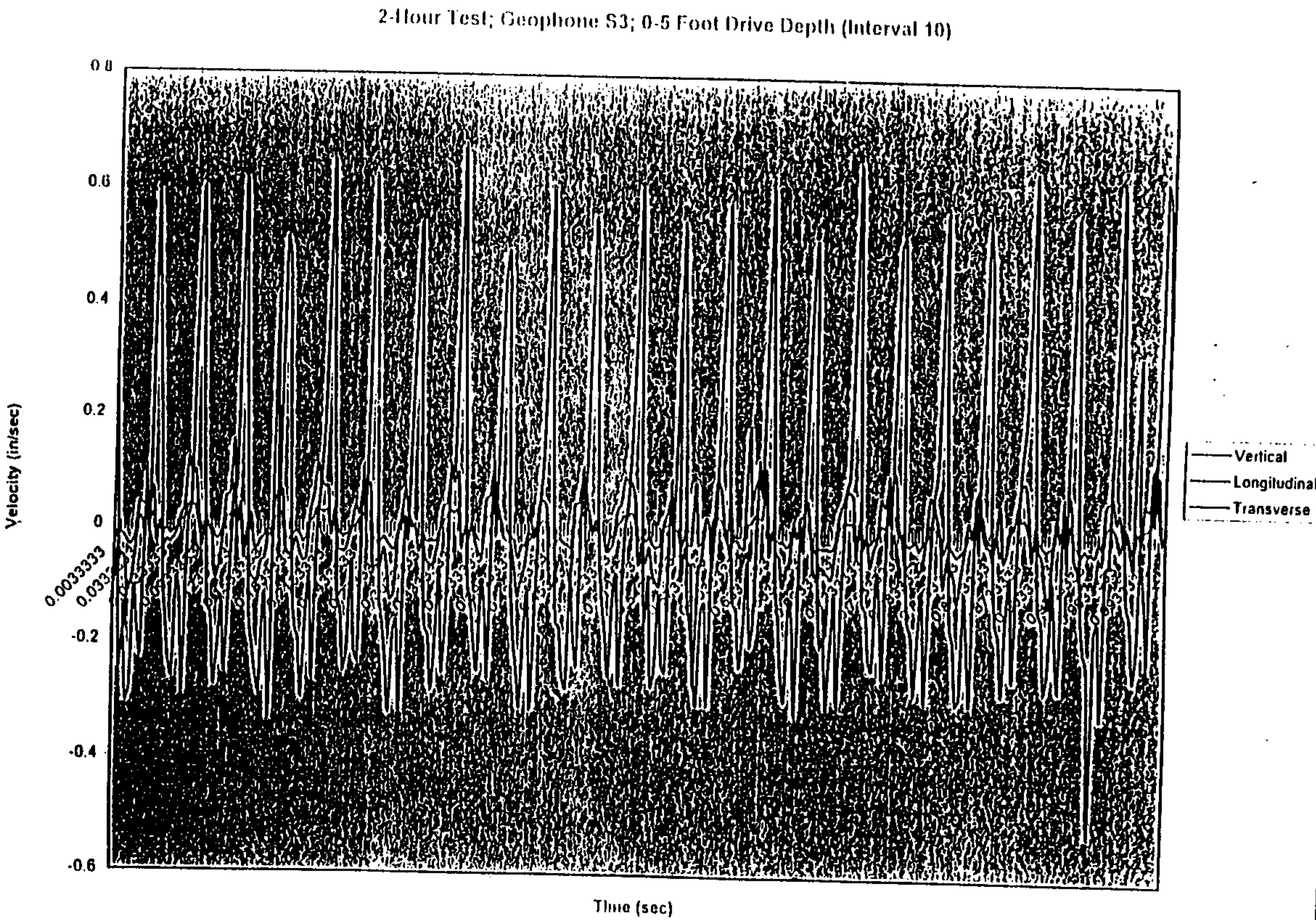
2-Hour Test; Geophone 32; 0-5 Foot Drive Depth (Interval 10)



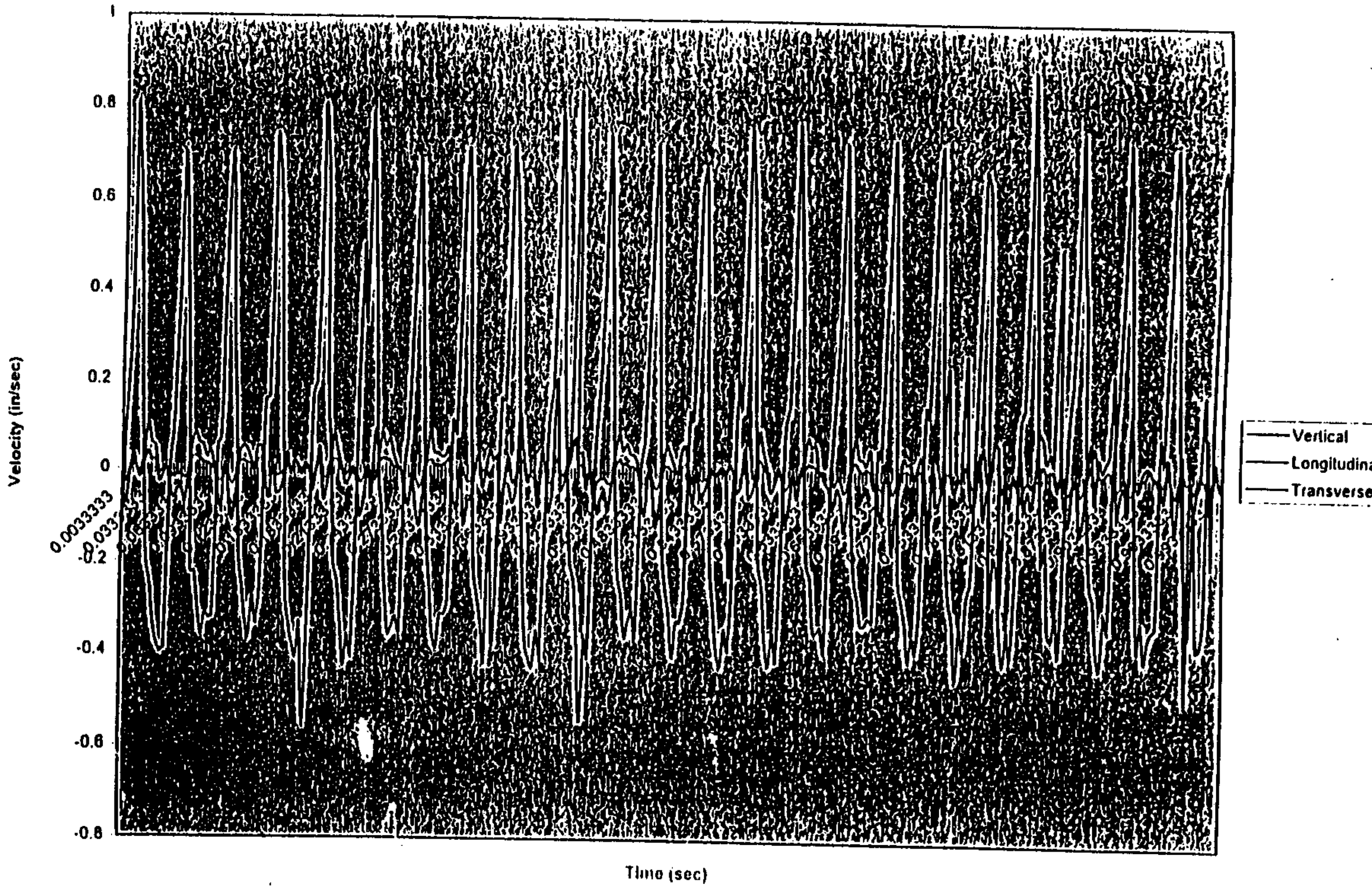
2-Hour Test; Geophone S2; 5-10 Foot Drive Depth (Interval 8)



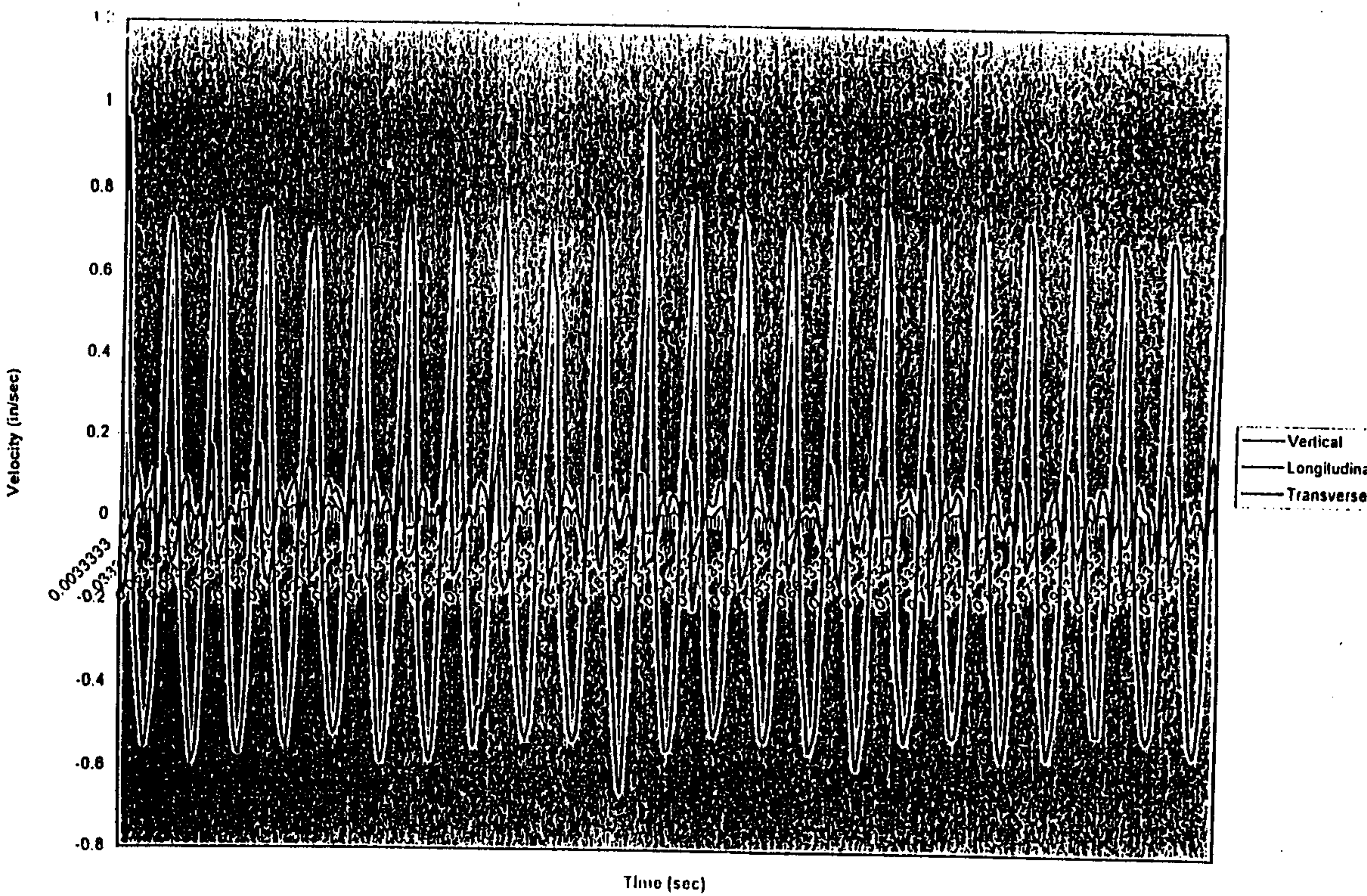
2-Hour Test; Geophone S2; Shaft Pullout (Interval 8)


2-Hour Test; Geophone S3; 0-5 Foot Drive Depth (Interval 10)
0.8
0.6
0.4
0.2
0
0.0033333
0.0333
-0.2
-0.4
-0.6
Velocity (in/sec)
Time (sec)
Vertical
Longitudinal
Transverse

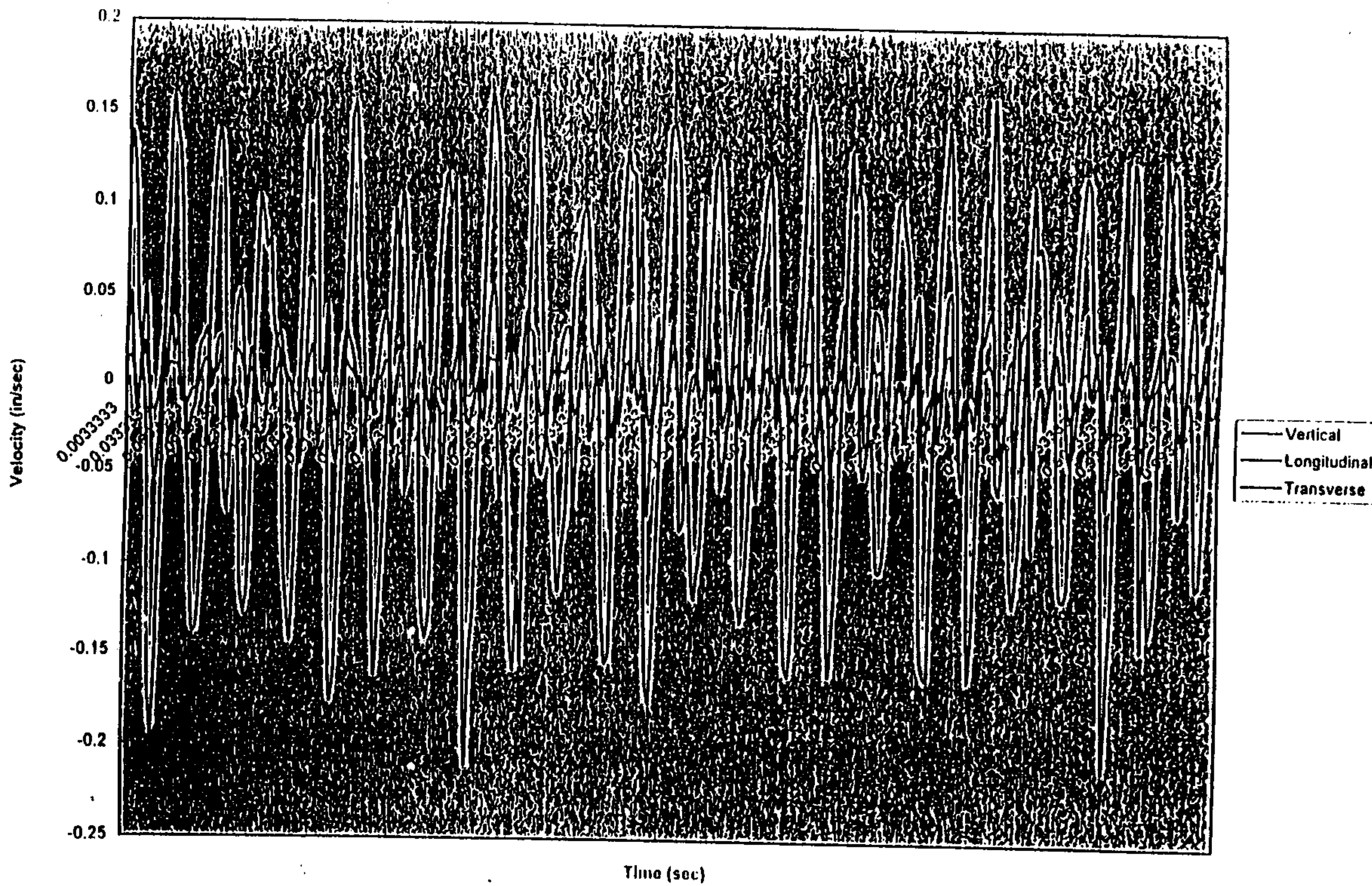
2-Hour Test; Geophone S3; 5-10 Foot Drive Depth (Interval 8)



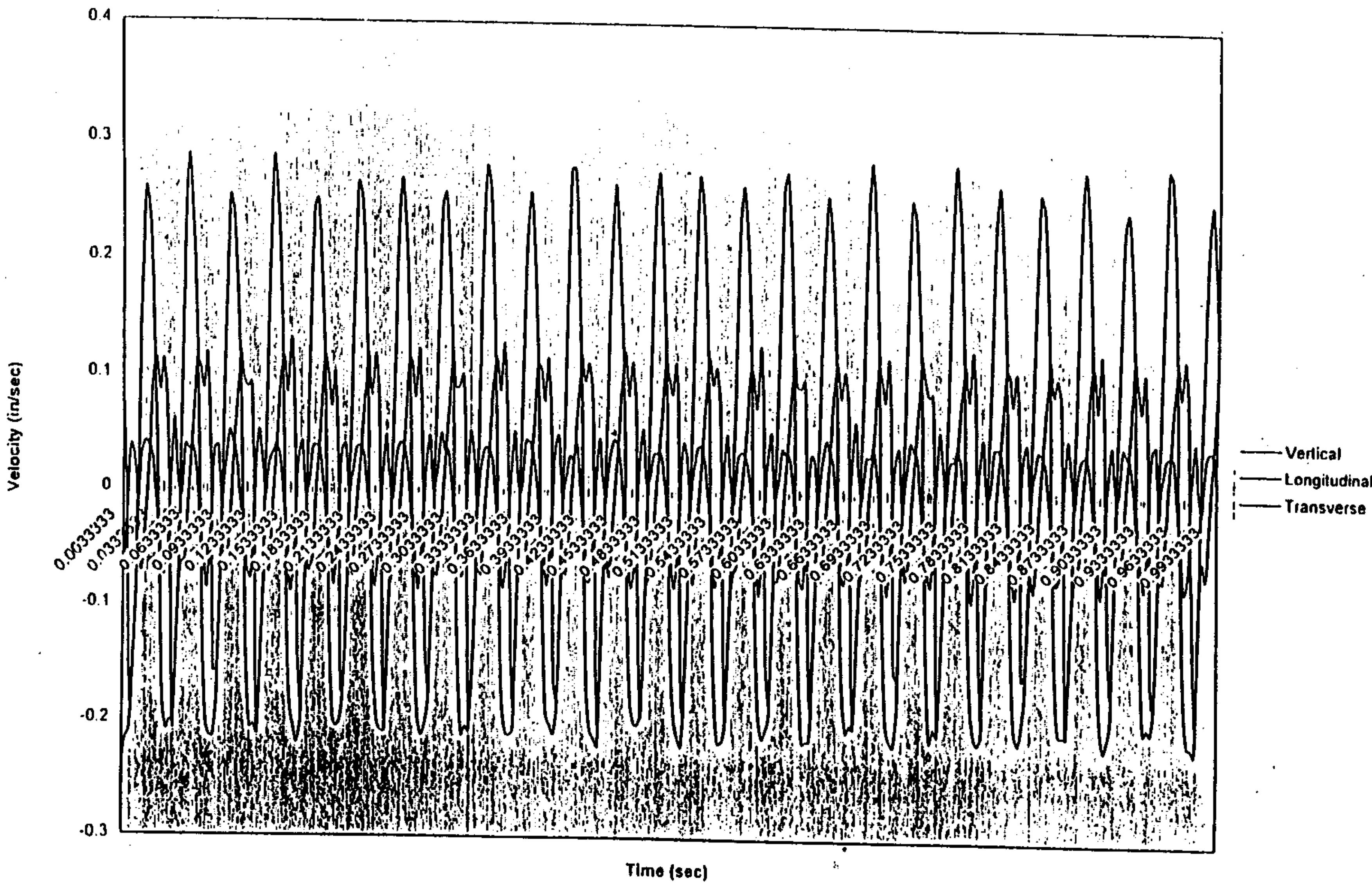
2-Hour Test; Geophone S3; 10-15 Foot Drive Depth (Interval 10)



2-Hour Test; Geophone S3; Shaft Pullout (Interval 7)



4-Hour Test; Geophone 3.3.2; 5-10 Foot Drive Depth (Interval 7)



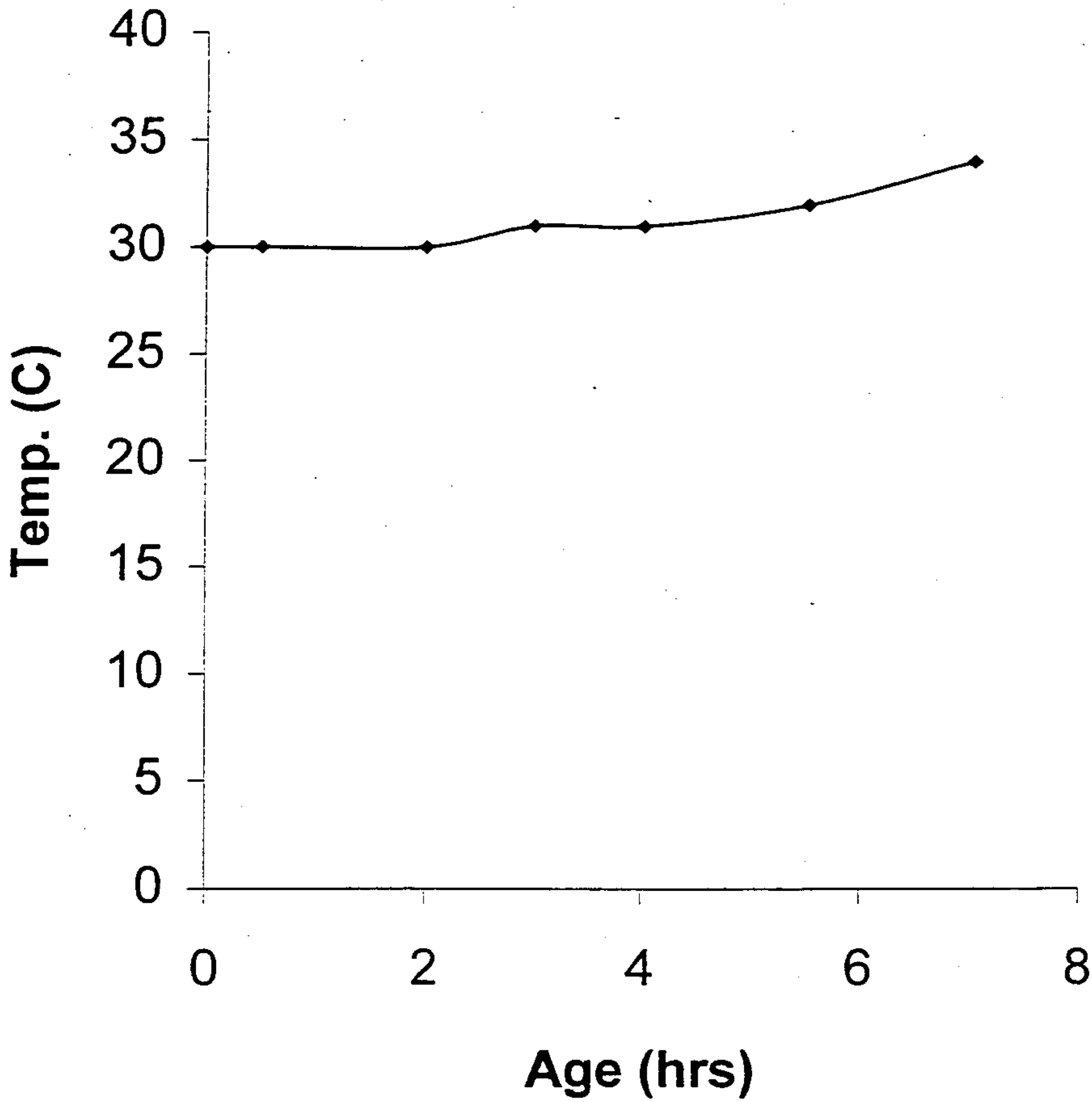
Appendix D

Concrete Test Results – Control Samples

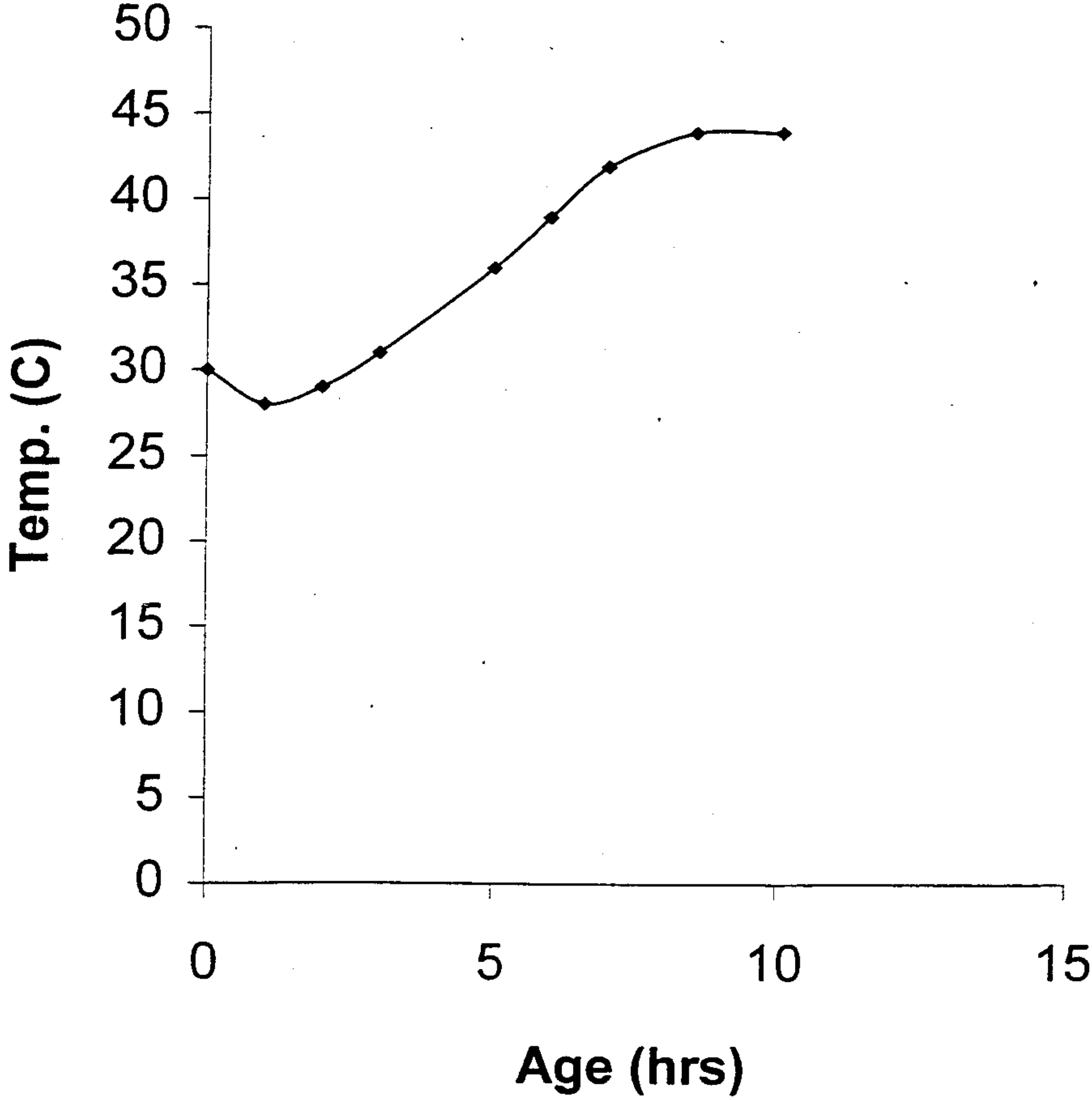
Law Engineering and Environmental Services, Inc.

April 1998.

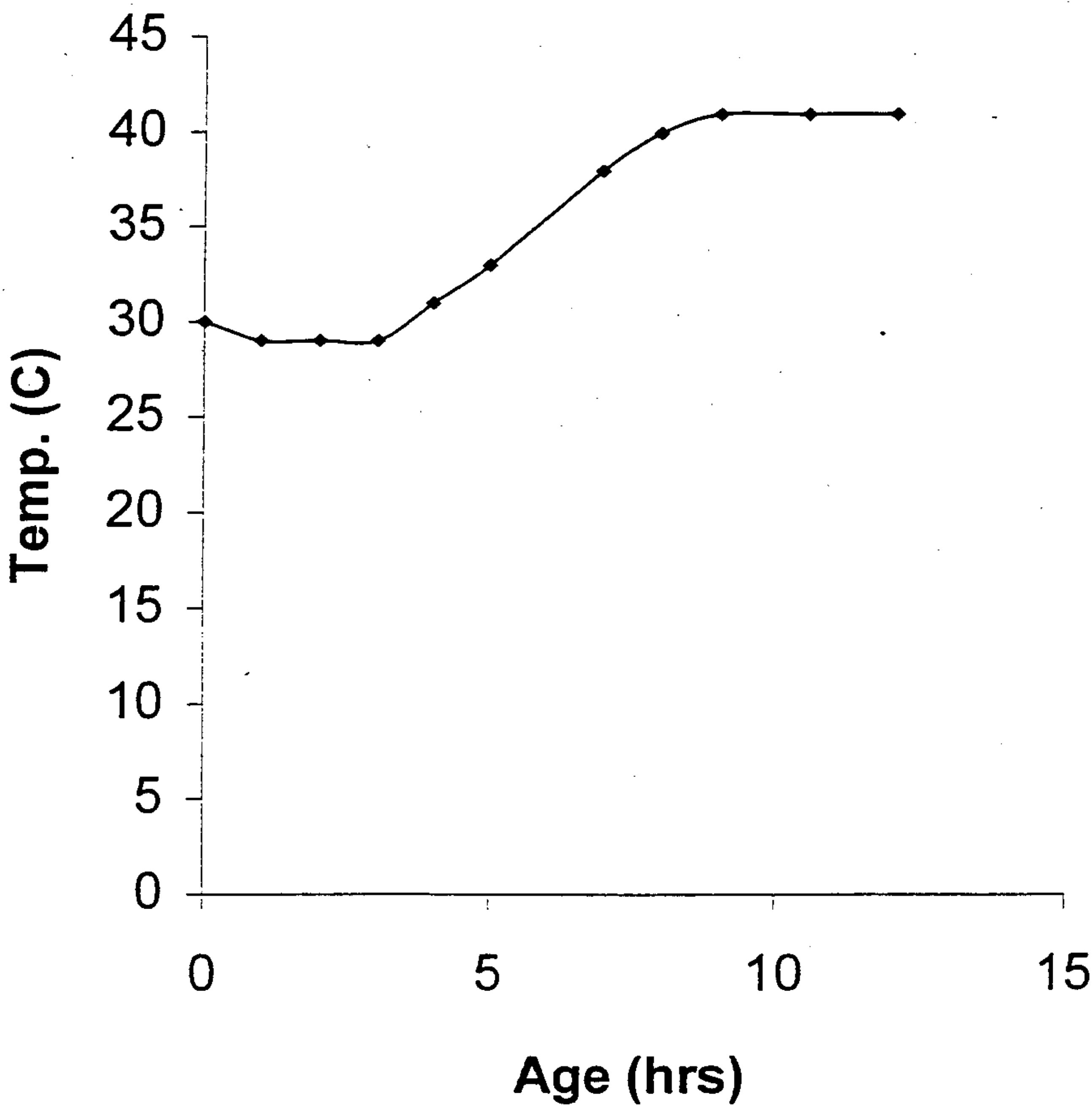
36-Inch Shaft Concrete Temp. vs. Age (Shaft Group 1)



36-Inch Shaft Concrete Temp. vs. Age (Shaft Group 3)



36-Inch Shaft Concrete Temp. vs. Age (Shaft Group 4)



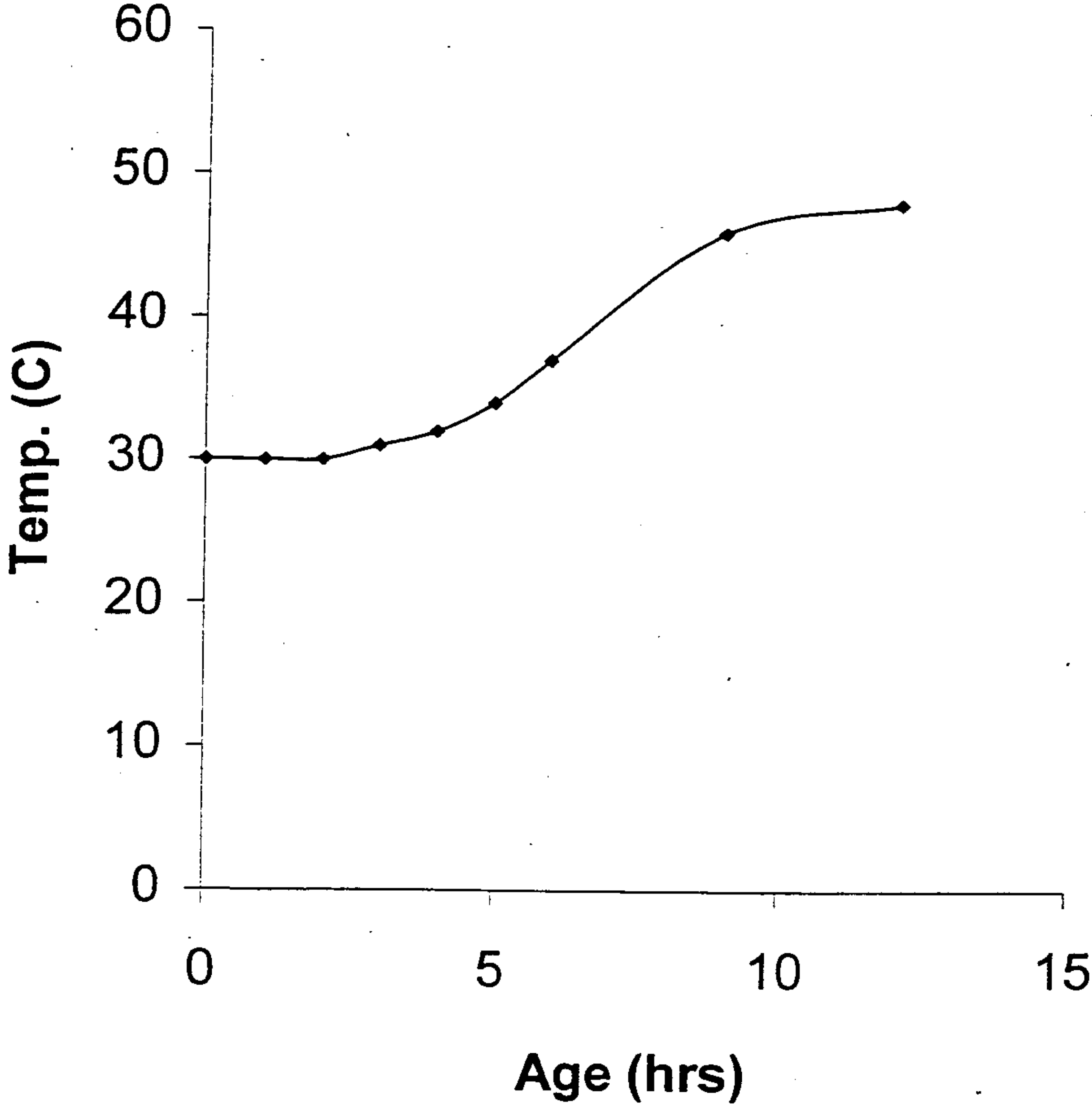
Appendix E

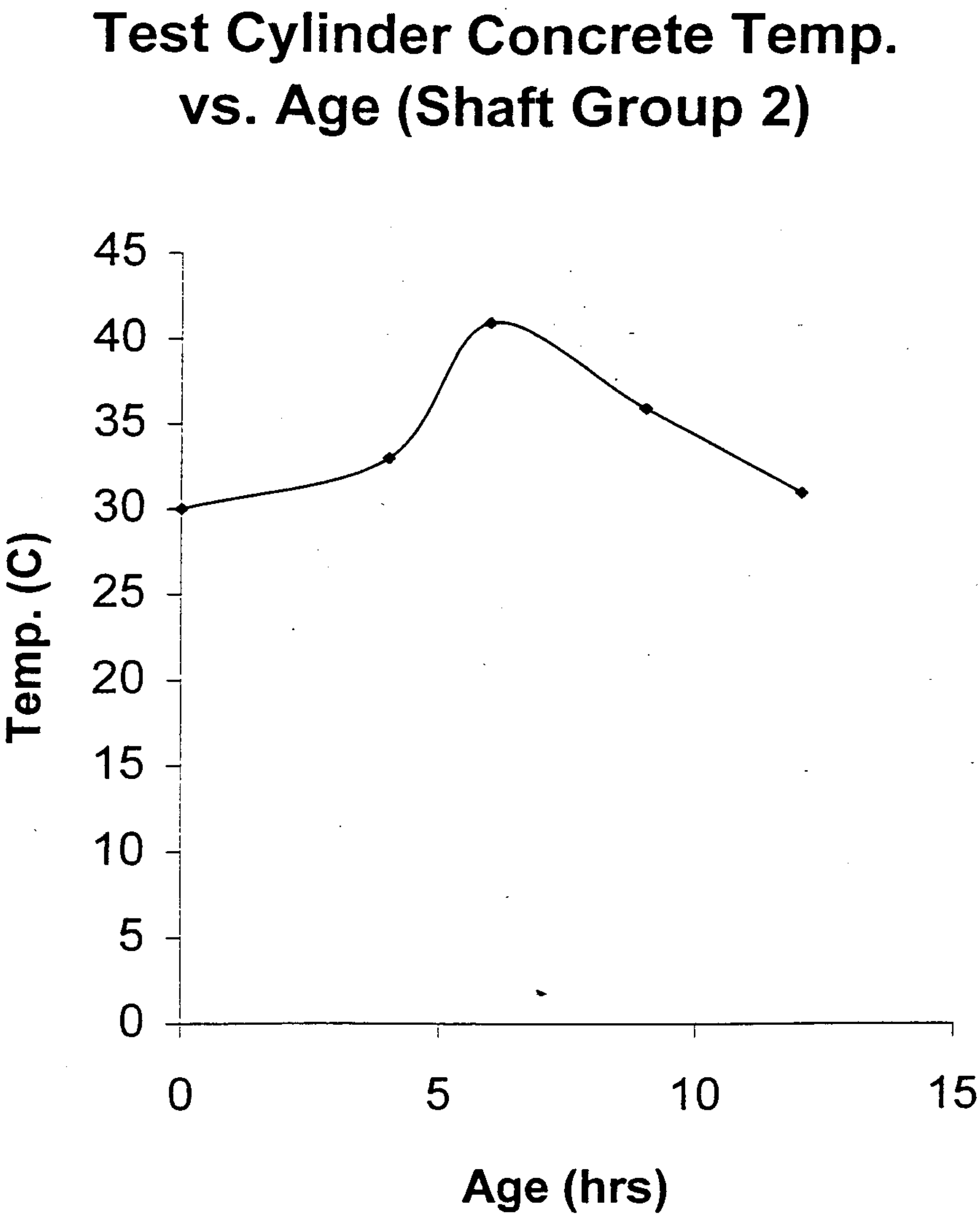
Concrete Test Results – Control Samples

Law Engineering and Environmental
Services, Inc.

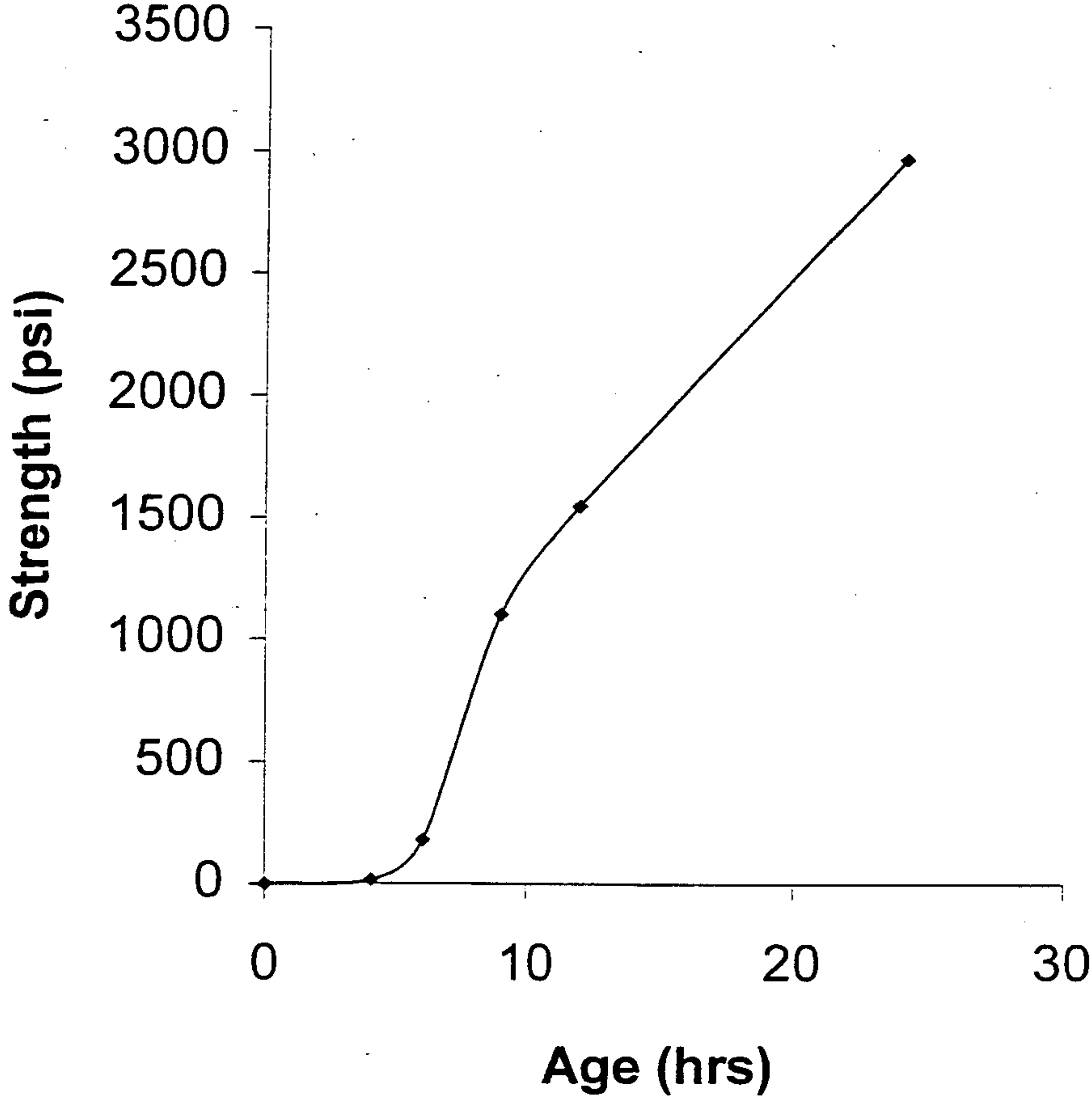
September 1998.

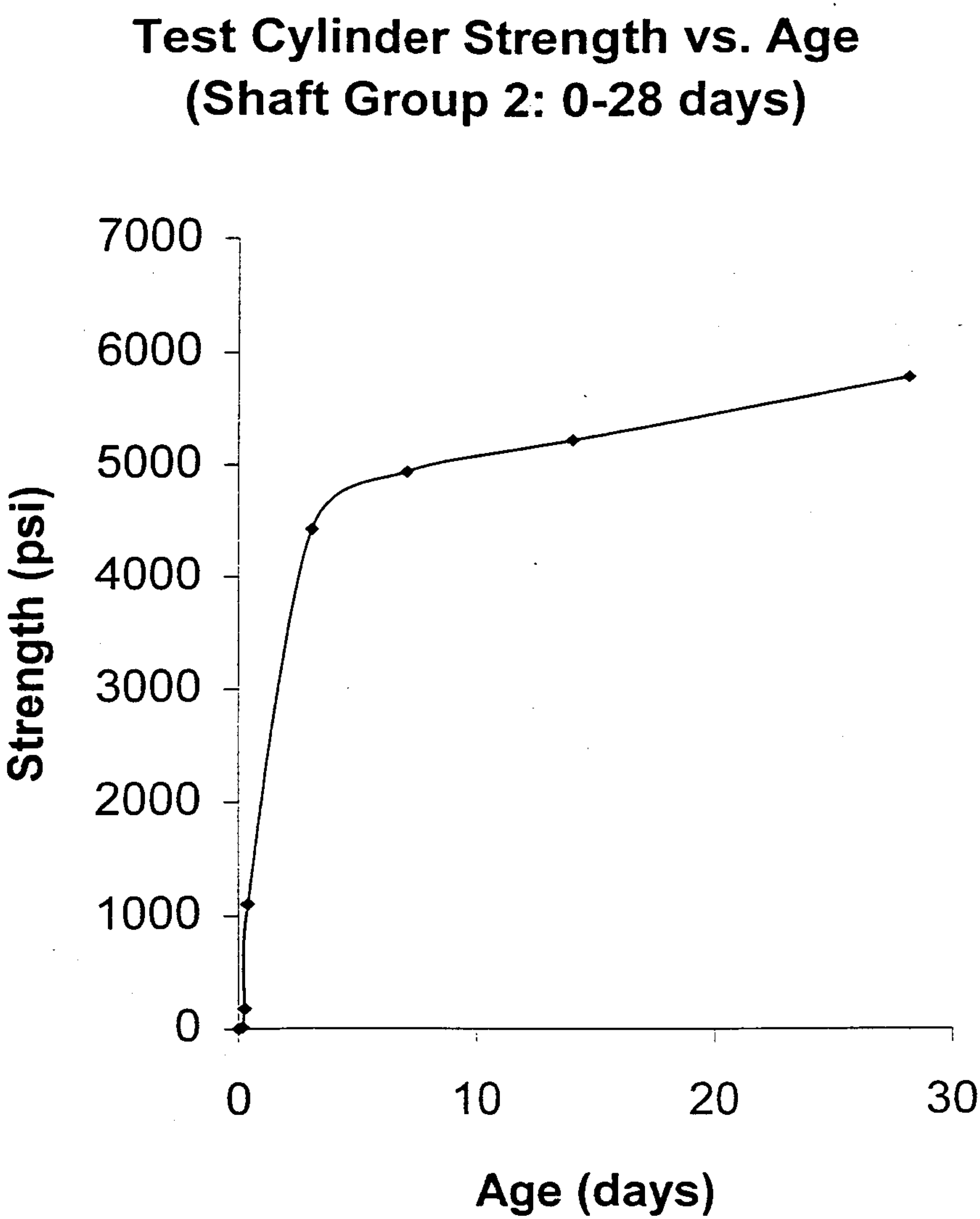
36-Inch Shaft Concrete Temp. vs. Age (Shaft Group 2)




Test Cylinder Concrete Temp.
vs. Age (Shaft Group 2)
45
40
35
30
25
20
15
10
5
0
Temp. (C)
0
5
10
15
Age (hrs)

Test Cylinder Strength vs. Age (Shaft Group 2: 0-24 hrs)




Test Cylinder Strength vs. Age
(Shaft Group 2: 0-28 days)
7000
6000
5000
4000
3000
2000
1000
0
Strength (psi)
0
10
20
30
Age (days)

LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT: FAU / FDOT

JOB NO: 40522-7-7891

PROJECT: FAU Vibration Monitoring

LAB NO:

MIX ID: 51-4709

SPECIFIED STRENGTH: 4,000

MIX DESC: Drilled Shaft

FIELD INFORMATION

DATE SAMPLED: 9/10/98 BY: LAW JB

TIME BATCHED: 10:25 a.m. SAMPLED: 11:15 a.m.

BATCH PLANT: Florida Rock

TRUCK/TICKET: 708/82 DATE RECEIVED: 9/10/98

FIELD TESTS
(SPECIFIED RANGE)

SLUMP: 8"

PERCENT AIR: N.I.

UNIT WEIGHT: N.I.

MIX/AIR TEMP: 30°/28°C

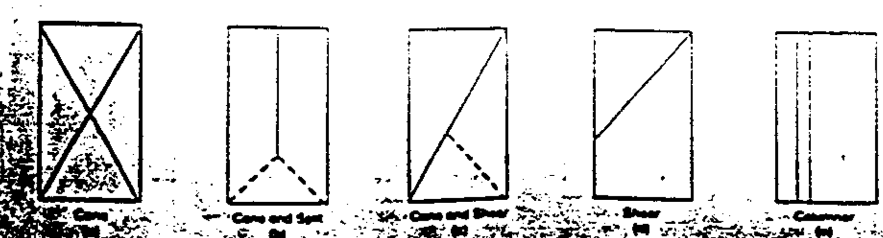
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
1A	6.00	28.27	9/10/98	4 hours	400	14	
1B	6.00	28.27	9/10/98	4 hours	350	12	
1C	6.00	28.27	9/10/98	4 hours	400	14	
2A	6.00	28.27	9/10/98	6 hours	5500	194	
2B	6.00	28.27	9/10/98	6 hours	4400	155	
2C	6.00	28.27	9/10/98	6 hours	5300	187	
3A	6.00	28.27	9/10/98	9 hours	30000	1061	
3B	6.00	28.27	9/10/98	9 hours	32500	1149	
3C	6.00	28.27	9/10/98	9 hours	31000	1096	
4A	6.00	28.27	9/10/98	12 hours	44000	1556	
4B	6.00	28.27	9/10/98	12 hours	42500	1503	
4C	6.00	28.27	9/10/98	12 hours	45000	1591	

UNLESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
C DENOTES CURED IN FIELD <<< DENOTES LOW COMPRESSIVE STRENGTH
FRACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
FRACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION: 24-inch and 36-inch diameter shafts

REMARKS: 10 gallons water added to 9 c.y.



RESPECTFULLY SUBMITTED

LAW

ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT: JOB NO:

PROJECT: LAB NO:

MIX ID: SPECIFIED STRENGTH:

MIX DESC:

FIELD INFORMATION — FIELD TESTS (SPECIFIED RANGE)

DATE SAMPLED: BY: SLUMP:

TIME BATCHED: SAMPLED: PERCENT AIR:

BATCH PLANT: UNIT WEIGHT:

TRUCK/TICKET: DATE RECEIVED: MIX/AIR TEMP:

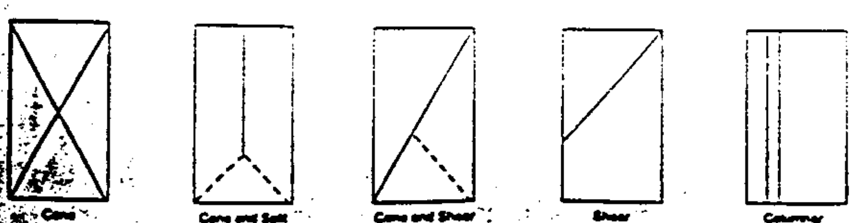
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED 98	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
5A	6.00	28.27	9/11/9[illegible]	1 day	81,000	2865	
5B	6.00	28.27	9/11/99	1 day	87,000	3077	
6A	6.00	28.27	9/13/99	3 days	123,000	4350	
6B	6.00	28.27	9/13/99	3 days	127,000	4492	
7A	6.00	28.27	9/17/99	7 days	139,000	4916	
7B	6.00	28.27	9/17/99	7 days	140,000	4952	
8A	6.00	28.27	9/24/99	14 days	147,500	5217	
8B	6.00	28.27	9/24/99	14 days	148,000	5235	
9A	6.00	28.27	10/08/99	28 days	161,000	5695	
9B	6.00	28.27	10/08/99	28 days	166,000	5871	

UNLESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
* DENOTES CURED IN FIELD <<< DENOTES LOW COMPRESSIVE STRENGTH
FRACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
FRACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION:

REMARKS:



RESPECTFULLY SUBMITTED

LAW

ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT: FAU / FDOT

JOB NO: 40522-7-7891

PROJECT: FAU Vibration Monitoring

LAB NO:

MIX ID: 51-4709

SPECIFIED STRENGTH: 4,000

MIX DESC: Drilled Shaft

FIELD INFORMATION

DATE SAMPLED: 9/10/98 BY: LAW JB

TIME BATCHED: 10:25 a.m. SAMPLED: 11:15 a.m.

BATCH PLANT:

TRUCK/TICKET: 708/82 DATE RECEIVED: 9/10/98

FIELD TESTS (SPECIFIED RANGE)

SLUMP: 8"

PERCENT AIR:

UNIT WEIGHT:

MIX/AIR TEMP: 30°/28°C

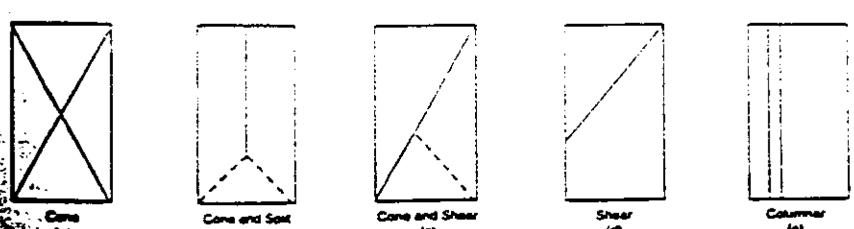
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
S1.1	6.00	28.27	9/24/99	14	160,000	5659	
S2.1	6.00	28.27	9/24/99	14	162,000	5730	
S3.1	6.00	28.27	9/24/99	14	154,000	5447	
S1.2	6.00	28.27	10/08/99	28	169,000	5978	
S2.2	6.00	28.27	10/08/99	28	172,000	6084	
S3.2	6.00	28.27	10/08/99	28	174,000	6155	

...LESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
...ENOTES CURED IN FIELD < < < DENOTES LOW COMPRESSIVE STRENGTH
...ACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
...ACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION: Surface cylinders

REMARKS: 10 gallons water added to 9 c.y.



RESPECTFULLY SUBMITTED

LAW
ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT:

JOB NO:

PROJECT:

LAB NO:

MIX ID:

SPECIFIED STRENGTH:

MIX DESC:

FIELD INFORMATION

DATE SAMPLED: BY:

TIME BATCHED: SAMPLED:

BATCH PLANT:

TRUCK/TICKET: DATE RECEIVED:

FIELD TESTS (SPECIFIED RANGE)

SLUMP:

PERCENT AIR:

UNIT WEIGHT:

MIX/AIR TEMP:

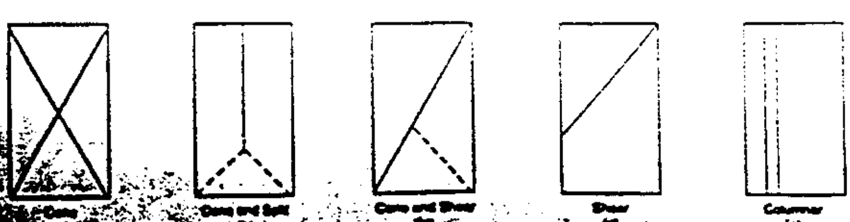
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
5A	6.00	28.27	9/11/99	1 day	81,000	2865	
5B	6.00	28.27	9/11/99	1 day	87,000	3077	
6A	6.00	28.27	9/13/99	3 days	123,000	4350	
6B	6.00	28.27	9/13/99	3 days	127,000	4492	
7A	6.00	28.27	9/17/99	7 days	139,000	4916	
7B	6.00	28.27	9/17/99	7 days	140,000	4952	
8A	6.00	28.27	9/24/99	14 days	147,500	5217	
8B	6.00	28.27	9/24/99	14 days	148,000	5235	
9A	6.00	28.27	10/08/99	28 days	161,000	5695	
9B	6.00	28.27	10/08/99	28 days	166,000	5871	

NLESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
DENOTES CURED IN FIELD <<< DENOTES LOW COMPRESSIVE STRENGTH
RACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
RACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION:

REMARKS:



RESPECTFULLY SUBMITTED

LAW

ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT: FAU / FDOT

JOB NO: 40522-7-7891

PROJECT: FAU Vibration Monitoring

LAB NO:

MIX ID: 51-4709

SPECIFIED STRENGTH: 4,000

MIX DESC: Drilled Shaft

FIELD INFORMATION

DATE SAMPLED: 9/10/98 BY: LAW JB

TIME BATCHED: 10:25 a.m. SAMPLED: 11:15 a.m.

BATCH PLANT: Florida Rock

TRUCK/TICKET: 708/82 DATE RECEIVED: 9/10/98

FIELD TESTS (SPECIFIED RANGE)

SLUMP: 8"

PERCENT AIR: N.I.

UNIT WEIGHT: N.I.

MIX/AIR TEMP: 30°/28°C

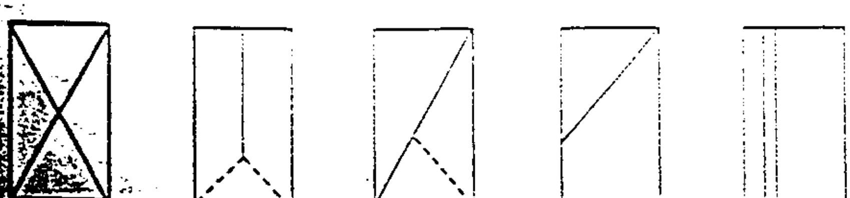
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
1A	6.00	28.27	9/10/98	4 hours	400	14	
1B	6.00	28.27	9/10/98	4 hours	350	12	
1C	6.00	28.27	9/10/98	4 hours	400	14	
2A	6.00	28.27	9/10/98	6 hours	5500	194	
2B	6.00	28.27	9/10/98	6 hours	4400	155	
2C	6.00	28.27	9/10/98	6 hours	5300	187	
3A	6.00	28.27	9/10/98	9 hours	30000	1061	
3B	6.00	28.27	9/10/98	9 hours	32500	1149	
3C	6.00	28.27	9/10/98	9 hours	31000	1096	
4A	6.00	28.27	9/10/98	12 hours	44000	1556	
4B	6.00	28.27	9/10/98	12 hours	42500	1503	
4C	6.00	28.27	9/10/98	12 hours	45000	1591	

NLESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
DENOTES CURED IN FIELD <<< DENOTES LOW COMPRESSIVE STRENGTH
RACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
RACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION: 24-inch and 36-inch diameter shafts

REMARKS: 10 gallons water added to 9 c.y.



RESPECTFULLY SUBMITTED

LAW

ENGINEERING AND ENVIRONMENTAL SERVICES

CONCRETE TEST REPORT

CLIENT: FAU / FDOT

JOB NO: 40522-7-7891

PROJECT: FAU Vibration Monitoring

LAB NO:

MIX ID: 51-4709

SPECIFIED STRENGTH: 4,000

MIX DESC: Drilled Shaft

FIELD INFORMATION

DATE SAMPLED: 9/10/98 BY: LAW JB

TIME BATCHED: 10:25 a.m. SAMPLED: 11:15 a.m.

BATCH PLANT:

TRUCK/TICKET: 708/82 DATE RECEIVED: 9/10/98

FIELD TESTS (SPECIFIED RANGE)

SLUMP: 8"

PERCENT AIR:

UNIT WEIGHT:

MIX/AIR TEMP: 30°/28°C

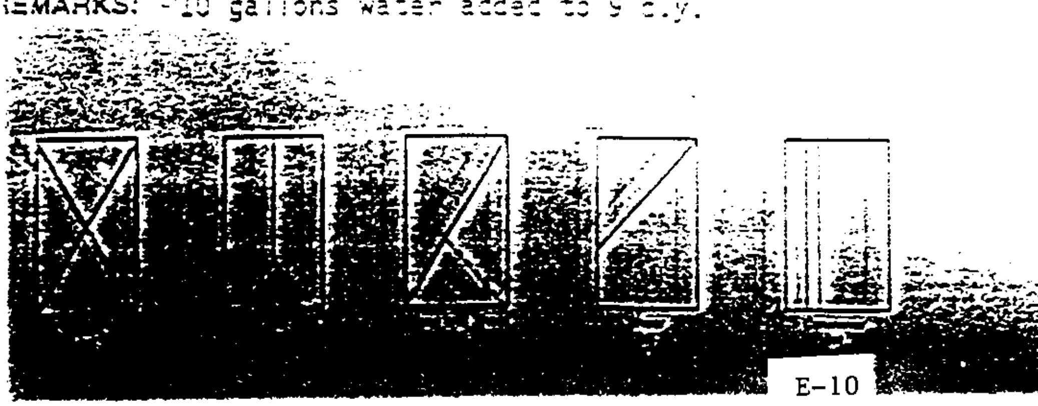
COMPRESSION TEST RESULTS

CYLINDER NUMBER	DIAMETER (IN.)	AREA (SQ. IN.)	DATE TESTED	TEST AGE (DAYS)	MAX LOAD (Lbs.)	COMP. STRENGTH (psi)	FRACTURE TYPE
S1.1	6.00	28.27	9/24/99	14	160,000	5659	
S2.1	6.00	28.27	9/24/99	14	162,000	5730	
S3.1	6.00	28.27	9/24/99	14	154,000	5447	
S1.2	6.00	28.27	10/08/99	28	169,000	5978	
S2.2	6.00	28.27	10/08/99	28	172,000	6084	
S3.2	6.00	28.27	10/08/99	28	174,000	6155	

UNLESS OTHERWISE INDICATED, ALL TESTS WERE PERFORMED IN GENERAL ACCORDANCE WITH ASTM C39 AND ASTM C1231.
DENOTES CURED IN FIELD <<< DENOTES LOW COMPRESSIVE STRENGTH
FRACTURE TYPE IS INDICATED BY LETTER: (A) CONE (B) CONE & SPLIT (C) CONE AND SHEAR (D) SHEAR (E) COLUMNAR
FRACTURE TYPE NOT APPLICABLE WHEN CYLINDERS TESTED IN ACCORDANCE WITH ASTM C1231.

POUR LOCATION: Surface cylinders

REMARKS: 10 gallons water added to 9 c.y.



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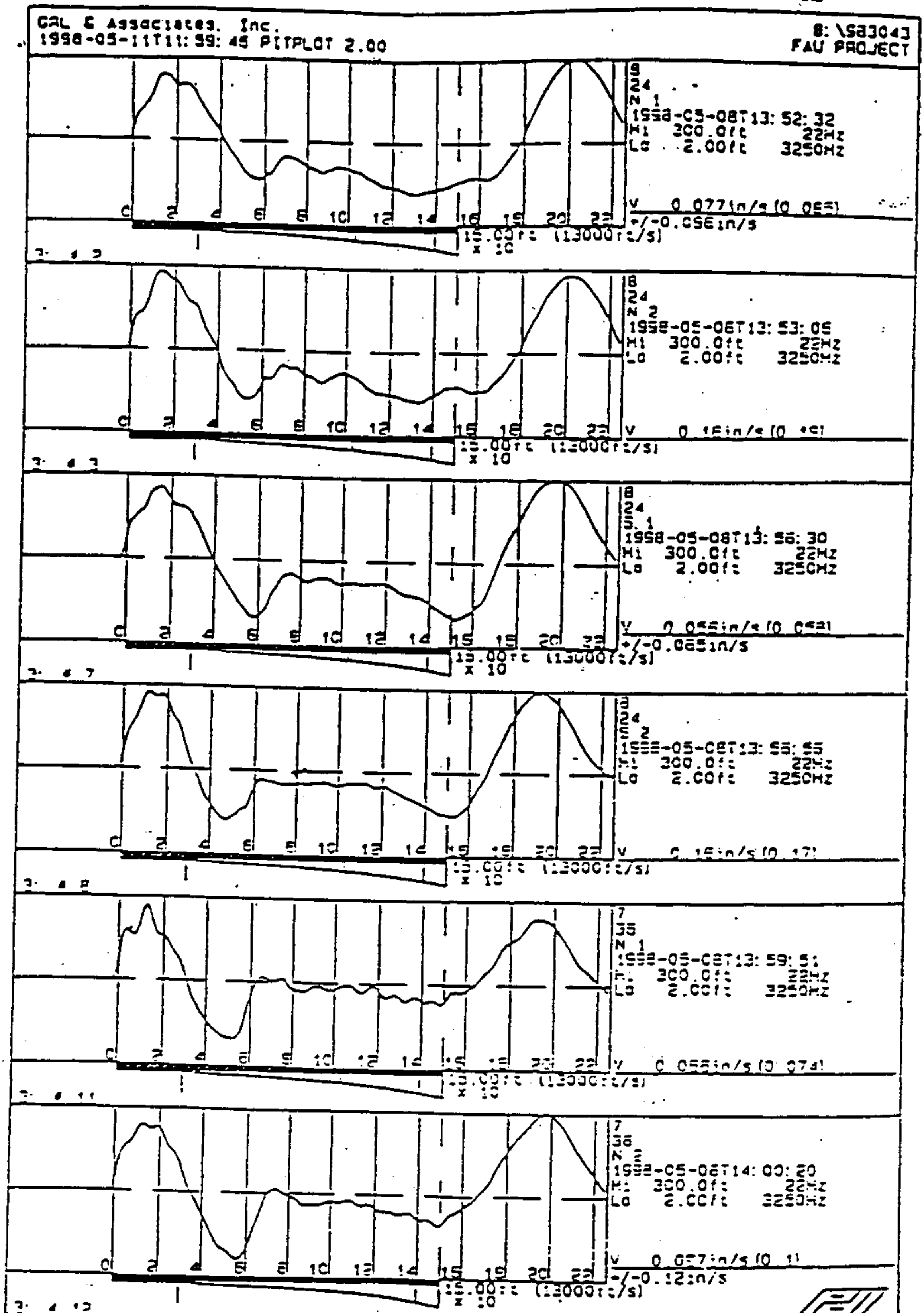
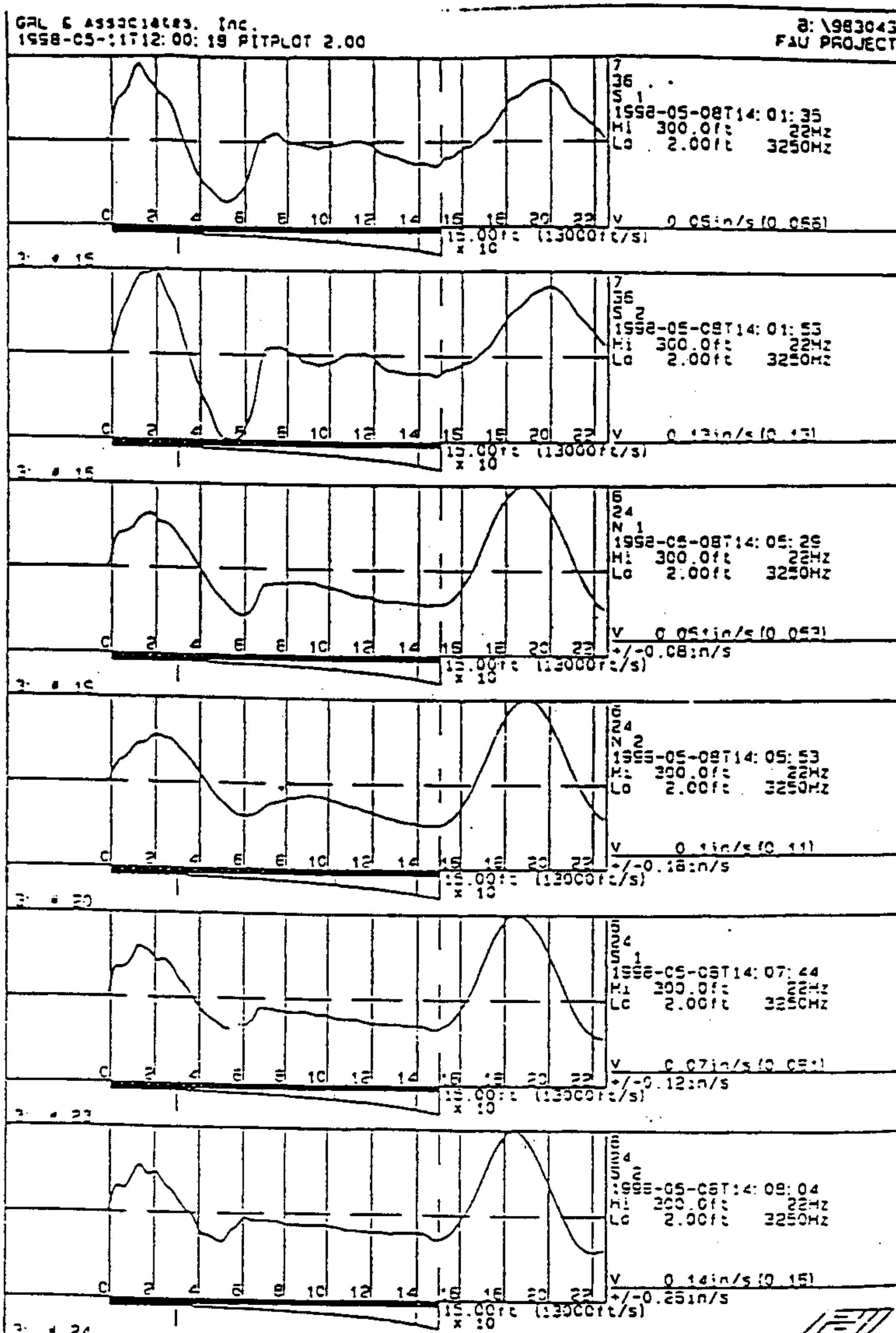
APPENDIX F

P.I.T. METHOD

GLOBAL RAUSCHE LIKINS AND ASSOCIATES, INC.(GRL)



GRL Goble Rausche Likins and Associates, Inc



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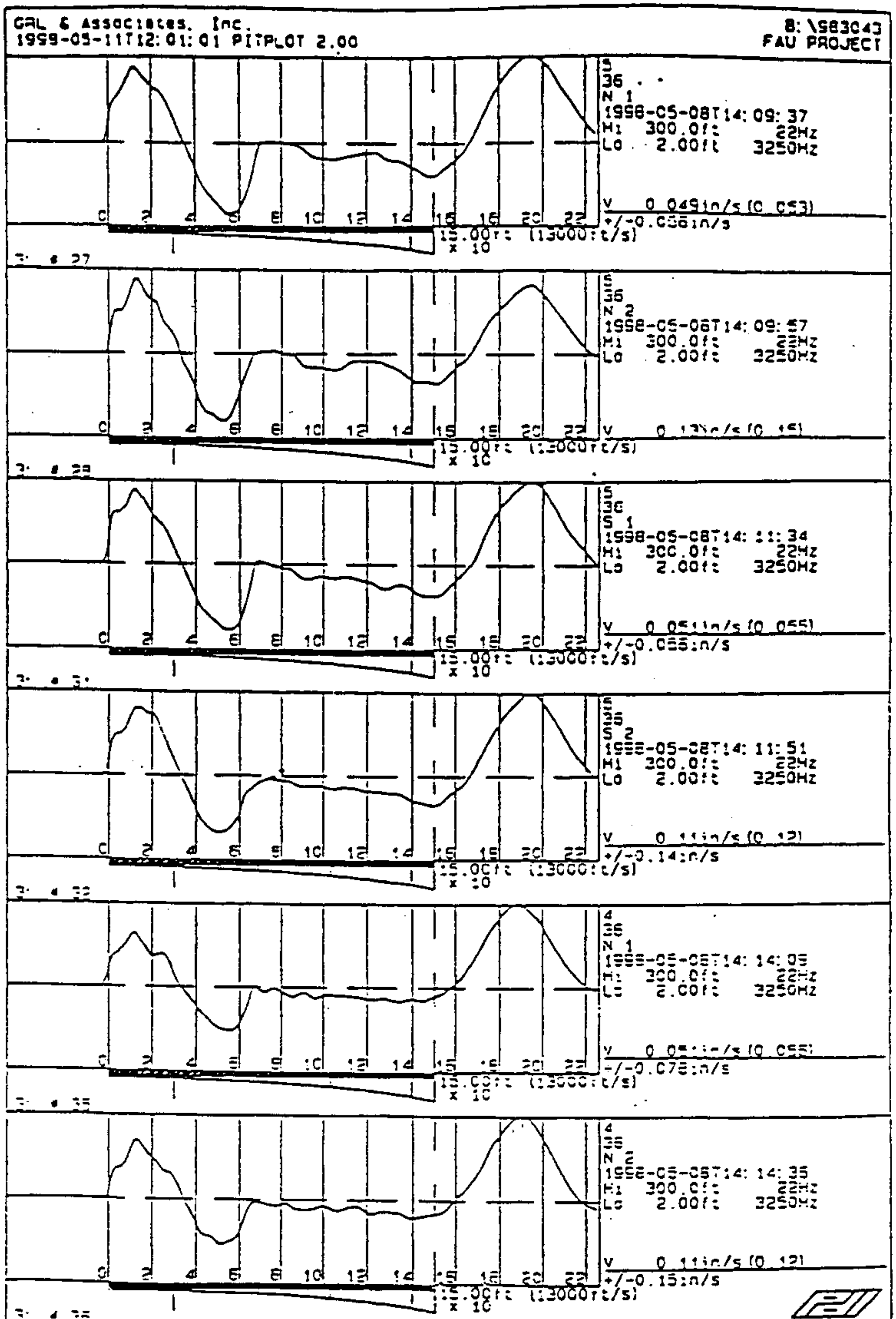

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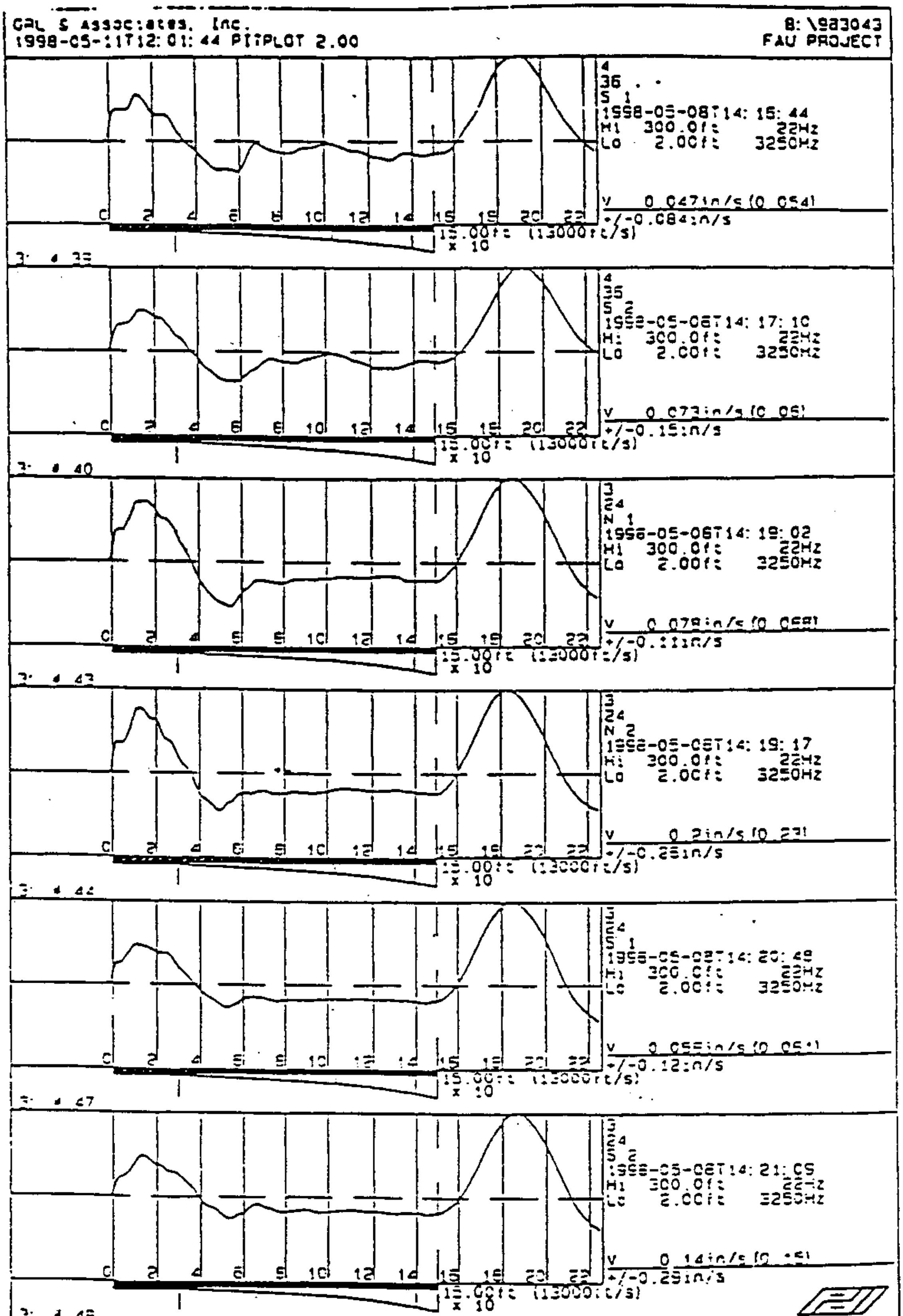
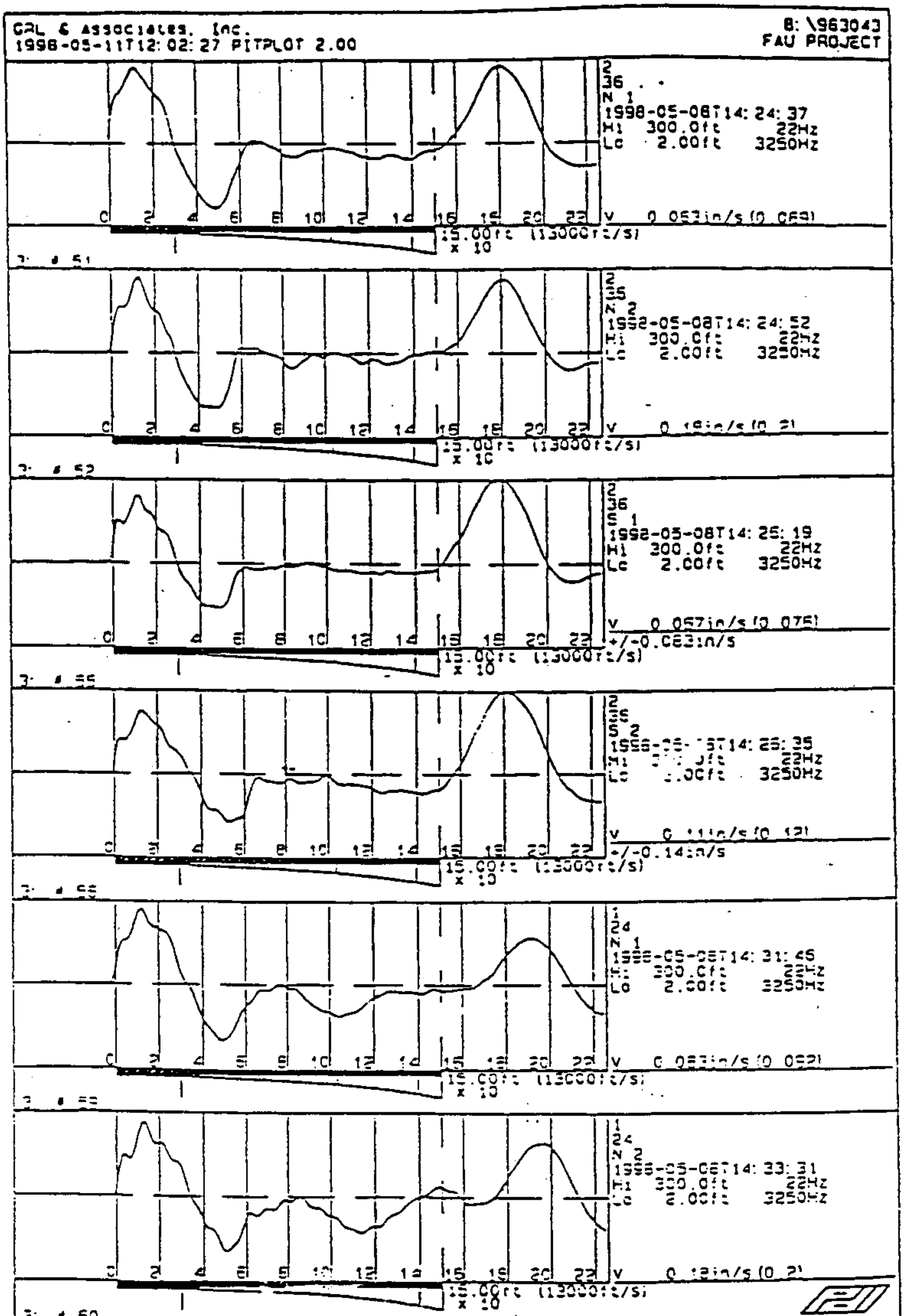
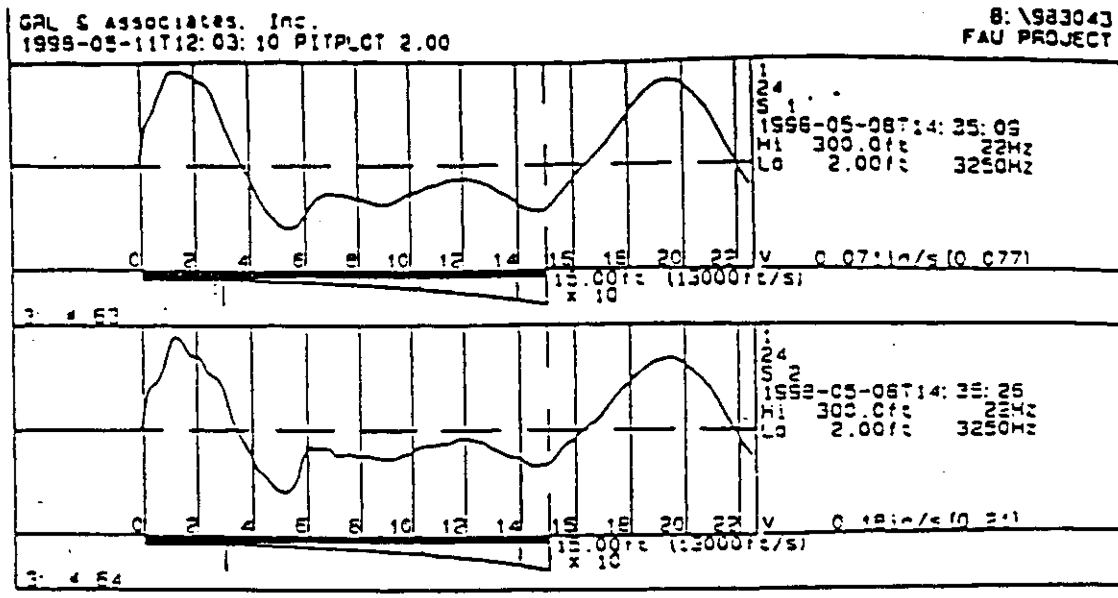


GRL Goble Rausche Likins and Associates, Inc.



GRL Goble Rausche Likins and Associates, Inc



GRL Goble Rausche Likins and Associates, Inc

APPENDIX A:

THE LOW STRAIN PULSE ECHO AND TRANSIENT RESPONSE METHOD FOR PILE INTEGRITY TESTING

INTRODUCTION

Pile integrity test methods of driven and cast-in-situ piles have been developed by several researchers using differing equipment and methods. GRL's low strain test method is easily applied, quick, inexpensive and, therefore, routinely applied world-wide. Often all piles on a site are tested and problem piles are identified for corrective action.

The method uses signals from a hand held hammer impacting the pile top and generating a compressive stress wave in the pile. Stress wave reflections from non-uniformities or the pile toe are observed at the pile top, processed and interpreted by the experienced test engineer. The Pulse Echo Method (PEM) records the pile top velocity as a function of time. The Transient Response Method (TRM) displays the mobility, *i.e.*, the ratio of frequency spectra of pile top velocity and force. P.I.T. combines both PEM and TRM.

BACKGROUND

When a long rod, such as a precast, driven or drilled shaft or pile, is struck with a small hammer, a stress wave is generated which travels down the shaft to the pile bottom where it is reflected. When the reflected stress wave returns to the pile top, a measurable pile top motion occurs. If this reflection wave occurs at the correct time and if no other earlier reflection is received at the pile top, then the pile shaft is most probably free of major defects.

When a lightweight hand held hammer strikes the pile top, a small pile top motion (velocity) is generated and measured. The associated pile strains are of such a low magnitude that they would be measured in the pile only with great difficulty. This test is therefore also known as low strain integrity test. However, the force applied by the hammer can be easily measured by instrumenting the hammer itself. Primarily, the velocity record and to a lesser degree the force record contain information about the location and magnitude of pile non-uniformities. Under the assumption of proportional force and velocity records, and for short duration impact pulse the velocity record may be sufficient. One of the distinguishing features of the Transient Response Method (TRM) is that it requires the measurement of both velocity and force while the Pulse Echo Method (PEM) only relies on velocity records. A second difference is the display of the TRM results in the frequency domain. PEM offers powerful record enhancement techniques and presents the resulting curves as a function of time.

STRESS WAVE PROPAGATION IN A PILE

An impact applied to the pile top generates momentary compression and a particle motion of the pile top surface. The compression is related to the force, F; the motion causes a particle velocity, v. In concrete, the stress wave travels along the pile with a stress wave speed, c, ranging from 10,000 to 15,000 ft/s (3,000 to 4,500 m/s).

$$c = \sqrt{\frac{E}{\rho}} \qquad (1)$$

where E is the pile's elastic modulus and ρ its mass density. Figure 1 shows, in the form of a time-depth plot, the path of a stress wave in the pile, illustrating the arrival times of reflection waves at the pile top. Both cross sectional changes and soil resistance forces generate reflection waves. The pile top velocity is affected by and therefore indicates the arrival of both tensile and compressive reflection waves.

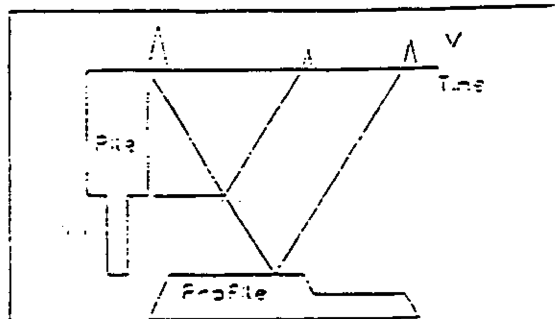


Figure 1: Traveling stress waves and the principle of the pile profile estimate.

the reflection from the pile toe is not readily apparent (as in the example of Figure 3), then the velocity is usually multiplied with an amplification function whose magnitude is unity at impact increasing exponentially with time until it reaches its maximum intensity at time 2L/c after impact (2L/c is the time which the stress wave requires to travel the pile length, L, and return). In Figure 4, the upper graph is the same average velocity trace as in Figure 3 but after an amplification of 40 was applied. Note that the pile toe now is clearly identifiable. For longer piles or stronger soils, even higher amplification factors may be used; this process requires signal conditioning and digital processing equipment with very low noise to signal ratios. If the toe signal is apparent, then it is possible to confirm the originally assumed wave speed.

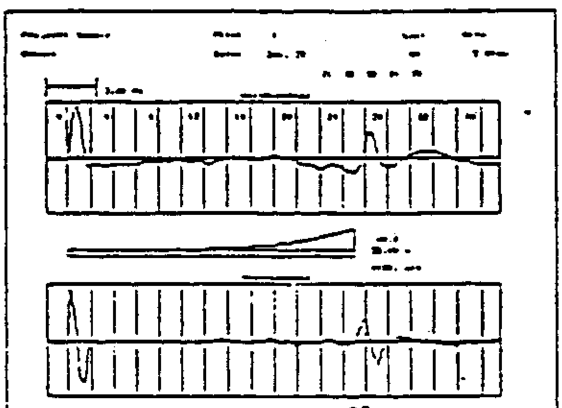


Figure 4: Amplified average velocity and acceleration from the standard P.I.T. output.

Figure 4 is the standard P.I.T. output. It includes the acceleration on the bottom and the exponential amplification function with the multiplier at time 2L/c. The title section includes the blow numbers averaged. The assumed wave speed and pile length are also included in the output. A clearly indicated toe signal together with a fairly steady velocity trace between the impact and toe signal are signs of a sound pile. Strong velocity variations may be the result of changes in pile cross section, concrete quality or soil resistance. For example, relative increases in pile top velocity may be the result of either a cross sectional decrease or a soft soil layer. In the absence of soil resistance changes, pile top variations are caused by pile impedance changes. The pile impedance is defined as

$$Z = EA/c = A\sqrt{E\rho} \qquad (2)$$

with A being the pile's cross sectional area. Thus, a impedance reduction can be caused by a decrea either in area, A, or in the concrete's modulus, E, in density, ρ. Since both modulus and density a related to concrete strength, it is fair to say th impedance depends on cross sectional area a concrete quality.

In general, relatively sharply defined reflections a attributed to impedance changes, slowly changi reflections are thought to be caused by the soil. Th basic assumption limits damage recognition integrity assessment to situations which occur over distance given by one impact pulse width. Grad pile tapers therefore cannot be detected. On t other hand, if the effect of soil resistance is kno from reference piles, then unusual shafts can be mo easily identified. Improved quantitative interpretatio may require signal matching, pile profile calculatio and comparison with records of other piles at t same site (see section on P.I.T.WAP). But even wi these more sophisticated methods, the question the effect of soil resistance still may not be clear.

The velocity curve can also be transformed to t frequency domain (Figure 5) and interpreted in manner similar to mobility discussed below. A additional transform of the transformed velocity m be used to extract significant record portions, calle "Velocity Reflectors", over a length scale.

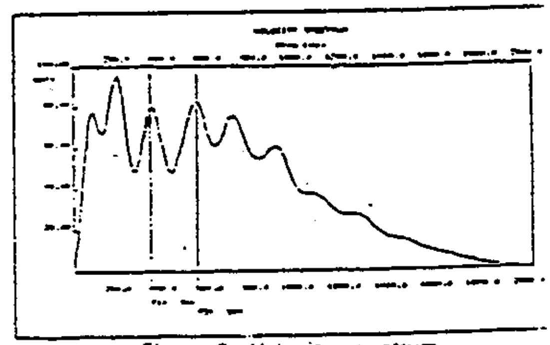


Figure 5: Velocity spectrum

THE TRANSIENT RESPONSE METHOD

The TRM requires that both the pile top motion a the impact force be measured. This concept h been borrowed from standard Non-Destruct Testing technology. In fact, the first applications NDT to piles required the measurement of force a velocity under a steady state vibrator which co apply substantial forces at variable frequencies. Fortunately, the force frequency spectrum of a hand held impact hammer is flat over a relatively wide frequency band. A simple hand held hammer can therefore adequately produce the frequency components necessary to test both well constructed or defective piles with TRM.

The standard result of TRM is a plot of the frequency spectrum of the ratio of velocity to force. This so-called mobility is really the inverse of the impedance and therefore an indication of the pile's velocity, $v(\omega)$, response to a particular excitation force, $F(\omega)$.

$$M(\omega) = v(\omega)/F(\omega) \quad (3)$$

A mobility peak occurs at a frequency indicative of the time when the velocity changes due to a reflection from the pile toe or an intermediate impedance reduction. Mobility peaks occurring at regular intervals are indicative of a dominant frequency Δf. The corresponding depth ($L_2 - L_1$, in Figure 6) at which the change occurs is calculated from

$$x = c/2\Delta f \quad (4)$$

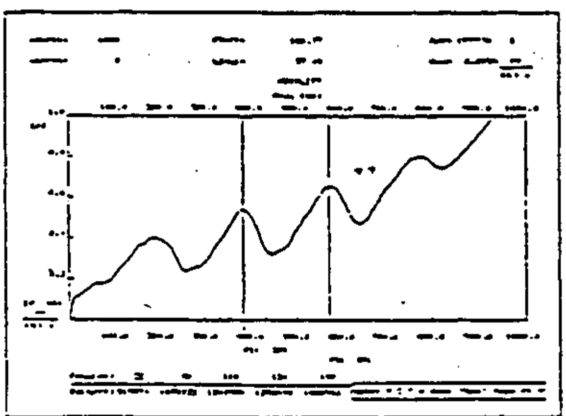


Figure 6: Mobility with dynamic stiffnesses

Furthermore, dividing the velocity by frequency leads to displacement. Dividing force by displacement at a given frequency leads to the so-called dynamic stiffness.

$$E_d = \omega F(\omega)/v(\omega) = 2\pi f/M(\omega) \quad (5)$$

where ω and f are the frequency in radians per second and Hz, respectively. In practice, low frequency values are divided by the associated mobility yielding a so-called dynamic stiffness. E This quantity increases with decreasing pile t response. A low pile toe response is often the res of high soil resistance. However, it may also b caused by highly variable pile properties or intern pile damping and is therefore only indirectly related quantitative pile bearing capacity. However, E_d calculated since it does provide a quantitative res for the evaluation of pile quality. Figure 6 shows t example of a mobility and, at the bottom, t associated E_d values for several frequencies.

P.I.T.WAP SIMULATED RESPONSE

P.I.T. yields some form of pile top motion curv Interpretation of these curves is left to the more less experienced engineer. An invaluable aid in th interpretation effort are similar curves analytica developed. The special purpose computer progra P.I.T.WAP™ (Pile Integrity Testing Wave Analys Program) which is based on CAPWAP® (CAse Pi Wave Analysis Program), requires that the descriptio of pile and soil are input, and generates as an outp pile top velocity vs. time or the mobility.

A large catalogue of these calculated responses wa compiled as a guide for record interpretation. On one of many possible demonstration cases is show in Figure 7. It demonstrates the calculated curves f a pile with sufficient uniform shaft resistance t reduce the pile toe reflection to a small pulse. Th pile was assumed to have an enlarged center sectio which first produces a negative and later a positiv velocity response. In the middle of the record, a ver slight secondary reflection can be observed. It wa caused when the initially negative reflection from th shaft increase again reached the enlarged pile sectio after reflection at the top.

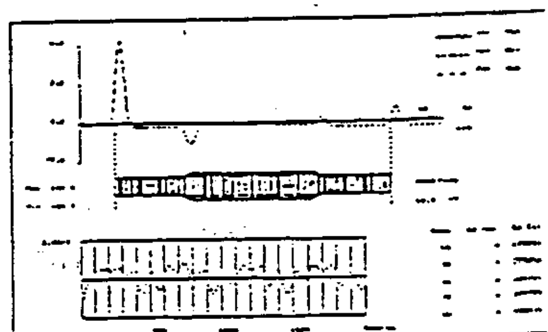


Figure 7: Calculated velocity and mobility for a non uniform pile.

P.I.T.WAP SIGNAL MATCHING

The P.I.T.WAP program can also be employed in the interpretation of measured P.I.T.-FV velocity or velocity and force records. Suppose that the measured force record is imposed as a pile top boundary condition for an analytical model of pile and soil. One result of this analysis would be the calculated pile top velocity. Comparison of the measured with the computed velocity allows the engineer to gain insight regarding the pile impedance variations. Reanalyzing with a variable impedance pile model should therefore lead to an improved match of measured and calculated pile top velocity. The process of changing impedance and reanalyzing is continued until a good match is achieved. At that point, the most likely pile impedance profile has been determined. Typically, P.I.T.WAP divides the pile in continuous segments of approximately 10 inches (250 mm) length. The program automatically calculates the pile impedance of all segments after the engineer has decided on a soil resistance model. (This soil resistance model bears no relationship with static resistance or with damping magnitudes encountered during pile driving.) Generally, it is possible to extract these relative soil resistance parameters from P.I.T.-FV tests on reference piles. These parameters are then used to analyze neighboring piles with impedance variations.

Figure 8 illustrates the results obtained from P.I.T.-WAP matching. The plot includes the velocity match, the predicted pile impedance variation and the mobility based on both calculated and measured velocity.

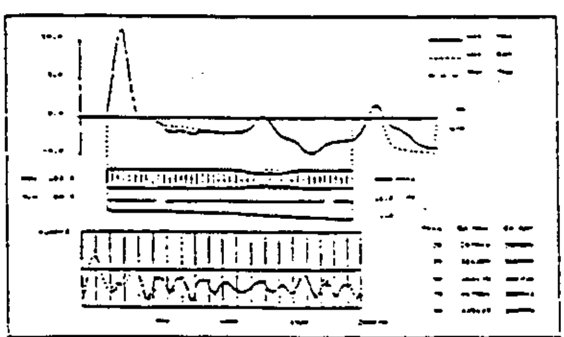


Figure 8: Results from P.I.T.WAP velocity matching, including velocity and mobility match and predicted pile impedance variation.

THE P.I.T.WAP PILE PROFILE

The P.I.T.WAP program contains a second option f pile impedance calculations. It has the advantage much greater simplicity and the disadvantage tha does not identify effects of secondary reflections. A estimated pile profile is calculated based on th difference between calculated and measured pile to velocity. The basis of the pile profile calculation the fact that a step-wise change in impedanc causes a pulse-like velocity wave effect at the pile to (Figure 1). In other words, the effect of a impedance change has the appearance of th derivative of the impedance change. Inversely, th profile is the integral of the wave effects at the pi top. In the absence of soil resistance effects, th profile therefore has the appearance of the pile to displacement. **Again, please note that the PI Profile option will not identify and correct fo secondary reflections. Furthermore, any im pedance reduction, whether crack or lack o concrete quality, will be identified in the form o a decreasing cross sectional area.**

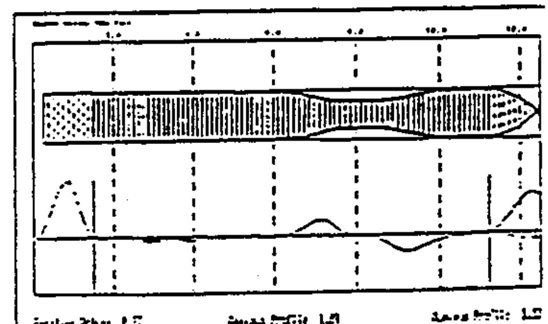


Figure 9: Results from P.I.T.WAP pile profi calculation

The pile profile results is shown in Figure 9 showin the following

- a length scale
- a relative volume calculated from the appare pile profile (this value may be compared wi actual construction records). A relative volum of 1.0 corresponds to the pile top cros sectional area times the pile length.
- The calculated pile profile graph include shaded areas which are uncertain due to th width of the input pulse.

- Minimum and maximum impedance values between the shaded areas.
- The measured velocity (solid line), and the calculated velocity (dash) which accounts for soil resistance effects.

CONCLUSIONS

The low strain integrity test, P.I.T., is powerful, quick, inexpensive but, naturally, limited. First, the length information obtained from a toe signal (or a governing frequency) is only as accurate as the wave speed value assumed in the processing of the records. Even at sites where concrete quality is well maintained, wave speed variations of 5% are not uncommon. A pile length calculated from a toe signal is therefore only well known within ± 5%. Second, certain reflections produce secondary and even tertiary wave reflections. For example, if an impedance reduction occurs in the middle of the pile, then what may appear to be the pile toe response may actually be a secondary reflection of the mid-pile defect. For piles with severe cracks or manufactured mechanical joints, the stress wave will, in general, not be transmitted below the "gap" and therefore the pile below this "defect" cannot be evaluated. Third, piles with multiple or highly variable cross sectional changes are difficult to analyze. Soil effects may severely interfere with pile impedance related signals. In fact, a rule of thumb limits the testable pile length to 30 diameters, however, this is probably only correct for soils with relatively high resistance. For extremely high resistance or strongly variable shaft impedance, the test length may be less than 30 diameters. It is often helpful to identify soil effects by comparing records of a large number of piles or by using the record of a statically loaded (or high strain tested) reference pile.

Piles which are rigidly attached to other parts of a structure can sometimes be tested and analyzed successfully, but often the analysis is more difficult than those with free pile tops.

The additional force measurement of P.I.T.-FV and TRM definitely provides supplemental information of cross sectional changes near the pile top, *i.e.*, within the distance corresponding to the impact signal. The extra expense of the force measurement is, therefore, worthwhile whenever questions arise as to the integrity of upper (say 5 ft. or 1.5 m) pile portion.

The record presentation in the frequency dom. may, on occasion be of benefit. For examp important record components may be hidden ir steady state signal caused by pile top reinforcement vibration. They also provide in mation on dynamic stiffness although no low str. method can truly give quantitative information on ultimate capacity of a pile. In general, however, interpretation of time records is much simpler th that of frequency records. Time records can also simply analyzed by the P.I.T.WAP signal matching the pile profile technique for a more objective a very illustrative result compared to the engineee verbal assessment.

IMPLEMENTATION

There is no point in doing the P.I.T. test if there is consensus among the owner, engineer and co tractor on corrective actions should the tests indica defects. Also, it must be anticipated that not all tes are conclusive.

- If serious defects are indicated by the methc a contingency plan must be in place whic allows the engineer(s)-in-charge to choose fro a menu of additional tests or correcti measures such as replacement pile, co drilling, pressure injection, *etc.*
- The test may be inconclusive for greater dept due to its limitations. However, it may b sufficient to accept the results for the upp shaft portion where most problems usual occur for drilled shafts.
- Other readily acceptable solutions may incluc additional testing after removing poor pile to concrete, tests by another method such as th high strain dynamic load test methc excavation around the pile, core drilling, *etc.*

APPENDIX G

CROSSHOLE SONIC LOGGING RESULTS
GLOBAL RAUSCHE LIKINS AND ASSOCIATES, INC. (GRL)

[illegible]

Fri May 09 08:43:25 1995
Site: FAU PROJECT
Pile: 7
Profile: BD
File: 1
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Y [illegible]
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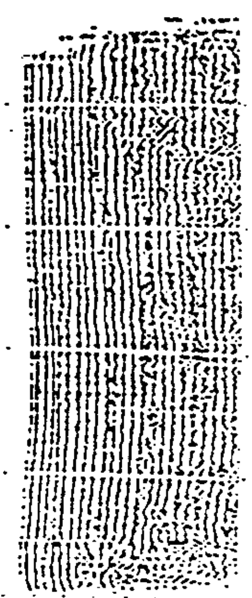
Distance [illegible]
Length [illegible]
Top Y [illegible]



[illegible]

Fri May [illegible] 09:22:12 1995
Site: FAU PROJECT
Pile: 7
Profile: CD
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Y [illegible]
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Length [illegible]
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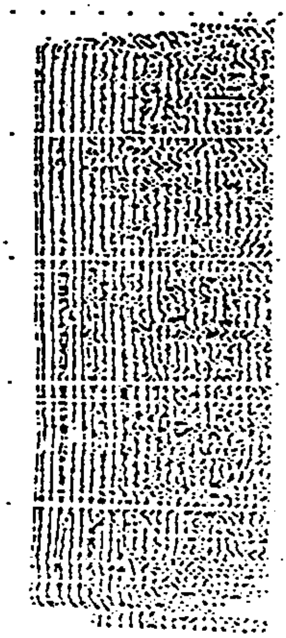

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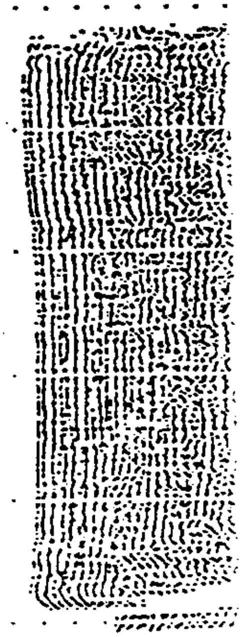

GPL Gobie Rausche Likins and Associates Inc.

Fri May [illegible] [illegible]:24:11 1998
Site: FAU PROJECT
File: 7
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File: 4
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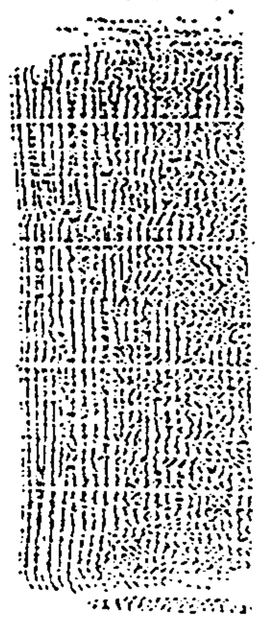

Fri May 22 [illegible] 1998
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File: 7
Profile: AD
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D [illegible]
Distance [illegible]
Length [illegible]
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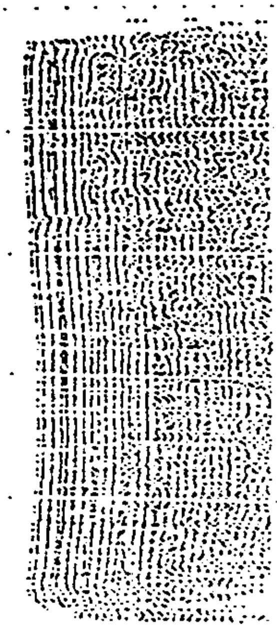

Fri May [illegible] [illegible]:55 1998
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Profile: EC
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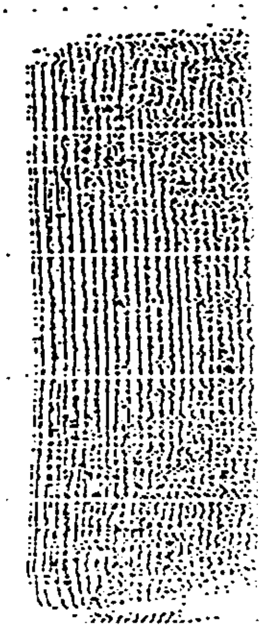

GPL Goble Rausche Likins and Associates, Inc

Fri May 08 10:01:47 1998
Site: FAU PROJECT
Pile: 5
Profile: BD
File: 7
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Y 22mm
0 8us
Distance [illegible]
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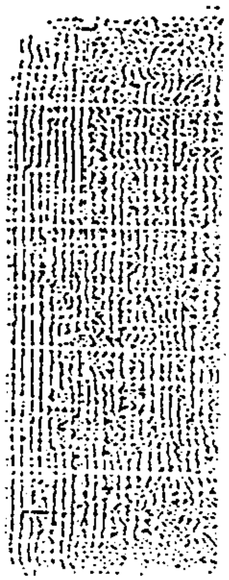
Top Y 224.92m



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Profile: BC
File: 8
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Y 22mm
0 8us
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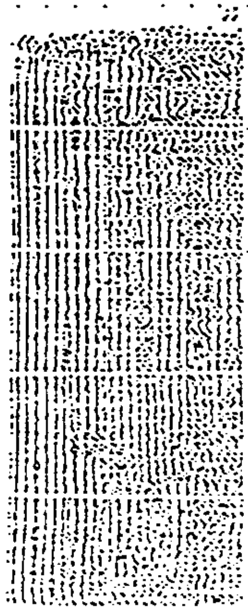
Top Y 224.96m



Fri May 08 10:20:23 19[illegible]
Site: FAU PROJECT
Pile: 5
Profile: AB
File: 9
X 60us
Y 22mm
0 8us
Distance [illegible]
Length 224.52m
Top Y 224.92m

GRL Goble Rausche Likins and Associates, Inc.

Fri May [illegible] 1998
Site: [illegible] PROJECT
Pile: 5
Profile: AC
File: 13
X 62us
Y [illegible]
D 8us
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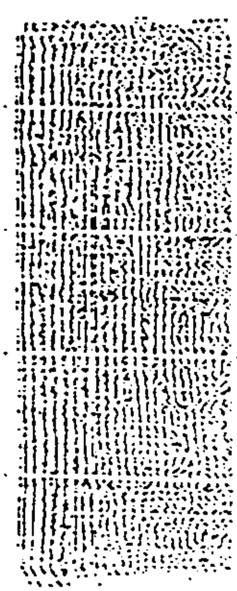
Length [illegible]
Top Y [illegible]



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Y [illegible]
D 8us
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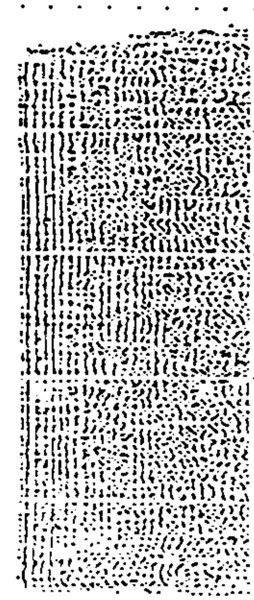

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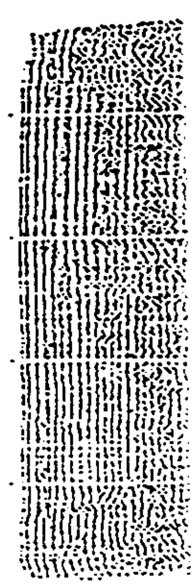


APPENDIX H

CONCRETE CORE TEST RESULTS

WILLIAMS EARTH SCIENCE INC.

LAW ENGINEERING &
ENVIRONMENTAL SCIENCE

LLIAMS EARTH SCIENCES, INC.

FIELD BORING LOG

PROJECT NAME: FAU DRILLED SHAFT STUDY

PROJECT Nº: J327094B

CLIENT: FLORIDA ATLANTIC UNIV.

ORING Nº: C-1 | INSPECTOR: Lewis Grace | ENGINEER: Mark Hirsch

TART DATE: 03/26/99 | START TIME: | RIG Nº: DR-4

INISH DATE: 03/26/99 | FINISH TIME: | BIT TYPE: Core Barrel

IETRIC | BIT SIZE: 2 7/8

TATION Nº: N/A | WATER LEVEL: N/A

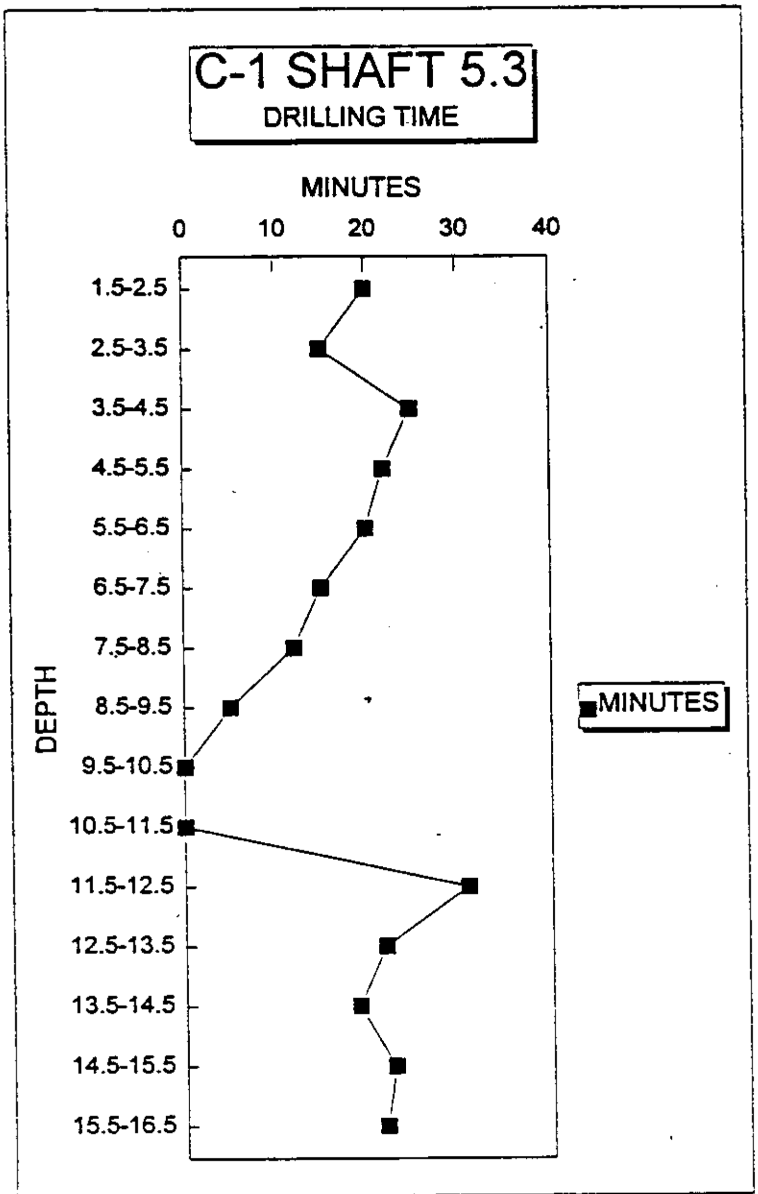
FFSET: N/A | WATER DEPTH: N/A | TOTAL CASING: N/A

LEVATION: N/A | MUDLINE: N/A | TOTAL GROUT: N/A

GROUNDWATER LEVEL: N/A | GROUT TIME: N/A

Sample		Classification
From	To	
0.0		CONCRETE CUT INTO PILE .
	1.5	
1.5		250 P.S.I. = 20 min.
	2.5	
2.5		250 P.S.I. = 15 min.
	3.5	
3.5		250 P.S.I = 25 min.
	4.5	
4.5		250 P.S.I. = 22 min. (100 % RECOVERY)
	5.5	
5.5		250 P.S.I. = 20 min.
	6.5	
6.5		250 P.S.I. = 15 min.
	7.5	
7.5		250 P.S.I. = 12 min.
	8.5	
8.5		250 P.S.I. = 5 min.
	9.0	Drop into other core hole, kelly stopped at 11.5ft.
11.5		250 P.S.I. = 31 min.
	12.5	
12.5		250 P.S.I. = 22 min.
	13.5	
13.5		250 P.S.I. = 19 min.
	14.5	
14.5		250 P.S.I. = 23 min.
	15.5	
15.5		250 P.S.I. = 22 min. (75 % RECOVERY)
	16.5	

WILLIAMS EARTH SCIENCES


C-1 SHAFT 5.3
DRILLING TIME
MINUTES
0
10
20
30
40
DEPTH
1.5-2.5
2.5-3.5
3.5-4.5
4.5-5.5
5.5-6.5
6.5-7.5
7.5-8.5
8.5-9.5
9.5-10.5
10.5-11.5
11.5-12.5
12.5-13.5
13.5-14.5
14.5-15.5
15.5-16.5
MINUTES

WILLIAMS EARTH SCIENCES, INC.

FIELD BORING LOG

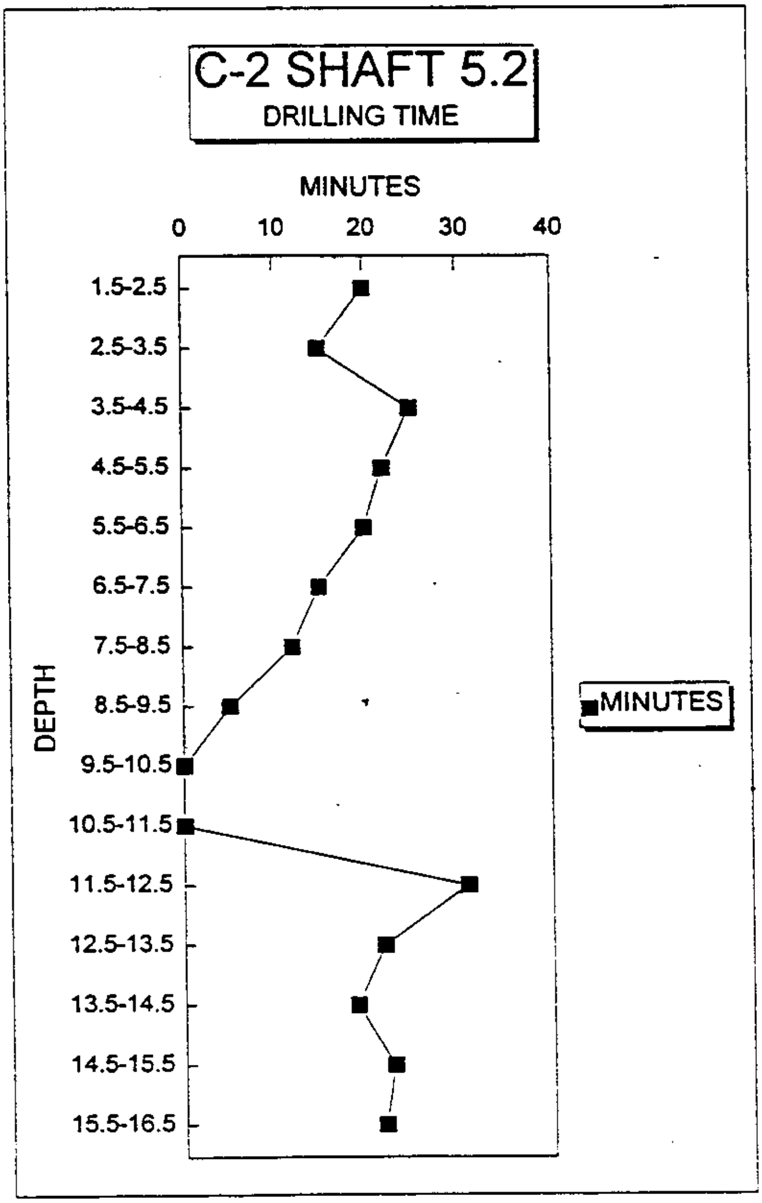
PROJECT NAME: FAU DRILLED SHAFT STUDY

PROJECT Nº: J327094B

CLIENT: FLORIDA ATLANTIC UNIV.

BORING Nº:	C-2	INSPECTOR:	Lewis Grace	ENGINEER	Mark Hirsch
START DATE:	03/29/99	START TIME:		RIG Nº	DR-4
FINISH DATE:	03/29/99	FINISH TIME:		BIT TYPE:	Core Barrel
METRIC				BIT SIZE:	2 7/8
STATION Nº	N/A	WATER LEVEL:	N/A		
OFFSET:	N/A	WATER DEPTH:	N/A	TOTAL CASING:	N/A
ELEVATION:	N/A	MUDLINE:	N/A	TOTAL GROUT:	N/A
		GROUNDWATER LEVEL:	N/A	GROUT TIME:	N/A

Sample		Classification
From	To	
0.0		FILL IN PILE AT 5 ft.
	5.0	
5.0		250 P.S.I. = 29 min.
	6.0	
6.0		250 P.S.I. = 18 min.
	7.0	
7.0		250 P.S.I = 37 min.
	8.0	
8.0		250 P.S.I. = 26 min.
	9.0	
9.0		250 P.S.I. = 26 min. (100 % RECOVERY)
	10.0	
10.0		250 P.S.I. = 39 min.
	11.0	
11.0		250 P.S.I. = 15 min.
	12.0	
12.0		250 P.S.I. = 23 min.
	13.0	
13.0		250 P.S.I. = 25 min.
	14.0	
14.0		250 P.S.I. = 42 min. (90 % RECOVERY)
	15.0	
		HIT STEEL AT 15ft. AND STOPPED


C-2 SHAFT 5.2
DRILLING TIME
MINUTES
0
10
20
30
40
DEPTH
1.5-2.5
2.5-3.5
3.5-4.5
4.5-5.5
5.5-6.5
6.5-7.5
7.5-8.5
8.5-9.5
9.5-10.5
10.5-11.5
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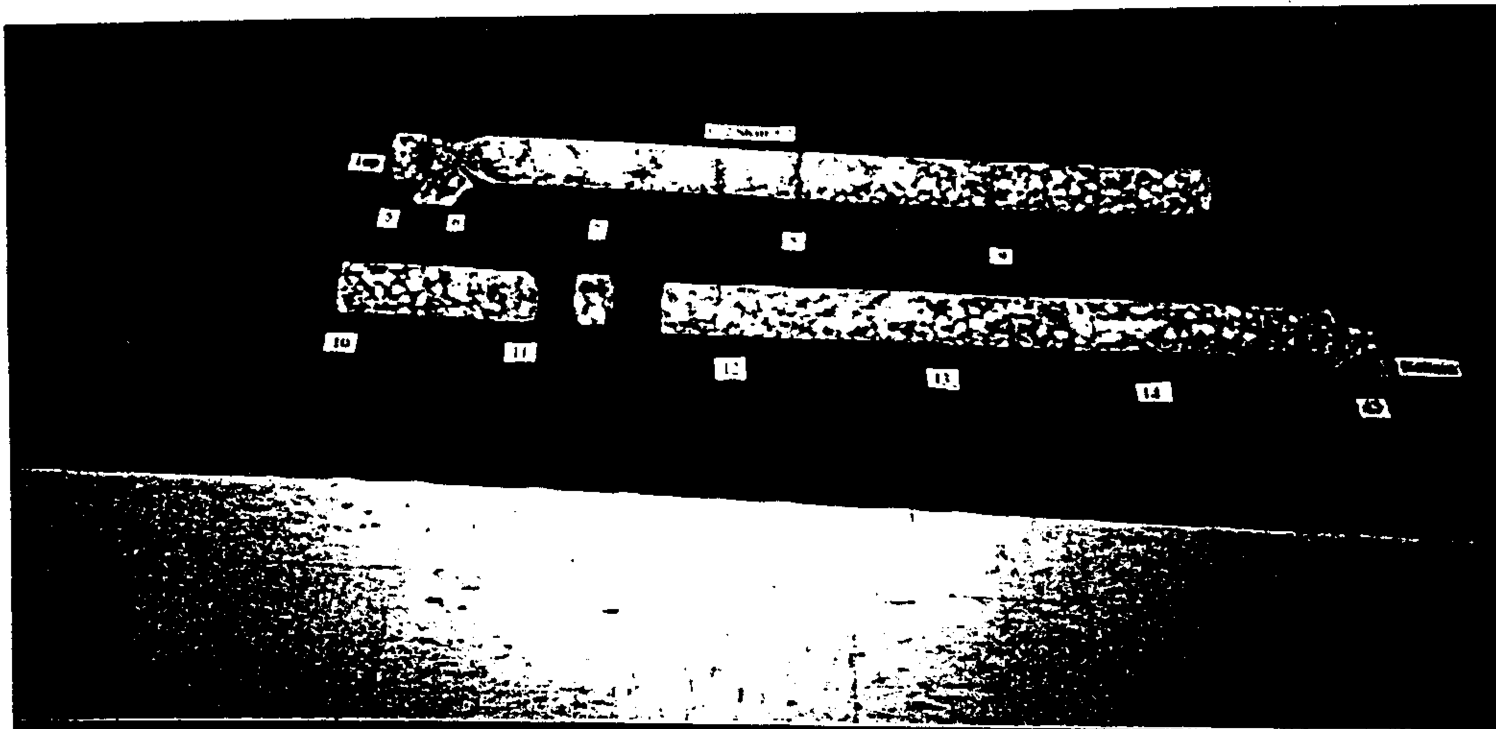
14.5-15.5
15.5-16.5
MINUTES



CORED SEGMENTS

LABORATORY MEASUREMENTS

SHAFT 1-2

	SAMPLE 1	SAMPLE 2
Depth, ft.	2.5	12
Diameter, in.	3.276	3.29
Core Length, in.	8.125	10.375
Initial Weight, lbs.	5.596	7.308
Saturated Weight, lbs	5.662	7.4
Dry Weight, lbs.	5.228	6.894
Core Volume, ft^3	0.0396	0.0510
Absorbed Water, ft^3	0.0070	0.0081
Saturated Unit Weight, lbs/ft^3	142.90	145.00
Dry Unit Weight, lbs/ft^3	132.02	135.18
Porosity, %	17.55	15.89

SHAFT 1-3

	SAMPLE 1	SAMPLE 2
Depth, ft.	8	11
Diameter, in.	3.281	3.289
Core Length, in.	8.125	11.875
Initial Weight, lbs.	5.726	8.332
Saturated Weight, lbs	5.8	8.432
Dry Weight, lbs.	5.418	7.856
Core Volume, ft^3	0.0398	0.0584
Absorbed Water, ft^3	0.0061	0.0092
Saturated Unit Weight, lbs/ft^3	14.90	144.40
Dry Unit Weight, lbs/ft^3	136.29	134.55
Porosity, %	15.40	15.81

SHAFT 2-2

	SAMPLE 1	SAMPLE 2
Depth, ft.	2.5	6
Diameter, in.	3.285	3.282
Core Length, in.	8.875	10
Initial Weight, lbs.	6.144	6.826
Saturated Weight, lbs	6.216	6.918
Dry Weight, lbs.	5.716	6.324
Core Volume, ft^3	0.0435	0.0490
Absorbed Water, ft^3	0.0080	0.0095
Saturated Unit Weight, lbs/ft^3	142.80	141.30
Dry Unit Weight, lbs/ft^3	131.31	129.17
Porosity, %	18.41	19.44

SHAFT 4-2

	SAMPLE 1	SAMPLE 2
Depth, ft.	2	9
Diameter, in.	3.266	3.268
Core Length, in.	10	11
Initial Weight, lbs.	6.816	7.542
Saturated Weight, lbs	6.916	7.632
Dry Weight, lbs.	6.36	7.086
Core Volume, ft^3	0.0485	0.0534
Absorbed Water, ft^3	0.0089	0.0087
Saturated Unit Weight, lbs/ft^3	142.70	142.90
Dry Unit Weight, lbs/ft^3	131.18	132.71
Porosity, %	18.38	16.39

SHAFT 4-3

	SAMPLE 1	SAMPLE 2
Depth, ft.	2.5	6.5
Diameter, in.	3.273	3.269
Core Length, in.	9.5	12
Initial Weight, lbs.	6.604	8.046
Saturated Weight, lbs	6.696	8.166
Dry Weight, lbs.	6.172	7.452
Core Volume, ft^3	0.0463	0.0583
Absorbed Water, ft^3	0.0084	0.0114
Saturated Unit Weight, lbs/ft^3	144.80	140.10
Dry Unit Weight, lbs/ft^3	133.43	127.85
Porosity, %	18.15	19.63

ASTM C 642 TEST RESULTS

SAMPLE NUMBER	WEIGHT A	WEIGHT B	WEIGHT C	WEIGHT D	ABSORPTION AFTER IMMERSION	ABSORPTION AFTER IMMERSION & BOILING
A1	785.0	848.4	849.5	468.6	8.08%	8.22%
A2	779.3	830.1	832.4	466.0	6.52%	6.81%
A3	838.6	906.3	907.5	498.0	8.07%	8.22%
A4	845.6	915.8	917.7	504.7	8.30%	8.53%
A5	837.9	897.4	898.5	504.4	7.10%	7.23%

BULK SP GR DRY	BULK SP GR AFTER IMMERSION	BULK SP GR AFTER IMMERSION & BOILING	APPARENT SP GR	VOLUME OF PERMEABLE PORE SPACE (VOIDS)
2.06	2.23	2.23	2.48	16.93%
2.13	2.27	2.27	2.49	14.49%
2.05	2.21	2.22	2.46	16.83%
2.05	2.22	2.22	2.48	17.46%
2.13	2.28	2.28	2.51	15.38%

CORRELATION TABLES

GAMMA-GAMMA COUNTS PER SECOND	COMPRESSIVE STRENGTH (p.s.i.)
5000	5770
5000	5530
4700	5160
4650	6970
4550	3170

NEUTRON-NEUTRON COUNTS PER SECOND	COMPRESSIVE STRENGTH (p.s.i.)
390	3170
380	6970
360	5530
350	5770
350	5160

GAMMA-GAMMA COUNTS PER SECOND	ABSORPTION PERCENT
5010	8.2
4980	8.2
4700	6.8
4600	8.5
4550	7.2

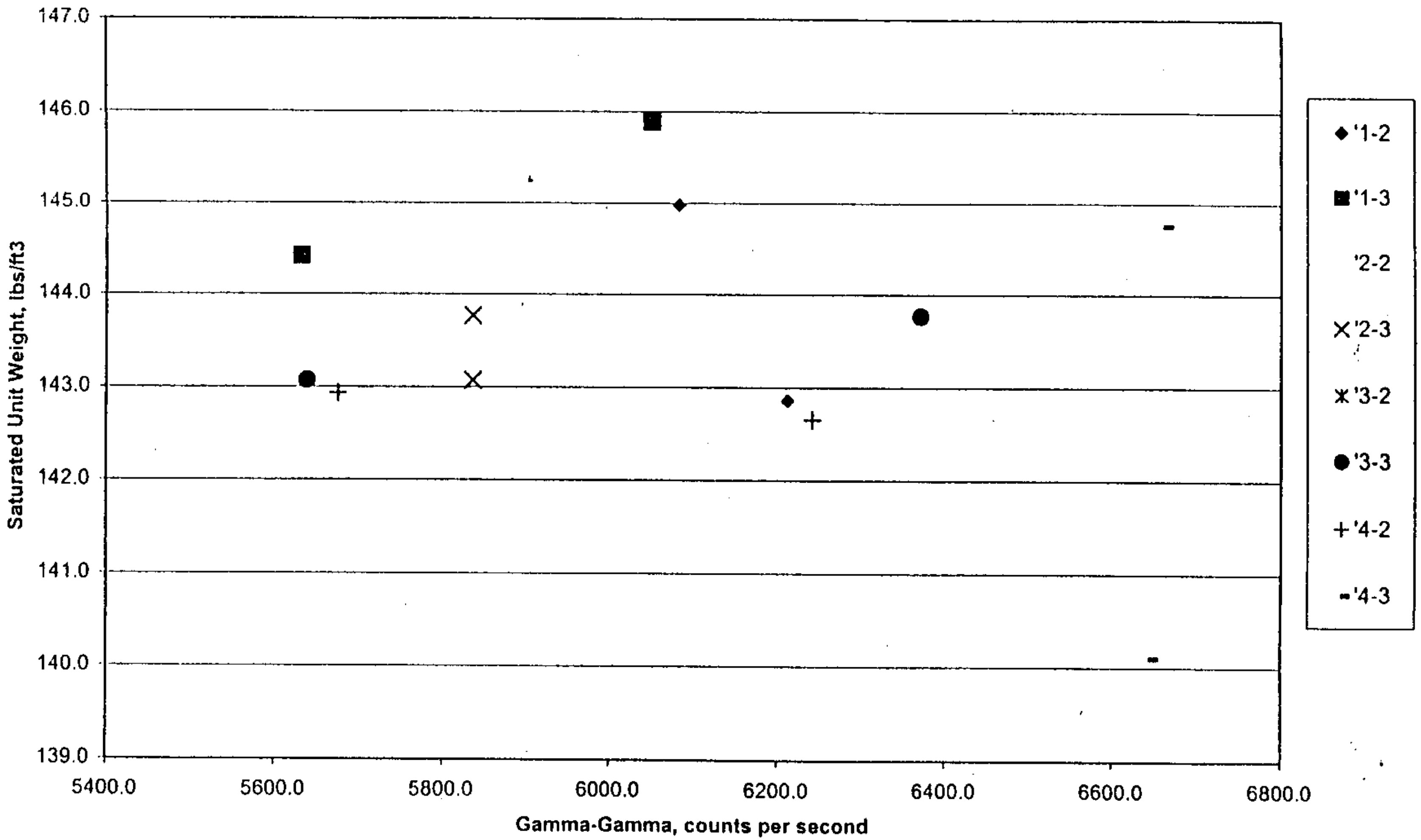
NEUTRON-NEUTRON COUNTS PER SECOND	ABSORPTION PERCENT
400	6.8
400	7.2
360	8.5
330	8.2
200	8.2

GAMMA-GAMMA COUNTS PER SECOND	SPECIFIC GRAVITY
5010	2.46
4980	2.48
4700	2.49
4600	2.48
4550	2.51

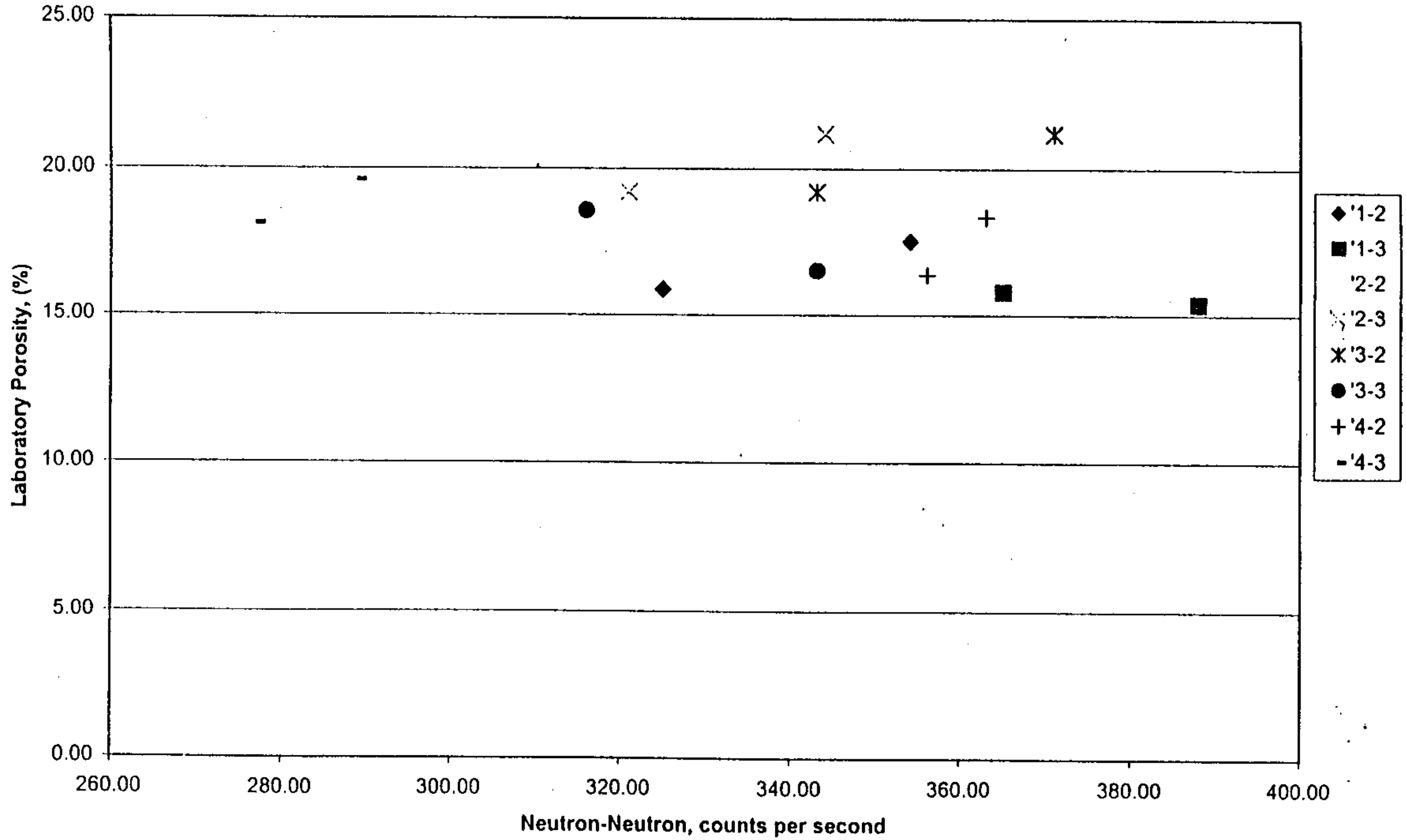
NEUTRON-NEUTRON COUNTS PER SECOND	SPECIFIC GRAVITY
400	2.51
400	2.49
360	2.48
330	2.46
200	2.48

GAMMA-GAMMA COUNTS PER SECOND	PERCENT VOIDS
5010	16.8
4980	16.9
4700	14.5
4600	17.5
4550	15.4

NEUTRON-NEUTRON COUNTS PER SECOND	PERCENT VOIDS
400	14.5
400	15.4
360	17.5
330	16.8
200	16.9



GRAPH 1. Laboratory Saturated Unit Weight vs. Gamma-Gamma



GRAPH 2. Laboratory Porosity vs. Neutron-Neutron

SHAFT ID	SAMPLE No.	DEPTH (ft)	LABORATORY SATURATED UNIT WEIGHT (lbs/ft³)	GAMMA-GAMMA counts per second	LABORATORY POROSITY (%)	NEUTRON-NEUTRON counts per second
1-2	1	2.5	[illegible]	6212.0	17.55	354.00
	2	12	145.0	6083.0	15.89	325.00
1-3	1	8	145.9	6051.0	15.40	388.00
	2	11	144.4	5632.0	15.81	365.00
2-2	1	2.5	142.8	6238.0	18.41	350.00
	2	6	[illegible]	5602.0	19.44	378.00
2-3	1	3.5	141.0	5836.0	19.22	321.00
	2	7.5	139.8	5836.0	21.17	344.00
3-2	1	2.5	143.8	6370.0	18.59	343.00
	2	13	143.1	5839.0	18.54	371.00
3-3	1	3	142.1	6444.0	19.37	316.00
	2	12.5	143.5	5864.0	18.30	343.00
4-2	1	2	142.7	6241.0	18.38	363.00
	2	9	142.9	5676.0	18.39	356.00
4-3	1	2.5	[illegible]	6662.0	18.15	277.00
	2	6.5	140.1	6646.0	19.63	289.00

TABLE 1. Summary of Laboratory Saturated Unit Weight and Laboratory Porosity Including Gamma-Gamma and Neutron-Neutron field values.

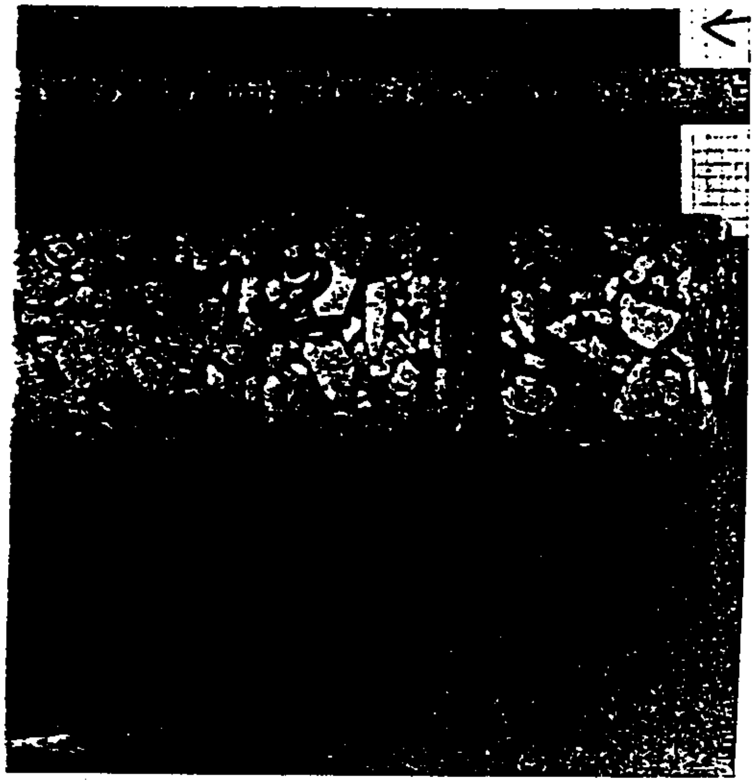


Photo No.3 Drilled Shaft 1-2 (Top Row). Drilled Shaft 1-3 core used for compression test. Core Depth = 4.5-5 ft.

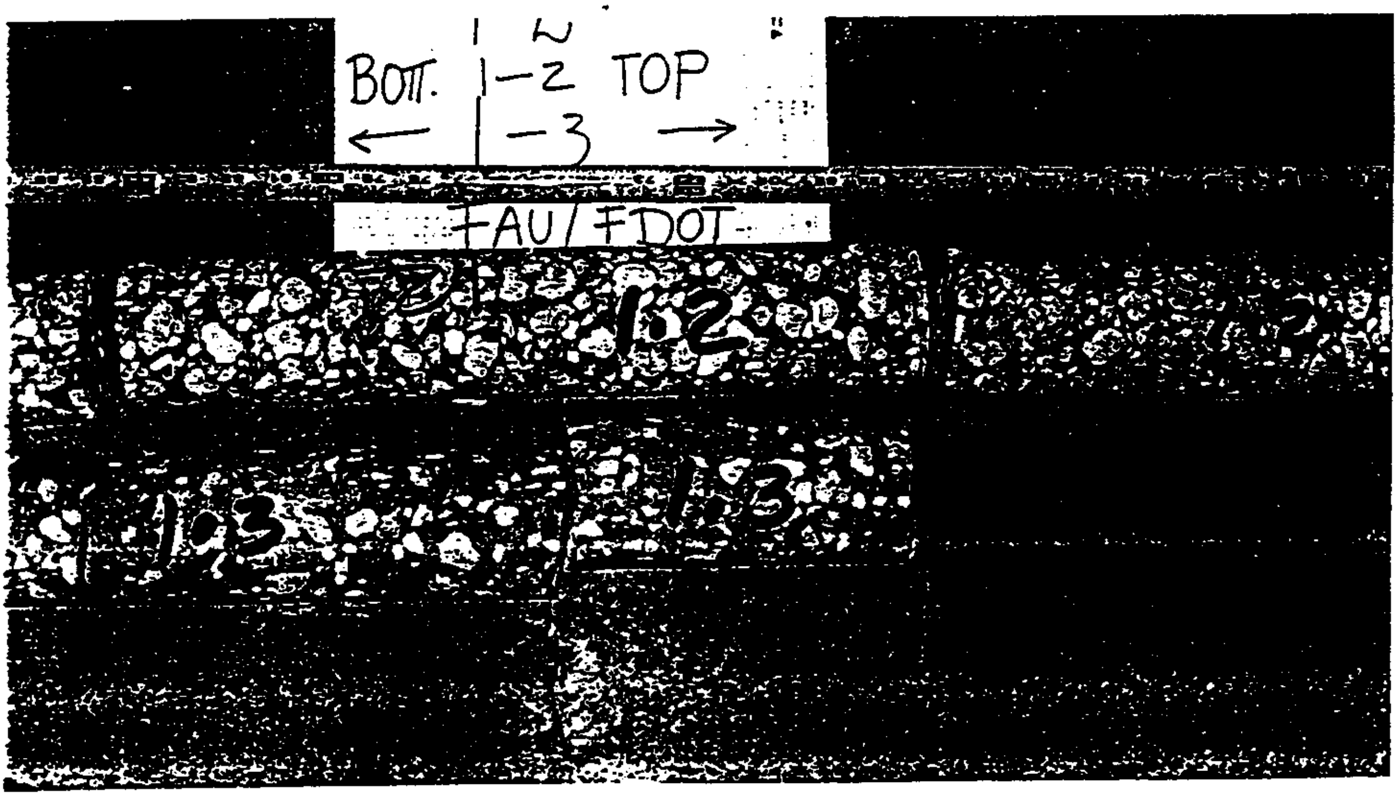


Photo No.4 Drilled Shaft 1-2 (Top Row), Drilled Shaft 1-3 (Bottom Row). Core Depth = 5-7 ft.

TABLE 4. Visual Observation Drilled Shaft 2-2

DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	Sign of aggregate segregation on the first 4-1/2-5 feet. Air voids are well distributed and ranging in size from 1/16" to 3/8". No sign of honeycomb.
5 - 10	Aggregates are well distributed with some small air void, ranging in size from 1/16" to 1/8". No sign of honeycomb or aggregate segregation.
10 - 15	Aggregates are well distributed with some small air void, ranging in size from 1/16" to 1/8". No sign of honeycomb or aggregate segregation

TABLE 5. Visual Observation Drilled Shaft 2-3

DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	Sign of aggregate segregation on the first 1-2 foot. Presence of honeycombing at a depth of 4-5 feet.
5 - 10	Aggregates appear well distributed. There is well distribution of air voids and no sign of honeycomb or aggregate segregation.
10 - 15	Aggregates are well distributed, no sign of honeycomb. Some air voids ranging in size from 1/16" to 1/8".

TABLE 6. Visual Observation of Drilled Shaft 3-2

DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	Sign of aggregate segregation on the first 1 foot. Sign of honeycomb on the first 2 feet.
5 - 10	Aggregates are well distributed with some small air void, ranging in size from 1/16" to 1/8". Segregation observed within the first two feet.
10 - 15	Aggregates are well distributed with some small air void in the aggregates. No sign of honeycomb or aggregate segregation

TABLE 7. Visual Observation of Drilled Shaft 3-3

DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	No sign of aggregate segregation or honeycomb. Small air voids were observed in the aggregates.
5 - 10	Segregation observed within the first two feet. Aggregates are poorly distributed. Some air voids are present, ranging in size from 1/16" to 1/8". No sign of honeycomb.
10 - 15	Aggregate and air voids are well distributed, no sign of honeycomb or aggregate segregation was observed.

TABLE 8. Visual Observation of Drilled Shaft 4-2

DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	No sign of aggregate segregation or honeycomb. A small amount of air voids up to 1/8" in size were observed.
5 - 10	No sign of aggregate segregation or honeycomb. A small amount of air voids up to 1/8" in size were observed
10 - 15	No sign of aggregate segregation or honeycomb. A small amount of air voids up to 1/8" in size were observed.

TABLE 9. Visual Observation of Drilled Shaft 4-3

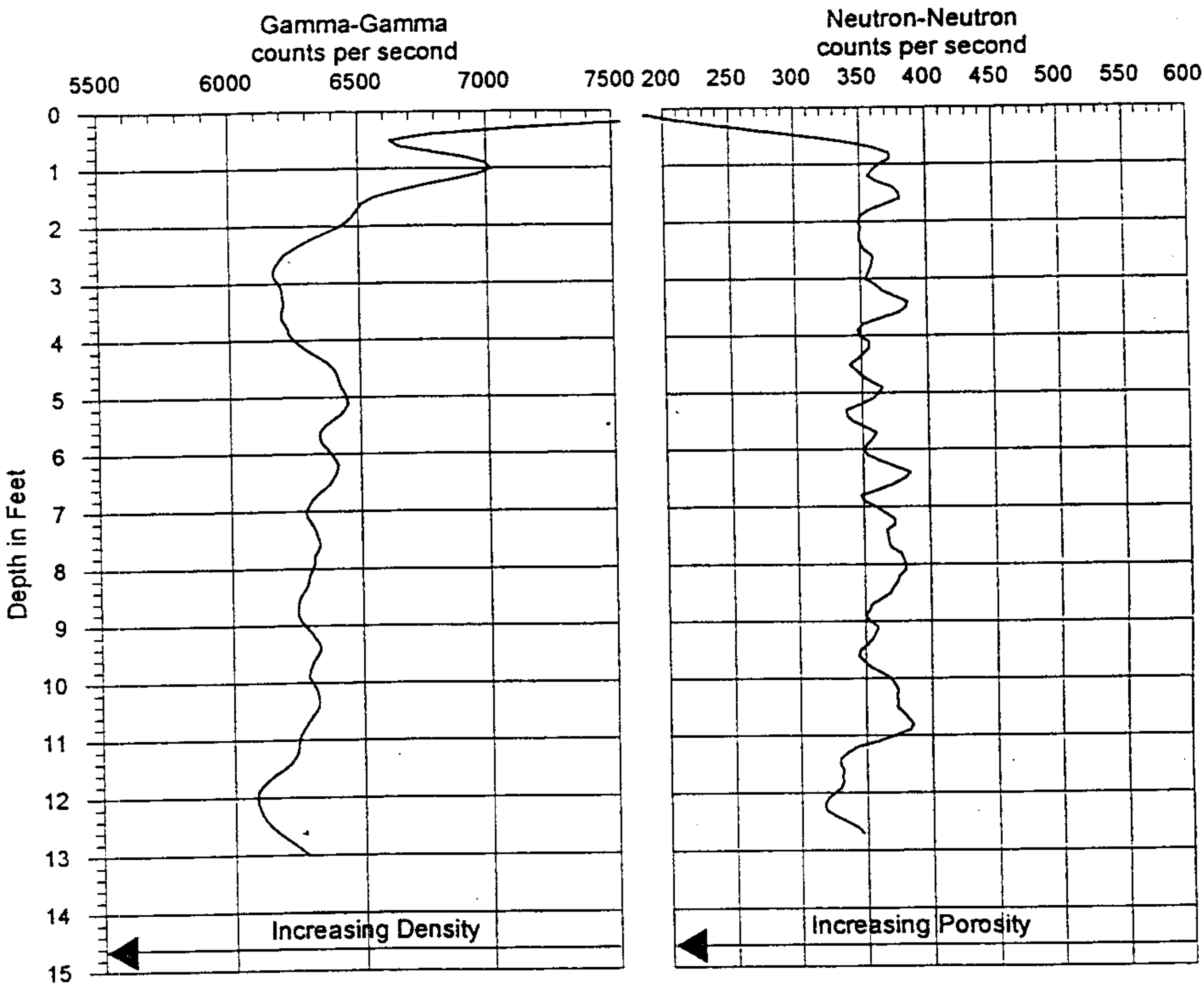
DEPTH (FT)	CONCRETE DESCRIPTION
0 - 5	Sign of aggregate segregation and honeycomb was observed within the first two feet. Air voids range in size from 1/16" to 1/8".
5 - 10	No aggregate segregation was observed. Some air voids are present, ranging in size from 1/16" to 1/8". Presence of honeycomb was not observed.
10 - 15	No aggregate segregation was observed. Some air voids are present, ranging in size from 1/16" to 1/8". Presence of honeycomb was not observed.

APPENDIX I

GEOPHYSICAL LOGGING

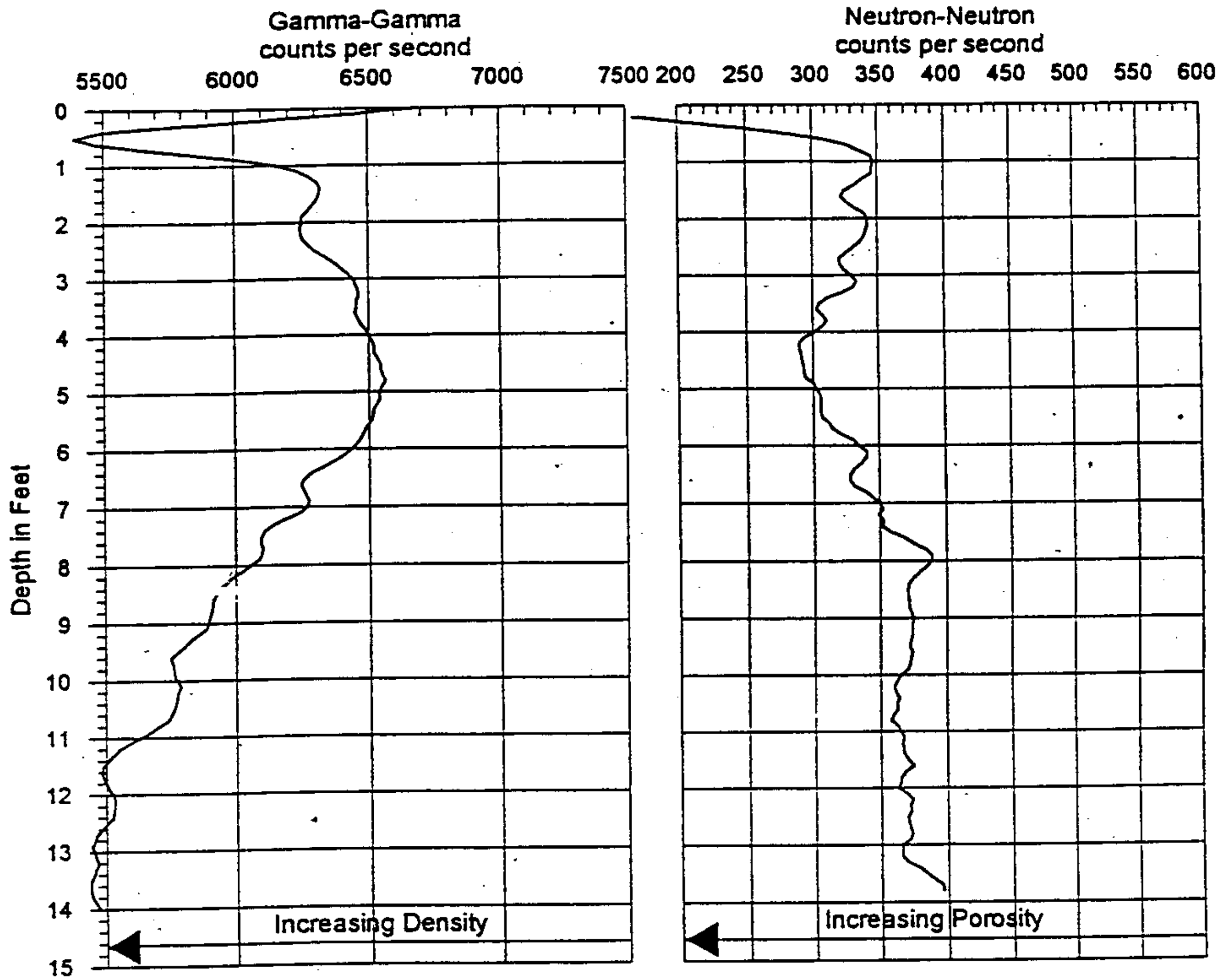
γ-γ DENSITY AND NEUTRON –NEUTRON POROSITY

1.2

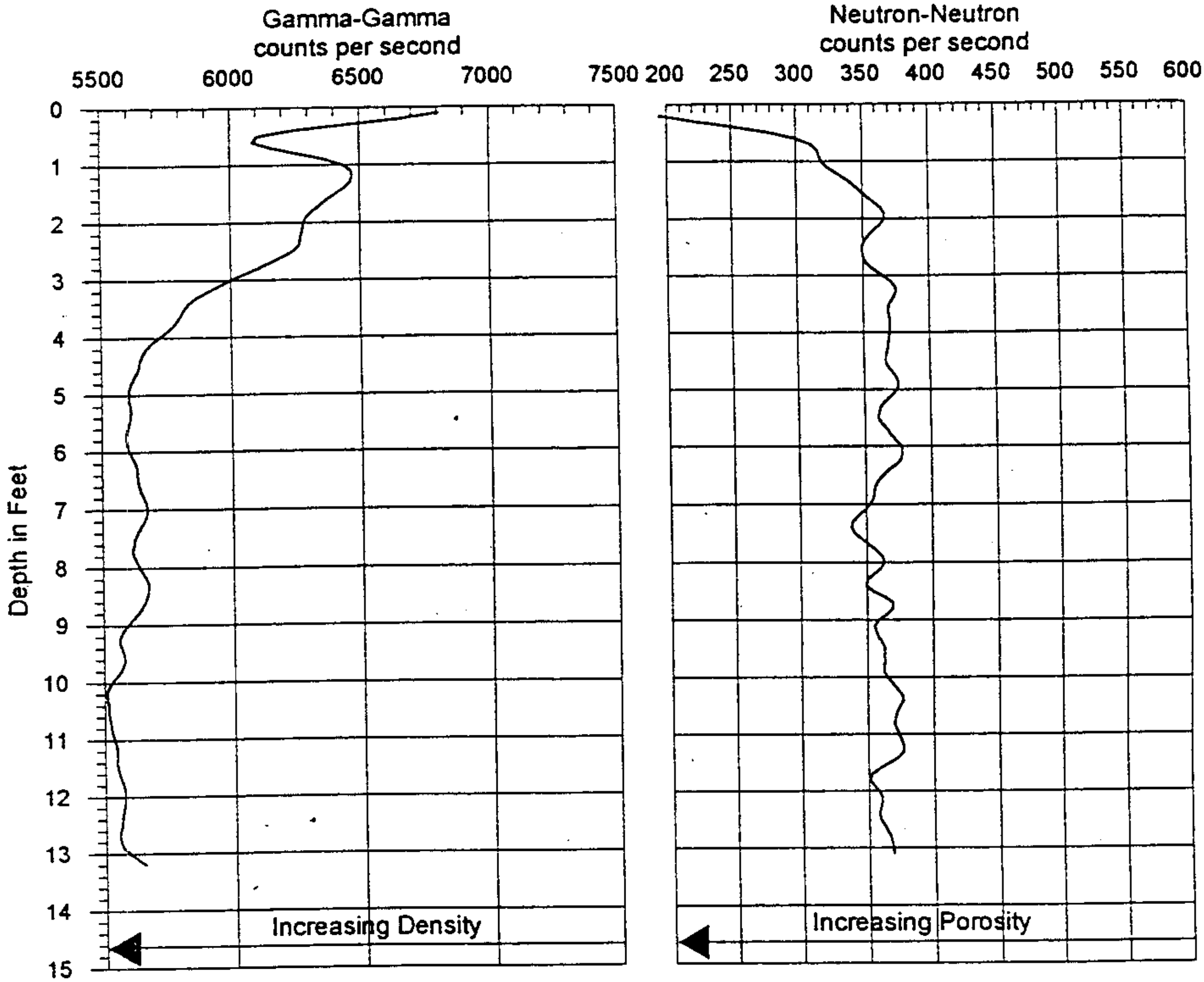

Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

TECHNOS

1.3

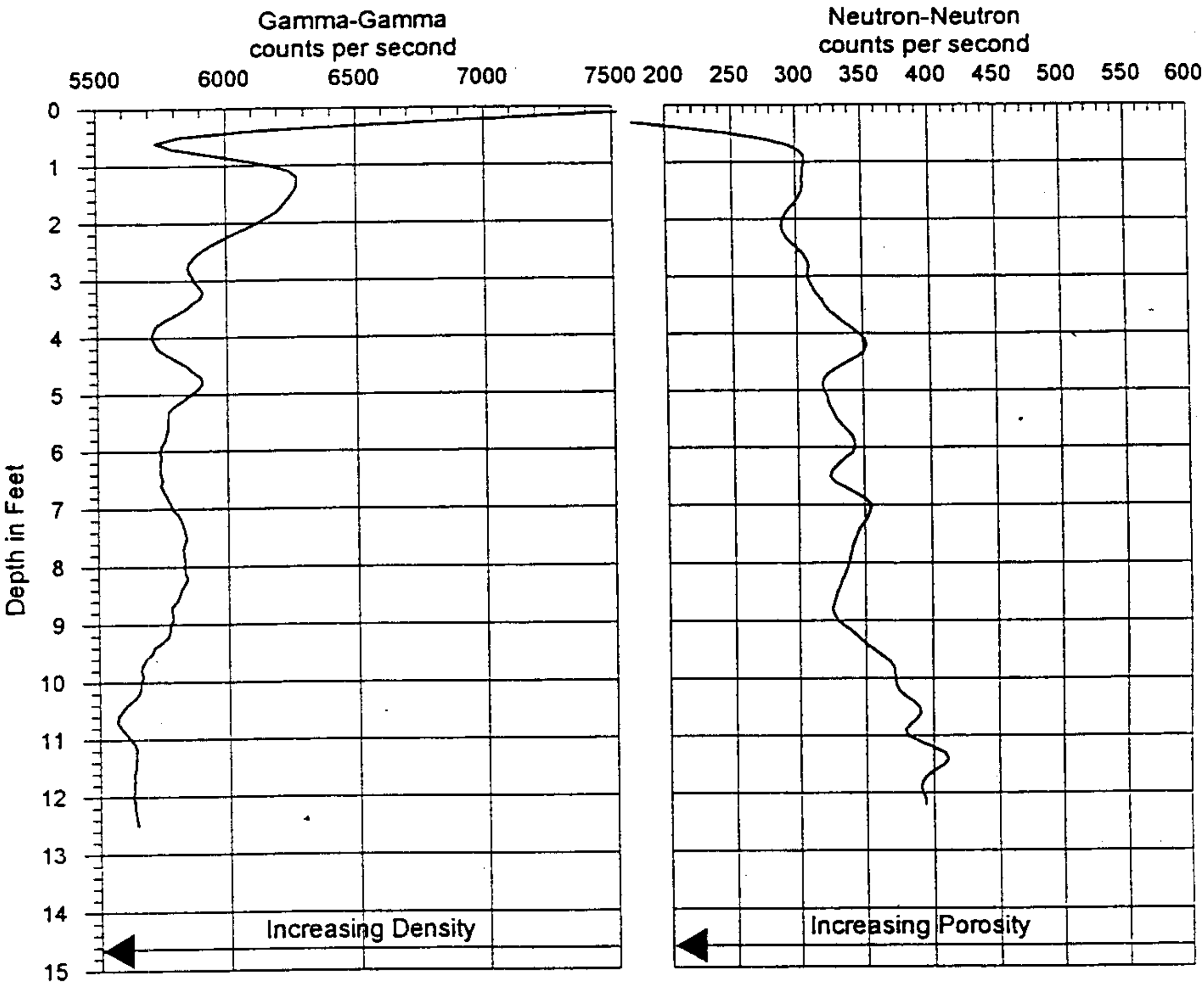

Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

2.2



Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

2.3


Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
0
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2
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9
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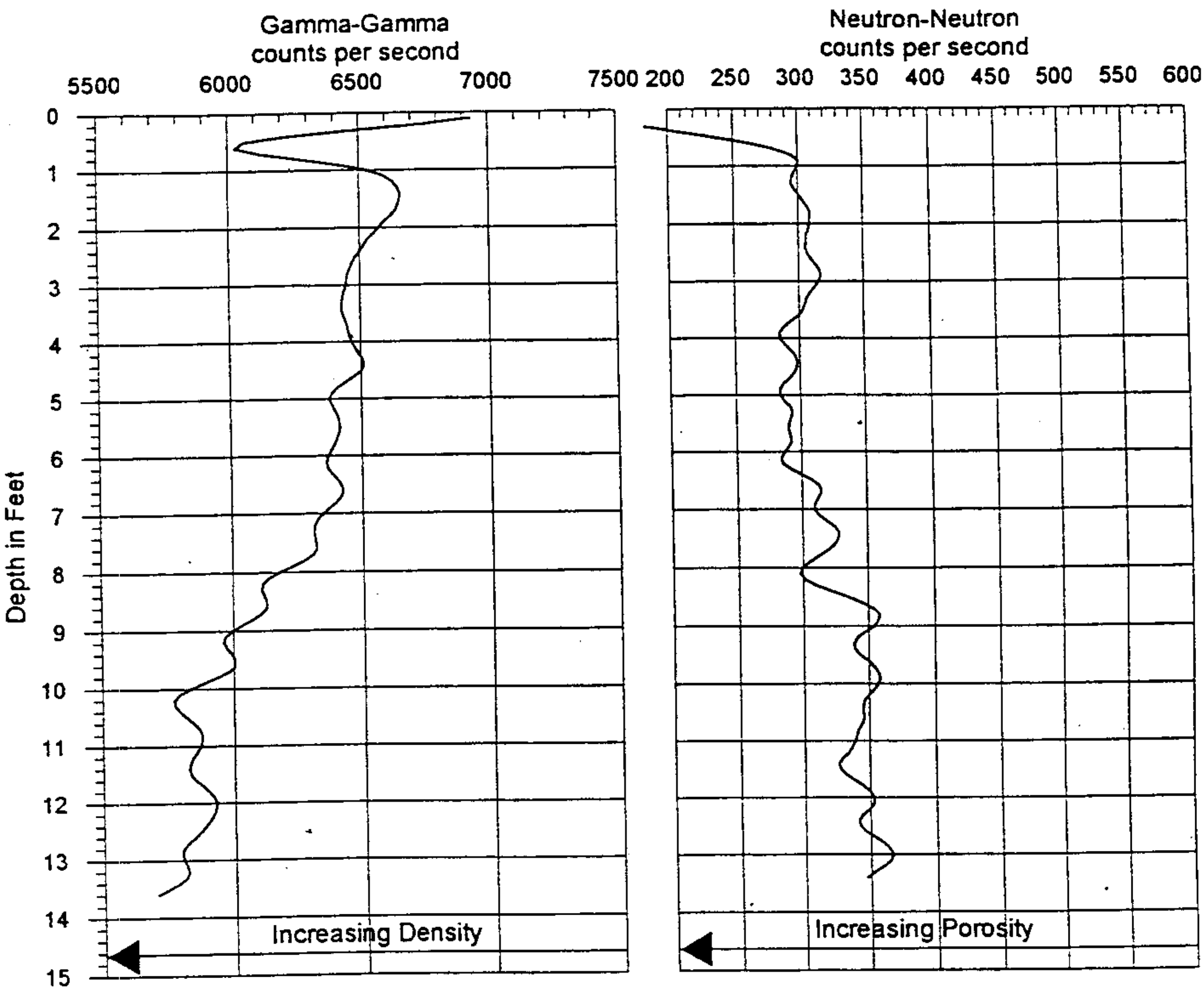
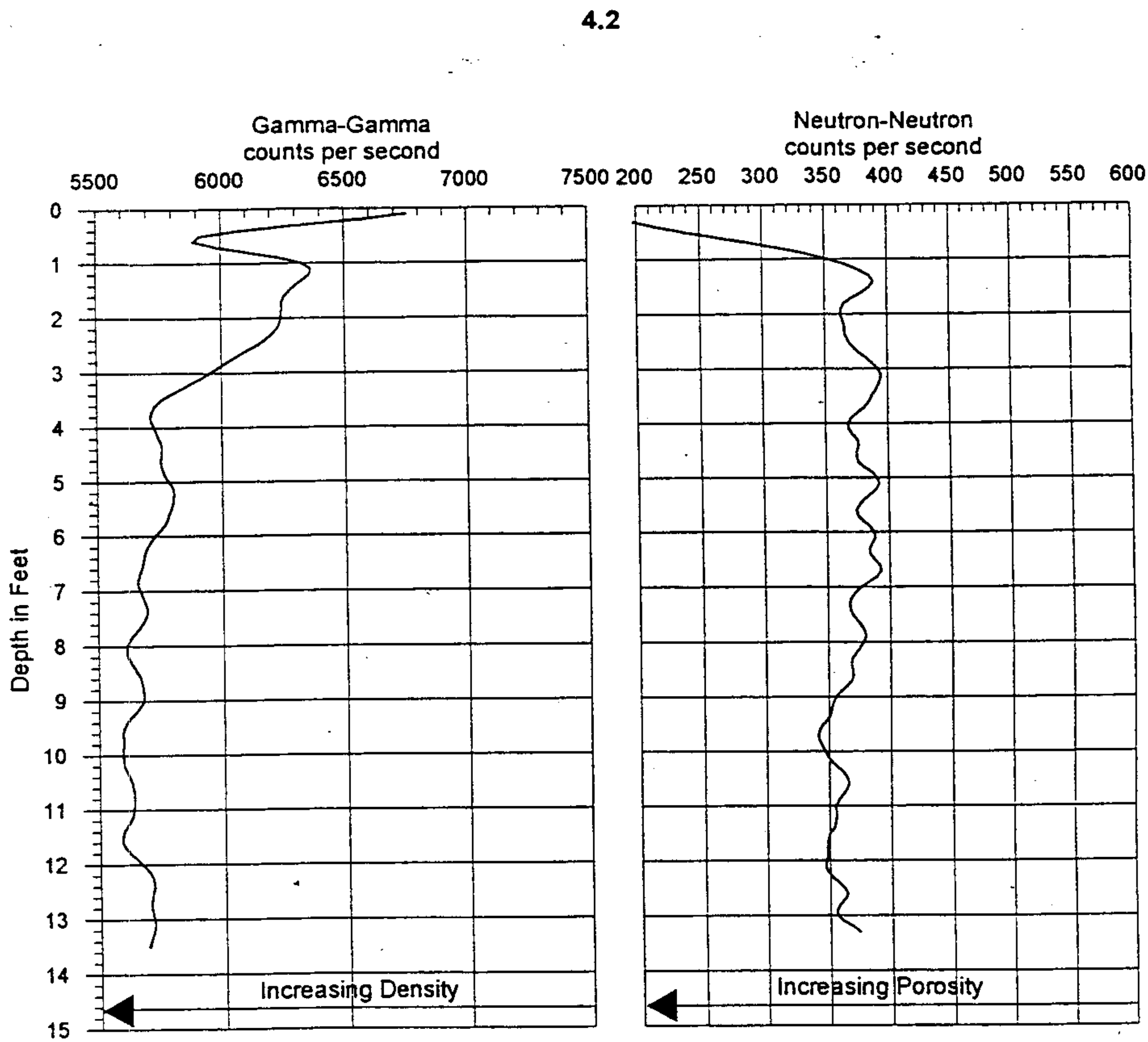
11
12
13
14
15
Depth in Feet
Increasing Density
Increasing Porosity

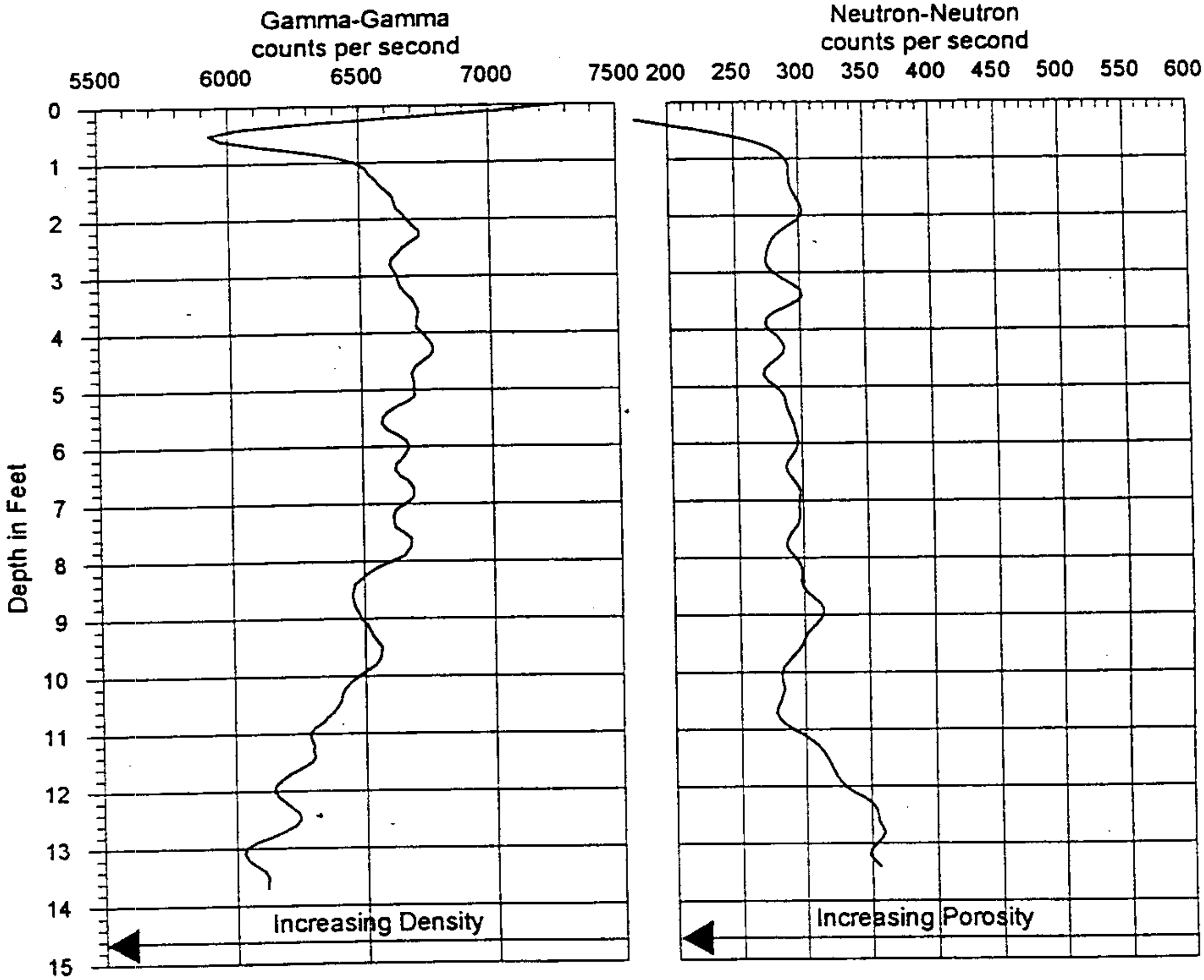
TECHNOS

3.3


Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity


4.2
Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

TECHNOS


Gamma-Gamma
counts per second
5500
6000
6500
7000
7500
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
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2
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7
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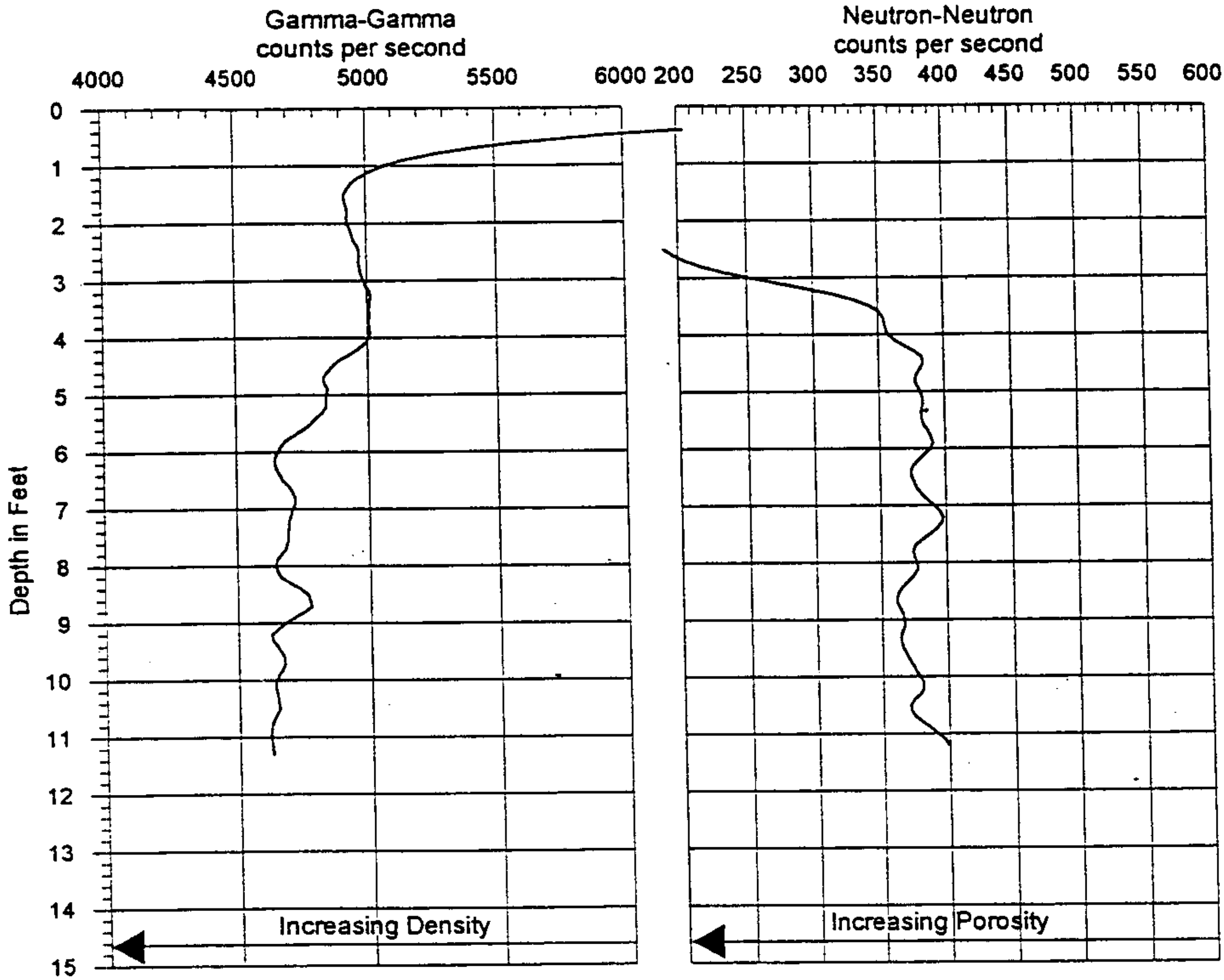
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

TECHNOS

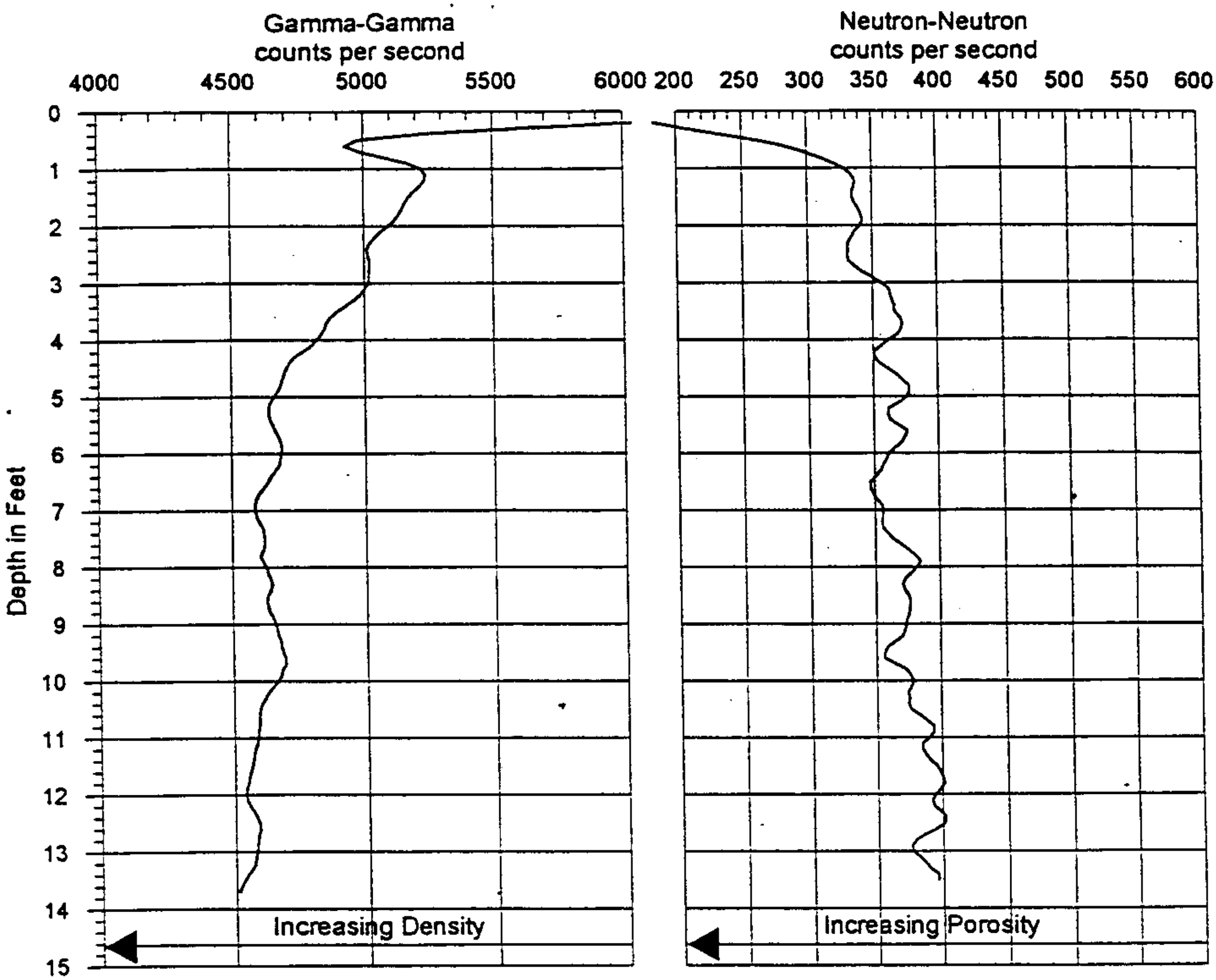
5.2



Gamma-Gamma
counts per second
4000
4500
5000
5500
6000
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
Depth in Feet
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
Increasing Density
Increasing Porosity

TECHNOS

5.3


Gamma-Gamma
counts per second
4000
4500
5000
5500
6000
Neutron-Neutron
counts per second
200
250
300
350
400
450
500
550
600
0
1
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3
4
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14
15
Depth in Feet
Increasing Density
Increasing Porosity

Appendix J

LAW Engineering and Environmental Services, Inc.

July 15, 1999

Mr. Tom Pierro
Florida Atlantic University
Department of Ocean Engineering
Building 36
7777 Glades Road
Boca Raton, Florida 33431

RE: **Report of Pile Driver Noise Impact and Insertion Loss Analysis**
Florida Atlantic University
Boca Raton, Florida
LAW Project No. 40750-9-198S

Dear Mr. Pierro:

Law Engineering and Environmental Services, Inc. (LAWGIBB) is pleased to present the Florida Atlantic University with the results of the Pile Driver Noise Impact and Insertion Loss Analysis conducted on July 8-9, 1999 at the Florida Atlantic University Campus in Boca Raton. Our services were conducted in general accordance with our proposal number 7248-sf dated June 1, 1999. The purpose of this analysis was to establish the noise impact associated with diesel hammer pile driving activities and to determine the insertion loss (noise reduction) associated with the installation of an acoustical blanket at distances of fifty feet, one hundred feet, and three hundred feet.

Noise Analysis Methodology

For the purposes of this analysis, an array of Quest 2900 Type II Sound Level Meters were installed at an angle from the diesel hammer pile driver as depicted on the attached figure. The sound level meters were placed at the following distances from the diesel hammer pile driver: 50 feet, 100 feet, and 300 feet. The sound level meters on the west leg of the array were installed on PVC piping supported by a concrete base at a height of approximately15 feet above ground level. The sound level meters on the east leg of the array were held by field personnel at a height of 5 feet above ground level.. A CEL 593 Real Time One Third Octave (OTO) Band Analyzer was placed at a distance of 100 feet from the diesel hammer pile driver at a location between both of the legs as depicted on the attached figure. This sound level meter was held by field personnel at a height of five feet above ground level. The sound level meters were calibrated prior to the commencement of the pile driving activities. Upon completion of the set up and installation of the sound level meters, field noise monitoring was conducted to establish the noise impact associated with the diesel hammer pile driver. The purpose of this phase of the analysis was to evaluate the magnitude of the noise impact prior to the installation or an acoustical blanket. The next phase of the analysis was conduct field noise monitoring with the acoustical blanket in place. The purpose of this phase of the analysis was to evaluate the magnitude of the insertion loss (noise reduction) associated with the acoustical.

LAW Engineering and Environmental Services Inc
2104 Corporate Drive • Boynton Beach, FL 33426
561-742-0371 • Fax 561-742-0875

Noise Analysis Results

The following table depicts the noise impact associated with the pile driver and the insertion loss (noise reduction) associated with the acoustical blanket. The field noise monitoring data obtained from the Quest 2900 Sound Level Meters and the CEL 593 Real Time Octave Band Analyzer is attached.

Date	Location	SLM	Distance From Source	Leq (dBA)* w/o Blanket	Leq (dBA)* w/ Blanket	Insertion Loss (dBA)*
7/8/99	West Leg	Quest 2900	50 Ft./ 15 Ft.	84.9	74.5	10.4
7/9/99	West Leg	Quest 2900	50 Ft./ 15 Ft.	85.4	73.5	11.9
7/9/99	West Leg	Quest 2900	100 Ft./15Ft.	78.5	70.1	8.4
7/9/99	West Leg	Quest 2900	100 Ft./15Ft.	79.4	68.8	10.6
7/9/99	West Leg	Quest 2900	300 Ft./15Ft.	73.3	64.5	8.8
7/9/99	West Leg	Quest 2900	300 Ft./15Ft.	74.0	62.8	11.2
7/9/99	East Leg	Quest 2900	50 Ft. / 5 Ft.	91.4	82.4	9.0
7/9/99	East Leg	Quest 2900	50 Ft. / 5 Ft.	89.7	79.7	10.0
7/9/99	East Leg	Quest 2900	100 Ft./ 5 Ft.	81.6	74.8	6.8
7/9/99	East Leg	Quest 2900	100 Ft./ 5 Ft.	81.4	71.7	9.7
7/9/99	East Leg	Quest 2900	300 Ft./ 5 Ft.	76.3	69.9	6.4
7/9/99	East Leg	Quest 2900	300 Ft./ 5 Ft.	75.7	70.1	5.6
7/8/99	Center	CEL 593	100 Ft. / 5Ft.	90.8	88.7	2.1
7/9/99	Center	CEL 593	100 Ft. / 5Ft.	88.9	85.5	3.4

* Leq is defined as the hourly average sound level over the entire monitoring period measured in decibels on the A weighted scale (dBA).

Noise Analysis Conclusions

The results of this analysis indicate that the noise impacts associated with the diesel hammer pile driver will require the implementation of noise abatement measures for construction activities adjacent to noise sensitive locations such as residential dwellings, hotels, and any other locations where noise impacts may disrupt normal human activity. Based upon the results of this analysis, noise abatement measures should be considered for noise sensitive locations within three hundred feet of the construction site where diesel hammer pile driving activities are to take place. One feasible on-site noise abatement measure is installing an acoustical blanket on the piledriver assembly. The results of the acoustical blanket utilized in this study indicated that the insertion loss at fifty feet was approximately 10 – 12 dBA at a height of 15 feet while the insertion loss at the same distance at a height of 5 feet was approximately 9 – 10 dBA. The insertion loss at one hundred feet was approximately 8 – 11 dBA at a height of 15 feet while the insertion loss at the same distance at a height of 5 feet was approximately 7 – 10 dBA. Finally the insertion loss at three hundred feet was approximately 9 – 11 dBA at a height of 15 feet while the insertion loss at the same distance at a height of 5 feet was approximately 6 dBA. The results of the real time octave band analysis at a distance of one hundred feet at a height of 5 feet indicated that the insertion loss was approximately 2 – 3 dBA. At this location, the noise monitoring point was directly within the line of sight of the pile driver. While the acoustical blanket provided a respectable level of noise reduction, modifications would be required to provide the optimum noise reduction. The acoustical blanket under study was assembled in ten foot panels and then attached to a metal frame. The assembly time (approximately 3 hours) was lengthy enough to potentially cause delays in the contractor's schedule. Also, the ten foot panels left gaps within the acoustical blanket assembly that likely reduced the insertion loss achieved. Therefore, the following modifications should be consider: single blanket construction with no gaps, cylindrical frame construction to fit around the pile driver, and an enclosure over the top of the pile driver. These modifications should also reduce the on-site installation time, which will be of benefit to the construction contractor.

It has been a pleasure serving you on this project. Should you have any questions, please feel free to contact us at (561) 742-0871.

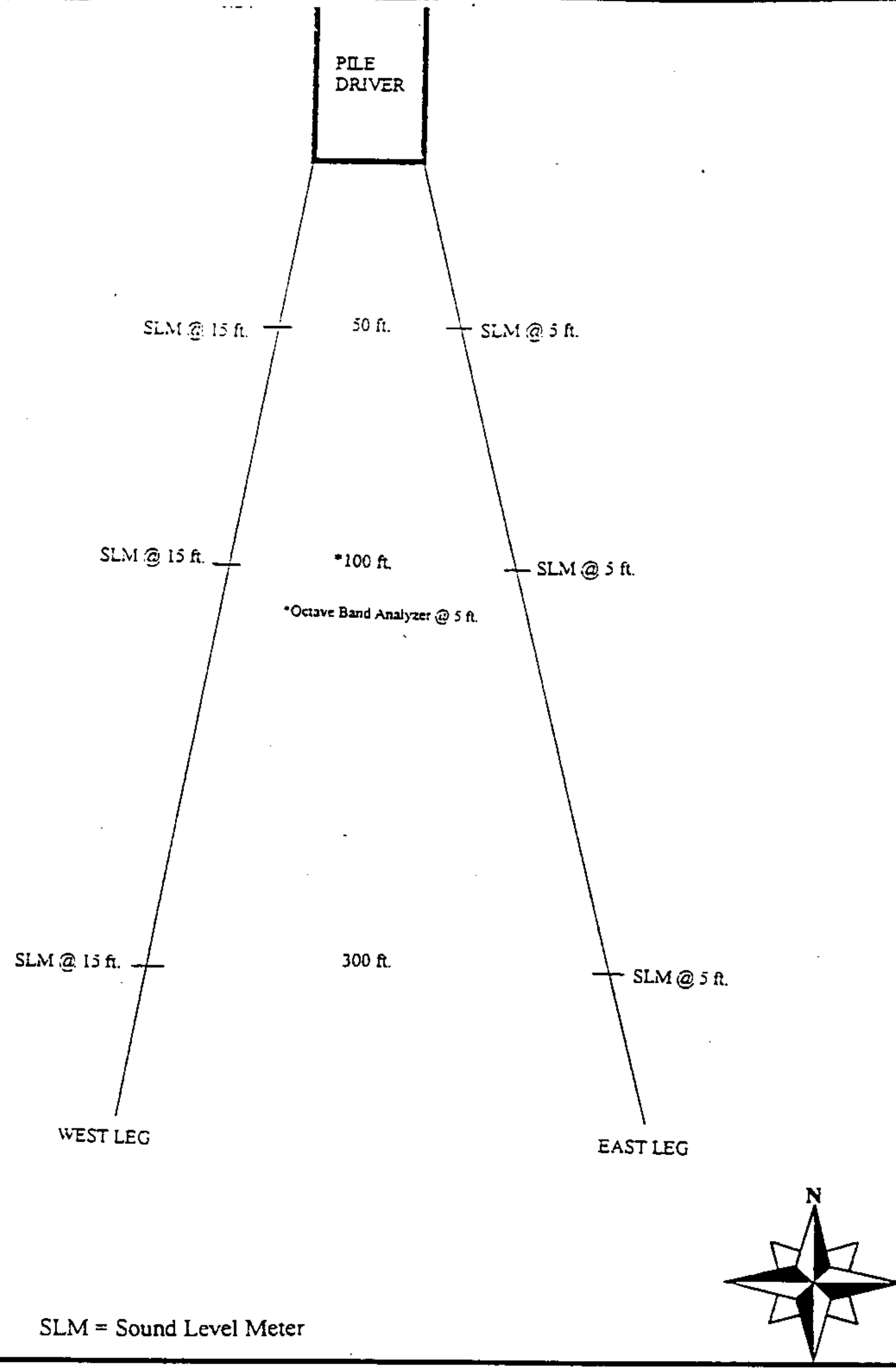
Very Truly Yours,

Bernard Kinney Jr.
Senior Acoustical Engineer
Environmental Noise Control

Scott G. Evanson, P.G.
Principal Geologist

Attachments: Figure 1 – Noise Monitoring Locations
Eastern Leq Quest 2900 Field Data
Western Leq Quest 2900 Field data
Octave Band analyzer Data Sheets

Figure 1
Noise Monitoring Locations



-ce: *Site Reconnaissance*

le: *Not to Scale*

SLM = Sound Level Meter

LAW

.WGIBB Group Member

Law Engineering and Environmental Services, Inc.
2104 Corporate Drive
Boynton Beach, Florida 33426
(561) 742-0871
Fax 742-0875

Figure 1

NOISE MONITORING LOCATIONS

Florida Atlantic University
Boca Raton, Florida

LAW Project No. 40750-9-1988

Eastern Leq Quest 2900 Field Data

Quest Technologies
2900 Integrating/Logging Sound Level Meter

Unit Version Number: 02.2　　Serial Number: CD7120036
Name: FAU ACOUSTIC PILE DRIVE ANALYSIS

Work Area: FIVE FEET HIGH - FIFTY FEET AWAY

Comments:

Meter Calibration: 114.0dB, 7/7/99 @ 11:39:30

Calibrator Serial Number:

Calibration Date:

Study 1

Measuring Parameters

Range: 60 - 120 dB	Weighting: A	Time Constant: Fast
Threshold: Off	Exchange Rate: 3dB	Peak Weighting: A

Study Started: 7/8/99 @ 12:26:23
Study Stopped: 7/8/99 @ 12:30:07
Run Time: 0:03:43
Peak Level: 129.0dB, 7/8/99 @ 12:29:30
Max Level: 105.7dB, 7/8/99 @ 12:29:29
Min Level: 51.6dB, 7/8/99 @ 12:26:55
Overload: 0.31%

LEQ: 91.4dB	SEL(3):114.9dB	TWA: 70.3dB	TAKM3: 100.2dB
LDN: 91.4dB	CNEL: 91.4dB	Pa2Sec: 121.7	
L5: 99.3dB	L10: 97.0dB	L50: 74.1dB	L90: 58.0dB

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
12:26:38	61.7dB	68.9dB	83.2dB	65.2dB	56.1dB	
12:26:53	72.1dB	84.5dB	97.7dB	75.8dB	57.5dB	
12:27:08	70.2dB	85.7dB	99.0dB	74.8dB	54.9dB	
12:27:23	71.0dB	80.1dB	97.2dB	74.6dB	60.8dB	
12:27:38	67.2dB	75.0dB	89.1dB	71.5dB	58.5dB	
12:27:53	62.2dB	71.1dB	86.8dB	65.5dB	56.2dB	
12:28:08	62.8dB	68.9dB	82.1dB	66.5dB	55.5dB	
12:28:23	88.2dB	103.9dB	125.5dB	91.0dB	65.5dB	*
12:28:38	94.5dB	103.4dB	125.4dB	99.3dB	78.6dB	*
12:28:53	94.6dB	104.0dB	125.7dB	99.7dB	78.5dB	*
12:29:08	95.5dB	105.3dB	127.2dB	100.5dB	78.2dB	*
12:29:23	94.2dB	104.3dB	125.1dB	99.1dB	76.5dB	*
12:29:38	94.3dB	105.7dB	129.0dB	99.2dB	75.7dB	*
12:29:53	94.6dB	104.0dB	126.1dB	99.4dB	76.8dB	*

Study 2

Measuring Parameters

Range: 60 - 120 dB
Weighting: A
Time Constant: Fast
Threshold: Off
Exchange Rate: 3dB
Peak Weighting: A

Study Started: 7/9/99 @ 06:34:09
Study Stopped: 7/9/99 @ 06:41:30
Run Time: 0:07:20
Peak Level: 117.8dB, 7/9/99 @ 06:40:39
Max Level: 98.5dB, 7/9/99 @ 06:40:42
Min Level: 51.6dB, 7/9/99 @ 06:37:26
Overload: 0.00%

LEQ: 81.4dB	SEL(3):107.8dB	TWA: 63.2dB	TAKM3: 89.3dB
LDN: 91.4dB	CNEL: 91.4dB	Pa2Sec: 24.0	
L5: 89.5dB	L10: 82.6dB	L50: 66.3dB	L90: 57.7dB

Study 2

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
06:34:24	76.1dB	88.8dB	103.0dB	80.1dB	64.3dB	
06:34:39	71.3dB	80.7dB	94.0dB	76.0dB	60.6dB	
06:34:54	67.3dB	74.4dB	88.1dB	70.7dB	62.8dB	
06:35:09	65.6dB	74.9dB	85.6dB	69.0dB	59.3dB	
06:35:24	67.5dB	76.6dB	88.0dB	71.7dB	59.6dB	
06:35:39	67.6dB	75.2dB	87.0dB	71.2dB	61.7dB	
06:35:54	73.0dB	84.4dB	94.0dB	77.0dB	59.2dB	
06:36:09	72.7dB	86.1dB	97.3dB	76.3dB	58.0dB	
06:36:24	67.6dB	76.1dB	89.2dB	71.9dB	58.0dB	
06:36:39	72.3dB	85.8dB	96.3dB	76.8dB	58.6dB	
06:36:54	64.5dB	74.8dB	85.6dB	68.3dB	58.2dB	
06:37:09	62.9dB	74.8dB	83.0dB	65.0dB	57.1dB	
06:37:24	73.6dB	85.7dB	96.5dB	78.1dB	56.0dB	
06:37:39	58.3dB	73.3dB	83.2dB	60.5dB	51.8dB	
06:37:54	53.8dB	58.0dB	75.2dB	55.3dB	51.8dB	
06:38:09	60.6dB	67.3dB	81.3dB	63.0dB	53.7dB	
06:38:24	63.0dB	67.7dB	83.8dB	66.4dB	57.6dB	
06:38:39	67.7dB	69.6dB	83.1dB	68.8dB	66.6dB	
06:38:54	67.5dB	70.8dB	84.9dB	69.1dB	66.0dB	
06:39:09	67.0dB	69.5dB	82.5dB	68.3dB	63.1dB	
06:39:24	64.9dB	73.1dB	90.1dB	65.5dB	63.3dB	
06:39:39	78.0dB	90.9dB	106.7dB	81.3dB	63.4dB	
06:39:54	65.6dB	72.6dB	85.8dB	67.3dB	63.8dB	
06:40:09	86.9dB	95.5dB	114.7dB	91.8dB	72.0dB	
06:40:24	87.7dB	96.3dB	115.9dB	92.3dB	73.2dB	
06:40:39	88.9dB	97.7dB	117.8dB	93.8dB	72.9dB	
06:40:54	88.8dB	98.5dB	117.2dB	93.6dB	72.2dB	
06:41:09	89.1dB	98.1dB	117.3dB	94.6dB	71.1dB	
06:41:24	85.1dB	96.6dB	114.7dB	90.6dB	63.9dB	

Study 3

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off

Weighting: A
Exchange Rate: 3dB

Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 09:10:15
Study Stopped: 7/9/99 @ 09:14:18
Run Time: 0:04:03
Peak Level: 109.3dB, 7/9/99 @ 09:12:49
Max Level: 90.6dB, 7/9/99 @ 09:12:48
Min Level: 56.1dB, 7/9/99 @ 09:14:13
Overload: 0.00%

LEQ: 74.8dB	SEL(3):98.7dB	TWA: 54.1dB	TAKM3: 82.6dB
LDN: 74.8dB	CNEL: 74.8dB	Pa2Sec: 3.0	
L5: 82.1dB	L10: 80.4dB	L50: 65.9dB	L90: 61.3dB

Study 3

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:10:30	71.9dB	84.2dB	98.4dB	75.6dB	63.3dB	
09:10:45	71.2dB	83.5dB	95.8dB	74.3dB	63.6dB	
09:11:00	71.3dB	83.6dB	100.0dB	76.8dB	60.9dB	
09:11:15	62.9dB	67.3dB	82.2dB	64.8dB	61.2dB	
09:11:30	74.7dB	84.7dB	100.9dB	80.3dB	61.5dB	
09:11:45	77.3dB	84.1dB	99.5dB	82.0dB	66.5dB	
09:12:00	77.8dB	86.7dB	103.2dB	82.3dB	66.5dB	
09:12:15	77.4dB	86.6dB	103.6dB	81.9dB	66.1dB	
09:12:30	76.6dB	84.9dB	103.8dB	81.4dB	64.9dB	
09:12:45	77.3dB	84.8dB	103.4dB	82.2dB	64.5dB	
09:13:00	76.0dB	90.6dB	109.3dB	80.6dB	60.8dB	
09:13:15	61.6dB	65.0dB	81.4dB	62.3dB	60.9dB	
09:13:30	61.9dB	63.1dB	77.4dB	62.7dB	61.2dB	
09:13:45	73.0dB	86.8dB	104.7dB	77.2dB	61.2dB	
09:14:00	77.3dB	88.2dB	108.4dB	82.2dB	63.6dB	
09:14:15	75.2dB	88.6dB	109.1dB	80.6dB	61.5dB	

Study 4

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off

Weighting: A
Exchange Rate: 3dB

Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 09:30:17
Study Stopped: 7/9/99 @ 09:38:19
Run Time: 0:08:01
Peak Level: 111.2dB, 7/9/99 @ 09:38:05
Max Level: 90.7dB, 7/9/99 @ 09:38:04
Min Level: 57.7dB, 7/9/99 @ 09:30:54
Overload: 0.00%

LEQ: 71.7dB	SEL(3):98.5dB	TWA: 53.9dB	TAKM3: 79.3dB
LDN: 71.7dB	CNEL: 71.7dB	Pa2Sec: 2.8	
L5: 79.5dB	L10: 75.0dB	L50: 61.7dB	L90: 59.9dB

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:30:32	70.5dB	83.6dB	98.8dB	73.4dB	63.7dB	
09:30:47	71.2dB	82.4dB	93.0dB	74.6dB	63.2dB	
09:31:02	67.2dB	77.5dB	89.7dB	71.1dB	59.2dB	
09:31:17	71.5dB	80.3dB	92.9dB	76.1dB	63.4dB	
09:31:32	71.6dB	84.9dB	97.3dB	75.8dB	61.5dB	
09:31:47	71.0dB	83.9dB	97.4dB	73.8dB	61.2dB	
09:32:02	64.5dB	77.7dB	93.9dB	64.0dB	61.5dB	
09:32:17	61.0dB	63.7dB	79.2dB	62.0dB	60.1dB	
09:32:32	60.3dB	61.3dB	77.8dB	60.8dB	59.6dB	
09:32:47	61.3dB	66.0dB	81.3dB	62.5dB	60.1dB	
09:33:02	62.5dB	70.1dB	85.3dB	64.2dB	60.3dB	
09:33:17	63.4dB	70.6dB	86.2dB	65.7dB	61.5dB	
09:33:32	60.7dB	62.2dB	78.8dB	61.6dB	59.7dB	
09:33:47	60.5dB	61.6dB	76.4dB	61.0dB	60.0dB	
09:34:02	63.4dB	75.6dB	94.3dB	64.8dB	60.4dB	
09:34:17	61.1dB	62.6dB	75.7dB	61.7dB	60.7dB	
09:34:32	60.6dB	63.6dB	79.0dB	61.3dB	59.9dB	
09:34:47	60.9dB	63.9dB	77.4dB	62.0dB	59.9dB	
09:35:02	69.7dB	82.3dB	97.4dB	72.3dB	60.7dB	
09:35:17	75.6dB	87.3dB	106.1dB	80.4dB	60.3dB	
09:35:32	60.7dB	66.1dB	80.0dB	61.3dB	60.0dB	
9:35:47	60.3dB	63.5dB	77.8dB	61.0dB	59.7dB	
09:36:02	60.2dB	61.1dB	77.6dB	60.6dB	59.7dB	
9:36:17	60.1dB	63.7dB	80.0dB	60.6dB	59.3dB	
9:36:32	60.0dB	61.6dB	76.3dB	60.4dB	59.5dB	
09:36:47	61.8dB	71.8dB	86.2dB	63.9dB	59.3dB	
9:37:02	76.7dB	85.3dB	103.9dB	81.3dB	66.1dB	
9:37:17	77.1dB	85.3dB	104.8dB	81.7dB	67.7dB	
09:37:32	77.3dB	86.1dB	105.4dB	81.8dB	65.7dB	
9:37:47	77.9dB	86.5dB	105.9dB	82.8dB	65.2dB	
9:38:02	79.1dB	88.1dB	106.9dB	84.0dB	65.3dB	

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:38:17	75.3dB	90.7dB	111.2dB	79.4dB	61.2dB	

Quest Technologies
2900 Integrating/Logging Sound Level Meter

Unit Version Number: 02.2 Serial Number: CD8020048
Name: FAU ACOUSTIC PILE DRIVE ANALYSIS

Work Area: FIVE FEET HIGH - 300 FEET AWAY

Comments:

Meter Calibration: 113.8dB, 7/7/99 @ 11:37:29

Calibrator Serial Number:

Calibration Date:

Study 1

Measuring Parameters

Range: 60 - 120 dB
Weighting: A
Time Constant: Fast
Threshold: Off
Exchange Rate: 3dB
Peak Weighting: A

Study Started: 7/8/99 @ 12:15:07
Study Stopped: 7/8/99 @ 12:25:17
Run Time: 0:10:10
Peak Level: 122.2dB, 7/8/99 @ 12:23:48
Max Level: 99.1dB, 7/8/99 @ 12:23:47
Min Level: 51.6dB, 7/8/99 @ 12:18:53
Overload: 0.00%

LEQ: 76.3dB
SEL(3):104.2dB
TWA: 59.6dB
TAKM3: 85.7dB
LDN: 76.3dB
CNEL: 76.3dB
Pa2Sec: 10.4
L5: 83.6dB
L10: 78.1dB
L50: 60.7dB
L90: 54.9dB

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
12:15:22	76.8dB	88.5dB	106.1dB	80.5dB	68.6dB	
12:15:37	72.3dB	85.1dB	101.6dB	76.0dB	61.0dB	
12:15:52	77.2dB	90.4dB	97.9dB	81.8dB	57.5dB	
12:16:07	76.5dB	93.6dB	106.3dB	75.4dB	57.1dB	
12:16:22	71.0dB	83.9dB	101.5dB	73.5dB	58.6dB	
12:16:37	60.4dB	68.4dB	83.5dB	62.6dB	56.4dB	
12:16:52	78.0dB	92.3dB	99.7dB	79.9dB	54.6dB	
12:17:07	69.0dB	82.1dB	97.5dB	73.5dB	54.6dB	
12:17:22	66.2dB	79.4dB	97.5dB	67.7dB	57.3dB	
12:17:37	66.7dB	82.2dB	98.1dB	67.7dB	56.8dB	
12:17:52	68.5dB	83.0dB	100.5dB	69.4dB	55.1dB	
12:18:07	77.8dB	89.6dB	110.6dB	82.6dB	57.3dB	
12:18:22	61.0dB	69.5dB	86.1dB	65.3dB	53.5dB	
12:18:37	60.1dB	67.5dB	85.5dB	63.0dB	56.0dB	
12:18:52	60.7dB	73.3dB	91.3dB	64.0dB	54.9dB	

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
12:19:07	55.8dB	62.7dB	82.5dB	58.4dB	52.8dB	
12:19:22	65.0dB	73.9dB	90.6dB	69.0dB	56.5dB	
12:19:37	68.5dB	76.3dB	93.5dB	72.2dB	60.5dB	
12:19:52	61.6dB	70.9dB	85.5dB	65.9dB	54.9dB	
12:20:07	57.9dB	65.0dB	82.0dB	61.3dB	53.3dB	
12:20:22	60.5dB	71.5dB	89.6dB	63.6dB	54.5dB	
12:20:37	59.0dB	71.0dB	88.1dB	62.8dB	51.6dB	
12:20:52	59.5dB	66.1dB	83.9dB	62.4dB	55.8dB	
12:21:07	61.7dB	69.6dB	84.5dB	65.3dB	52.9dB	
12:21:22	57.5dB	68.0dB	82.1dB	61.0dB	51.6dB	
12:21:37	61.0dB	71.4dB	87.4dB	64.6dB	53.7dB	
12:21:52	61.6dB	72.1dB	86.8dB	65.0dB	52.7dB	
12:22:07	65.2dB	77.1dB	94.2dB	69.4dB	56.4dB	
12:22:22	60.0dB	68.9dB	88.9dB	64.0dB	54.7dB	
12:22:37	60.1dB	71.1dB	85.7dB	63.2dB	53.8dB	
12:22:52	62.2dB	72.8dB	88.5dB	67.0dB	54.2dB	
12:23:07	65.1dB	73.4dB	89.9dB	69.1dB	57.3dB	
12:23:22	81.1dB	90.3dB	111.7dB	86.6dB	60.7dB	
12:23:37	84.2dB	95.1dB	115.3dB	88.8dB	68.5dB	
12:23:52	85.2dB	99.1dB	122.2dB	89.6dB	68.4dB	
12:24:07	84.4dB	95.5dB	115.9dB	89.2dB	66.0dB	
12:24:22	81.0dB	92.6dB	112.9dB	85.7dB	65.0dB	
12:24:37	80.1dB	90.2dB	110.2dB	85.1dB	62.9dB	
12:24:52	81.1dB	92.8dB	114.5dB	85.7dB	65.2dB	
12:25:07	73.2dB	88.6dB	107.8dB	77.0dB	55.3dB	

Study 2

Measuring Parameters

Range: 60 - 120 dB
Weighting: A
Time Constant: Fast
Threshold: Off
Exchange Rate: 3dB
Peak Weighting: A

Study Started: 7/9/99 @ 06:28:08
Study Stopped: 7/9/99 @ 06:35:53
Run Time: 0:07:44
Peak Level: 118.2dB, 7/9/99 @ 06:34:19
Max Level: 96.8dB, 7/9/99 @ 06:34:18
Min Level: 51.6dB, 7/9/99 @ 06:31:40
Overload: 0.00%

LEQ: 75.7dB
SEL(3):102.4dB
TWA: 57.8dB
TAKM3: 84.1dB
LDN: 85.7dB
CNEL: 85.7dB
Pa2Sec: 6.9
L5: 83.2dB
L10: 77.0dB
L50: 62.6dB
L90: 56.4dB

Study 2

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
06:28:23	71.5dB	82.3dB	95.6dB	76.7dB	61.7dB	
06:28:38	73.2dB	82.5dB	96.8dB	76.0dB	67.4dB	
06:28:53	65.8dB	71.9dB	86.0dB	68.6dB	61.9dB	
06:29:08	68.1dB	79.0dB	93.0dB	71.8dB	58.9dB	
06:29:23	65.2dB	75.0dB	89.7dB	68.8dB	57.4dB	
06:29:38	67.0dB	75.6dB	89.3dB	70.6dB	60.1dB	
06:29:53	70.1dB	81.1dB	91.3dB	74.2dB	59.1dB	
06:30:08	72.4dB	82.2dB	96.0dB	76.3dB	62.9dB	
06:30:23	68.8dB	84.4dB	96.9dB	70.1dB	56.6dB	
06:30:38	67.4dB	75.9dB	94.9dB	70.6dB	62.0dB	
06:30:53	64.0dB	72.5dB	88.4dB	67.4dB	56.5dB	
06:31:08	66.6dB	76.9dB	94.8dB	69.7dB	59.7dB	
06:31:23	61.1dB	69.3dB	92.5dB	64.3dB	56.6dB	
06:31:38	55.5dB	61.7dB	79.9dB	57.7dB	53.1dB	
06:31:53	55.8dB	66.9dB	82.4dB	58.2dB	52.3dB	
06:32:08	60.2dB	70.6dB	84.9dB	63.2dB	54.6dB	
06:32:23	61.5dB	69.9dB	85.6dB	64.9dB	57.3dB	
06:32:38	59.7dB	62.9dB	78.8dB	61.7dB	56.6dB	
06:32:53	58.8dB	66.5dB	82.0dB	60.1dB	56.6dB	
06:33:08	59.6dB	62.8dB	80.0dB	61.3dB	58.3dB	
06:33:23	58.7dB	61.9dB	81.5dB	60.0dB	57.0dB	
06:33:38	71.9dB	85.3dB	102.0dB	75.1dB	56.1dB	
06:33:53	60.3dB	65.1dB	79.5dB	62.1dB	56.5dB	
06:34:08	79.1dB	90.1dB	110.3dB	84.6dB	59.8dB	
06:34:23	83.1dB	96.8dB	118.2dB	86.9dB	67.4dB	
06:34:38	84.0dB	94.6dB	114.7dB	88.6dB	68.0dB	
06:34:53	82.0dB	92.5dB	113.0dB	87.0dB	66.5dB	
06:35:08	82.1dB	92.5dB	111.5dB	87.1dB	65.1dB	
06:35:23	81.8dB	91.1dB	108.2dB	87.6dB	63.6dB	
06:35:38	60.0dB	64.1dB	80.1dB	62.4dB	55.3dB	

Study 3

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off
Weighting: A
Exchange Rate: 3dB
Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 09:04:12
Study Stopped: 7/9/99 @ 09:08:17
Run Time: 0:04:05
Peak Level: 109.1dB, 7/9/99 @ 09:06:54
Max Level: 88.7dB, 7/9/99 @ 09:06:53
Min Level: 51.6dB, 7/9/99 @ 09:05:06
Overload: 0.00%

LEQ: 69.9dB	SEL(3):93.8dB	TWA: 49.2dB	TAKM3: 78.1dB
LDN: 69.9dB	CNEL: 69.9dB	Pa2Sec: 0.9	
L5: 76.3dB	L10: 74.4dB	L50: 63.4dB	L90: 54.0dB

Study 3

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:04:27	69.4dB	80.0dB	94.8dB	73.6dB	61.3dB	
09:04:42	72.6dB	81.9dB	102.3dB	76.1dB	62.4dB	
09:04:57	63.6dB	71.3dB	96.9dB	67.9dB	54.5dB	
09:05:12	61.6dB	73.9dB	90.9dB	65.5dB	51.6dB	
09:05:27	59.8dB	71.2dB	88.6dB	62.8dB	53.1dB	
09:05:42	73.1dB	81.3dB	98.5dB	77.6dB	62.1dB	
09:05:57	71.2dB	80.9dB	99.8dB	75.8dB	60.2dB	
09:06:12	71.8dB	82.6dB	101.5dB	76.0dB	60.4dB	
09:06:27	71.7dB	81.8dB	99.3dB	76.0dB	60.7dB	
09:06:42	69.4dB	78.9dB	95.1dB	74.1dB	57.7dB	
09:06:57	73.9dB	88.7dB	109.1dB	78.1dB	57.2dB	
09:07:12	54.3dB	65.0dB	79.7dB	55.3dB	52.5dB	
09:07:27	62.7dB	74.7dB	87.7dB	67.1dB	52.6dB	
09:07:42	65.1dB	74.9dB	90.9dB	69.6dB	54.1dB	
09:07:57	70.6dB	79.4dB	98.9dB	74.4dB	58.5dB	
09:08:12	71.1dB	84.1dB	103.7dB	75.0dB	60.3dB	

Study 4

Measuring Parameters

Range: 60 - 120 dB	Weighting: A	Time Constant: Fast
Threshold: Off	Exchange Rate: 3dB	Peak Weighting: A

Study Started: 7/9/99 @ 09:24:16
Study Stopped: 7/9/99 @ 09:32:18
Run Time: 0:08:01
Peak Level: 110.3dB, 7/9/99 @ 09:24:57
Max Level: 88.8dB, 7/9/99 @ 09:24:31
Min Level: 51.6dB, 7/9/99 @ 09:26:22
Overload: 0.00%

LEQ: 70.1dB	SEL(3):96.9dB	TWA: 52.4dB	TAKM3: 77.9dB
LDN: 70.1dB	CNEL: 70.1dB	Pa2Sec: 2.0	
L5: 77.3dB	L10: 74.2dB	L50: 57.0dB	L90: 51.6dB

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:24:31	75.4dB	88.8dB	102.3dB	77.6dB	62.1dB	
09:24:46	78.5dB	88.0dB	104.5dB	82.1dB	70.8dB	
09:25:01	78.6dB	87.5dB	110.3dB	82.7dB	69.4dB	
09:25:16	67.5dB	76.4dB	91.0dB	71.4dB	62.0dB	
09:25:31	68.2dB	79.0dB	93.7dB	71.7dB	62.3dB	
09:25:46	67.9dB	81.9dB	97.7dB	69.8dB	59.5dB	
09:26:01	61.1dB	73.2dB	89.1dB	62.7dB	56.6dB	
09:26:16	59.4dB	68.1dB	90.8dB	61.6dB	55.5dB	
09:26:31	54.2dB	58.6dB	76.5dB	56.3dB	52.5dB	
09:26:46	57.0dB	67.2dB	83.9dB	59.8dB	51.7dB	
09:27:01	56.6dB	64.0dB	83.1dB	60.1dB	51.6dB	
09:27:16	53.7dB	59.7dB	76.1dB	56.4dB	51.6dB	
09:27:31	51.6dB	52.0dB	76.3dB	51.6dB	51.6dB	
09:27:46	51.7dB	55.9dB	76.0dB	51.6dB	51.6dB	
09:28:01	51.6dB	51.6dB	76.3dB	51.6dB	51.6dB	
09:28:16	51.6dB	52.6dB	75.8dB	51.6dB	51.6dB	
09:28:31	57.8dB	70.1dB	85.7dB	56.6dB	51.6dB	
09:28:46	58.9dB	67.4dB	83.8dB	63.5dB	51.6dB	
09:29:01	62.4dB	76.2dB	92.1dB	64.3dB	54.1dB	
09:29:16	69.4dB	79.9dB	97.1dB	74.3dB	57.4dB	
09:29:31	67.8dB	84.5dB	101.0dB	61.3dB	52.2dB	
09:29:46	53.5dB	57.4dB	82.6dB	55.1dB	51.6dB	
09:30:01	52.3dB	54.0dB	76.5dB	52.9dB	51.6dB	
09:30:16	54.5dB	58.9dB	77.0dB	56.2dB	51.6dB	
09:30:31	53.6dB	57.1dB	81.6dB	54.5dB	52.7dB	
09:30:46	53.0dB	65.3dB	81.3dB	54.0dB	52.1dB	
09:31:01	69.7dB	81.9dB	97.7dB	75.0dB	54.5dB	
09:31:16	72.1dB	80.9dB	98.6dB	76.6dB	61.5dB	
09:31:31	72.0dB	81.1dB	99.0dB	76.7dB	60.6dB	
09:31:46	73.2dB	83.0dB	102.2dB	78.3dB	58.9dB	
09:32:01	73.5dB	82.8dB	103.5dB	78.5dB	60.1dB	

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
09:32:16	73.8dB	87.8dB	107.6dB	78.3dB	57.3dB	

Western Leq Quest 2900 Field data

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
13:17:22	62.9dB	75.9dB	86.3dB	63.3dB	59.9dB	
13:17:37	64.9dB	70.6dB	83.2dB	66.4dB	62.9dB	
13:17:52	62.6dB	65.3dB	80.7dB	64.2dB	61.5dB	
13:18:07	60.0dB	64.4dB	79.2dB	63.0dB	56.3dB	
13:18:22	61.1dB	69.2dB	83.0dB	64.0dB	54.7dB	
13:18:37	59.1dB	64.6dB	80.1dB	63.1dB	53.6dB	
13:18:52	69.7dB	86.8dB	97.9dB	61.7dB	53.9dB	
13:19:07	57.4dB	62.4dB	77.6dB	59.9dB	52.3dB	
13:19:22	54.7dB	60.3dB	76.8dB	57.0dB	51.8dB	
13:19:37	56.4dB	60.9dB	77.4dB	58.3dB	54.1dB	
13:19:52	55.3dB	60.8dB	81.2dB	57.4dB	52.9dB	
13:20:07	54.6dB	59.5dB	75.8dB	56.1dB	52.6dB	
13:20:22	56.8dB	61.0dB	77.2dB	58.6dB	54.8dB	
13:20:37	57.2dB	62.2dB	77.0dB	59.1dB	55.0dB	
13:20:52	59.1dB	63.0dB	76.9dB	61.4dB	56.4dB	
13:21:07	61.2dB	66.6dB	81.1dB	65.2dB	56.7dB	
13:21:22	85.8dB	99.6dB	119.3dB	90.0dB	62.0dB	
13:21:37	92.4dB	101.0dB	119.1dB	97.3dB	75.9dB	
13:21:52	91.4dB	99.0dB	117.9dB	96.7dB	74.4dB	
13:22:07	92.0dB	100.5dB	120.3dB	97.0dB	74.0dB	
13:22:22	91.7dB	100.3dB	120.2dB	97.1dB	72.7dB	
13:22:37	92.3dB	100.6dB	119.5dB	97.6dB	73.0dB	
13:22:52	92.0dB	99.8dB	119.0dB	97.3dB	73.5dB	
13:23:07	90.5dB	99.9dB	117.1dB	96.6dB	63.4dB	
13:23:22	60.1dB	65.1dB	79.2dB	63.1dB	55.1dB	
13:23:37	60.7dB	69.0dB	85.8dB	63.9dB	54.8dB	
13:23:52	67.5dB	77.8dB	93.5dB	72.1dB	56.3dB	

Study 2

Measuring Parameters

Range: 60 - 120 dB
Weighting: A
Time Constant: Fast
Threshold: Off
Exchange Rate: 3dB
Peak Weighting: A

Study Started: 7/9/99 @ 07:27:25
Study Stopped: 7/9/99 @ 07:34:56
Run Time: 0:07:31
Peak Level: 119.9dB, 7/9/99 @ 07:32:10
Max Level: 101.4dB, 7/9/99 @ 07:32:56
Min Level: 52.6dB, 7/9/99 @ 07:29:48
Overload: 0.00%

LEQ: 85.4dB	SEL(3):112.0dB	TWA: 67.4dB	TAKM3: 92.9dB
LDN: 85.4dB	CNEL: 85.4dB	Pa2Sec: 62.7	
L5: 93.8dB	L10: 85.8dB	L50: 64.6dB	L90: 56.3dB

Study 2

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
07:27:40	58.4dB	62.9dB	78.3dB	59.9dB	56.0dB	
07:27:55	64.6dB	68.3dB	83.1dB	67.0dB	58.9dB	
07:28:10	64.0dB	69.3dB	82.2dB	66.1dB	56.8dB	
07:28:25	61.3dB	68.2dB	81.4dB	64.2dB	56.7dB	
07:28:40	59.5dB	64.4dB	78.7dB	63.6dB	55.3dB	
07:28:55	65.4dB	71.2dB	84.8dB	69.9dB	56.5dB	
07:29:10	62.2dB	66.4dB	80.4dB	64.9dB	58.7dB	
07:29:25	58.9dB	63.3dB	78.6dB	61.3dB	55.8dB	
07:29:40	56.6dB	62.6dB	76.7dB	57.9dB	55.1dB	
07:29:55	55.6dB	63.1dB	77.9dB	57.9dB	53.4dB	
07:30:10	56.7dB	60.1dB	82.6dB	58.2dB	55.3dB	
07:30:25	66.5dB	71.2dB	86.4dB	69.6dB	58.4dB	
07:30:40	65.5dB	69.4dB	84.2dB	68.5dB	59.5dB	
07:30:55	68.2dB	69.2dB	84.8dB	68.8dB	67.3dB	
07:31:10	67.4dB.	68.6dB	82.0dB	68.1dB	66.8dB	
07:31:25	67.0dB	68.7dB	83.2dB	68.3dB	63.7dB	
07:31:40	68.2dB	77.2dB	92.1dB	69.5dB	65.0dB	
07:31:55	81.4dB	94.4dB	108.5dB	85.6dB	62.6dB	
07:32:10	81.6dB	99.0dB	119.9dB	77.2dB	65.7dB	
07:32:25	91.6dB	99.4dB	119.0dB	96.3dB	76.0dB	
07:32:40	91.9dB	99.9dB	119.2dB	96.5dB	76.6dB	
07:32:55	92.9dB	100.4dB	119.1dB	98.1dB	75.4dB	
07:33:10	93.5dB	101.4dB	118.7dB	99.0dB	74.9dB	
07:33:25	93.3dB	101.4dB	118.9dB	99.2dB	73.8dB	
07:33:40	89.1dB	101.1dB	117.7dB	94.1dB	63.7dB	
07:33:55	59.0dB	67.7dB	79.2dB	61.0dB	55.5dB	
07:34:10	65.6dB	72.9dB	82.8dB	68.7dB	60.9dB	
07:34:25	64.8dB	68.4dB	81.8dB	67.0dB	61.6dB	
07:34:40	62.1dB	66.9dB	81.4dB	65.3dB	57.1dB	
07:34:55	65.0dB	77.5dB	102.7dB	65.7dB	61.9dB	

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Study 3

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off

Weighting: A
Exchange Rate: 3dB

Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 09:59:55
Study Stopped: 7/9/99 @ 10:07:51
Run Time: 0:07:56
Peak Level: 110.2dB, 7/9/99 @ 10:04:03
Max Level: 90.5dB, 7/9/99 @ 10:03:36
Min Level: 51.6dB, 7/9/99 @ 10:06:27
Overload: 0.00%

LEQ: 74.5dB	SEL(3):101.3dB	TWA: 56.7dB	TAKM3: 81.2dB
LDN: 74.5dB	CNEL: 74.5dB	Pa2Sec: 5.3	
L5: 83.4dB	L10: 78.0dB	L50: 59.0dB	L90: 51.8dB

Study 3

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:00:10	58.9dB	64.8dB	85.8dB	59.9dB	57.0dB	
10:00:25	59.1dB	63.0dB	77.3dB	59.9dB	58.4dB	
10:00:40	57.4dB	59.0dB	77.2dB	58.0dB	56.9dB	
10:00:55	58.3dB	61.1dB	76.6dB	59.2dB	57.4dB	
10:01:10	60.1dB	64.8dB	77.8dB	61.8dB	58.6dB	
10:01:25	58.6dB	60.2dB	76.7dB	59.1dB	58.2dB	
10:01:40	58.5dB	59.7dB	77.4dB	59.0dB	58.0dB	
10:01:55	58.8dB	60.3dB	77.4dB	59.2dB	58.3dB	
10:02:10	58.9dB	60.3dB	76.6dB	59.4dB	58.4dB	
10:02:25	58.7dB	59.9dB	76.8dB	59.2dB	58.3dB	
10:02:40	59.0dB	62.8dB	78.0dB	59.7dB	58.1dB	
10:02:55	59.7dB	64.0dB	77.6dB	60.6dB	58.9dB	
10:03:10	59.6dB	62.3dB	76.8dB	60.5dB	58.8dB	
10:03:25	61.8dB	70.7dB	81.1dB	64.4dB	59.3dB	
10:03:40	77.3dB	90.5dB	106.7dB	82.3dB	58.9dB	
10:03:55	82.7dB	89.9dB	106.2dB	87.4dB	69.0dB	
10:04:10	81.5dB	89.9dB	110.2dB	86.1dB	68.7dB	
10:04:25	80.5dB	87.5dB	104.6dB	85.3dB	68.2dB	
10:04:40	80.0dB	86.9dB	103.0dB	84.9dB	66.0dB	
10:04:55	79.7dB	86.5dB	101.9dB	84.8dB	65.2dB	
10:05:10	77.9dB	88.2dB	103.0dB	84.2dB	60.2dB	
10:05:25	59.8dB	66.5dB	81.1dB	60.9dB	58.6dB	
10:05:40	58.6dB	60.5dB	77.2dB	59.2dB	57.9dB	
10:05:55	67.7dB	84.2dB	98.5dB	62.7dB	58.6dB	
10:06:10	78.6dB	85.3dB	101.5dB	83.9dB	63.0dB	
10:06:25	76.6dB	86.0dB	101.1dB	83.0dB	58.2dB	
10:06:40	55.0dB	60.2dB	76.9dB	57.9dB	51.6dB	
10:06:55	55.8dB	59.6dB	76.2dB	57.8dB	53.1dB	
10:07:10	52.7dB	57.0dB	74.8dB	54.9dB	51.6dB	
10:07:25	51.7dB	57.2dB	84.7dB	51.6dB	51.6dB	
10:07:40	51.6dB	53.2dB	74.9dB	51.6dB	51.6dB	

Study 4

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off

Weighting: A
Exchange Rate: 3dB

Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 10:21:21
Study Stopped: 7/9/99 @ 10:31:44
Run Time: 0:10:23
Peak Level: 111.4dB, 7/9/99 @ 10:29:14
Max Level: 93.2dB, 7/9/99 @ 10:29:17
Min Level: 51.6dB, 7/9/99 @ 10:31:24
Overload: 0.00%

LEQ: 73.5dB
LDN: 73.5dB
L5: 81.3dB

SEL(3):101.4dB
CNEL: 73.5dB
L10: 72.6dB

TWA: 56.8dB
Pa2Sec: 5.5
L50: 55.6dB

TAKM3: 81.0dB
L90: 53.7dB

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:21:36	56.4dB	66.5dB	94.9dB	57.4dB	54.8dB	
10:21:51	56.9dB	66.9dB	80.2dB	57.5dB	54.7dB	
10:22:06	58.1dB	62.8dB	77.0dB	60.5dB	54.8dB	
10:22:21	57.9dB	62.8dB	76.9dB	61.8dB	54.3dB	
10:22:36	54.5dB	56.8dB	77.2dB	55.2dB	54.0dB	
10:22:51	54.5dB	58.0dB	76.8dB	56.1dB	53.5dB	
10:23:06	54.2dB	57.0dB	75.9dB	55.3dB	53.3dB	
10:23:21	53.6dB	55.5dB	76.2dB	54.3dB	52.8dB	
10:23:36	54.2dB	56.1dB	77.0dB	55.1dB	53.3dB	
10:23:51	55.2dB	60.1dB	76.6dB	58.0dB	52.7dB	
10:24:06	55.2dB	56.7dB	76.5dB	55.8dB	54.5dB	
10:24:21	58.9dB	62.4dB	77.2dB	61.3dB	56.5dB	
10:24:36	55.1dB	56.9dB	76.8dB	55.8dB	54.5dB	
10:24:51	54.3dB	56.1dB	76.7dB	54.9dB	53.7dB	
10:25:06	57.6dB	63.2dB	76.7dB	59.7dB	54.9dB	
10:25:21	57.5dB	63.8dB	78.8dB	60.7dB	54.2dB	
10:25:36	55.2dB	61.9dB	77.8dB	56.8dB	53.7dB	
10:25:51	55.0dB	59.5dB	76.1dB	56.1dB	53.7dB	
10:26:06	55.5dB	61.1dB	77.0dB	56.9dB	54.1dB	
10:26:21	56.5dB	59.8dB	76.3dB	58.2dB	54.8dB	
10:26:36	56.8dB	64.4dB	80.8dB	58.7dB	54.6dB	
10:26:51	56.8dB	68.9dB	83.3dB	58.6dB	53.3dB	
10:27:06	71.0dB	86.8dB	101.7dB	72.7dB	53.8dB	
10:27:21	77.1dB	88.2dB	106.7dB	83.0dB	55.0dB	
10:27:36	76.9dB	89.1dB	106.3dB	82.7dB	53.4dB	
10:27:51	54.8dB	58.2dB	77.0dB	56.4dB	53.6dB	
10:28:06	64.8dB	81.4dB	93.5dB	60.1dB	54.1dB	
10:28:21	57.2dB	65.0dB	80.8dB	58.7dB	55.2dB	
10:28:36	56.8dB	65.7dB	77.9dB	58.5dB	54.5dB	
10:28:51	55.3dB	57.3dB	76.8dB	56.8dB	54.1dB	
10:29:06	78.2dB	89.6dB	106.9dB	83.9dB	54.4dB	

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Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:29:21	83.7dB	93.2dB	111.4dB	88.4dB	69.0dB	
10:29:36	82.1dB	90.0dB	109.5dB	86.9dB	68.1dB	
10:29:51	80.5dB	88.7dB	104.5dB	85.6dB	65.0dB	
10:30:06	80.1dB	88.4dB	105.5dB	85.2dB	63.9dB	
10:30:21	80.4dB	88.4dB	104.4dB	85.6dB	63.9dB	
10:30:36	63.8dB	78.5dB	89.1dB	63.6dB	56.2dB	
10:30:51	62.1dB	70.2dB	84.7dB	65.0dB	58.0dB	
10:31:06	64.4dB	71.2dB	83.4dB	66.9dB	60.1dB	
10:31:21	55.9dB	63.1dB	76.7dB	57.6dB	54.0dB	
10:31:36	52.7dB	58.9dB	76.3dB	54.5dB	51.6dB	

Quest Technologies
2900 Integrating/Logging Sound Level Meter

Unit Version Number: 02.3
Serial Number: CD7120033
Name: FAU ACOUSTIC PILE DRIVING ANALYSIS

Work Area: FIFTEEN FEET HIGH - 300 FEET AWAY

Comments:

Meter Calibration: 114.0dB, 7/7/99 @ 12:48:45

Calibrator Serial Number:

Calibration Date:

Study 1

Measuring Parameters

Range: 60 - 120 dB	Weighting: A	Time Constant: Fast
Threshold: Off	Exchange Rate: 3dB	Peak Weighting: A

Study Started: 7/8/99 @ 13:15:35
Study Stopped: 7/8/99 @ 13:24:42
Run Time: 0:09:06
Peak Level: 109.8dB, 7/8/99 @ 13:16:56
Max Level: 89.8dB, 7/8/99 @ 13:16:55
Min Level: 51.6dB, 7/8/99 @ 13:18:44
Overload: 0.00%

LEQ: 73.3dB	SEL(3):100.6dB	TWA: 56.1dB	TAKM3: 81.2dB
LDN: 73.3dB	CNEL: 73.3dB	Pa2Sec: 4.6	
L5: 81.9dB	L10: 75.2dB	L50: 56.9dB	L90: 51.8dB

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
13:15:50	60.1dB	72.8dB	87.5dB	60.6dB	53.7dB	
13:16:05	66.5dB	78.3dB	96.9dB	71.2dB	55.4dB	
13:16:20	65.1dB	79.4dB	97.5dB	65.7dB	56.4dB	
13:16:35	66.0dB	81.4dB	97.8dB	64.0dB	58.5dB	
13:16:50	71.1dB	82.4dB	100.7dB	76.4dB	55.3dB	
13:17:05	77.0dB	89.8dB	109.8dB	82.7dB	56.7dB	
13:17:20	57.0dB	60.3dB	75.8dB	58.8dB	54.3dB	
13:17:35	61.7dB	65.6dB	81.6dB	64.4dB	58.1dB	
13:17:50	56.9dB	63.4dB	81.6dB	60.1dB	53.7dB	
3:18:05	55.5dB	61.7dB	74.9dB	58.0dB	53.3dB	
13:18:20	59.1dB	64.3dB	81.1dB	62.6dB	55.6dB	
13:18:35	56.7dB	59.5dB	75.1dB	58.5dB	55.3dB	
3:18:50	55.9dB	63.7dB	80.6dB	58.9dB	51.8dB	

Study 1

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
13:19:05	59.2dB	67.1dB	81.2dB	63.6dB	51.7dB	
13:19:20	57.0dB	62.8dB	80.3dB	60.1dB	51.6dB	
13:19:35	61.1dB	77.7dB	88.1dB	57.8dB	51.6dB	
13:19:50	55.2dB	59.5dB	74.6dB	58.3dB	51.6dB	
13:20:05	53.0dB	56.5dB	74.5dB	54.6dB	51.6dB	
13:20:20	53.0dB	56.4dB	74.3dB	54.7dB	51.6dB	
13:20:35	52.0dB	56.6dB	75.3dB	52.9dB	51.6dB	
13:20:50	52.2dB	54.9dB	74.3dB	53.2dB	51.6dB	
13:21:05	53.1dB	57.3dB	75.0dB	54.3dB	51.6dB	
13:21:20	54.1dB	57.1dB	75.7dB	55.9dB	52.5dB	
13:21:35	56.7dB	59.1dB	76.0dB	58.0dB	55.1dB	
13:21:50	57.1dB	61.6dB	75.4dB	58.9dB	55.6dB	
13:22:05	72.6dB	86.5dB	104.9dB	74.0dB	55.5dB	
13:22:20	79.9dB	88.5dB	106.5dB	84.8dB	65.4dB	
13:22:35	80.0dB	89.3dB	107.6dB	85.0dB	64.7dB	
13:22:50	79.5dB	89.2dB	108.5dB	84.7dB	63.3dB	
13:23:05	79.5dB	88.4dB	107.1dB	84.9dB	62.8dB	
13:23:20	79.7dB	88.8dB	106.2dB	85.2dB	62.6dB	
13:23:35	80.3dB	88.6dB	107.1dB	85.5dB	63.4dB	
13:23:50	79.5dB	89.3dB	106.9dB	85.3dB	59.3dB	
13:24:05	56.0dB	61.0dB	74.3dB	58.9dB	52.1dB	
13:24:20	56.7dB	66.1dB	80.2dB	58.8dB	52.5dB	
13:24:35	53.3dB	63.7dB	82.3dB	54.5dB	51.6dB	

Study 2

Measuring Parameters

Range: 60 - 120 dB
Threshold: Off
Weighting: A
Exchange Rate: 3dB
Time Constant: Fast
Peak Weighting: A

Study Started: 7/9/99 @ 07:29:04
Study Stopped: 7/9/99 @ 07:36:44
Run Time: 0:07:40
Peak Level: 108.7dB, 7/9/99 @ 07:34:09
Max Level: 90.6dB, 7/9/99 @ 07:33:43
Min Level: 51.7dB, 7/9/99 @ 07:29:39
Overload: 0.00%

LEQ: 74.0dB	SEL(3):100.6dB	TWA: 56.0dB	TAKM3: 81.5dB
LDN: 74.0dB	CNEL: 74.0dB	Pa2Sec: 4.6	
L5: 82.0dB	L10: 74.3dB	L50: 61.1dB	L90: 56.9dB

Study 2

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
07:29:19	62.2dB	78.7dB	99.4dB	63.4dB	53.8dB	
07:29:34	63.5dB	69.6dB	83.0dB	68.1dB	54.3dB	
07:29:49	57.6dB	63.5dB	80.7dB	60.9dB	53.0dB	
07:30:04	56.6dB	61.5dB	82.3dB	58.3dB	54.5dB	
07:30:19	58.1dB	61.1dB	75.5dB	59.4dB	56.5dB	
07:30:34	57.7dB	60.4dB	75.5dB	58.9dB	56.3dB	
07:30:49	58.9dB	61.5dB	76.8dB	60.0dB	57.2dB	
07:31:04	62.9dB	68.3dB	80.7dB	66.5dB	58.4dB	
07:31:19	61.8dB	65.7dB	80.9dB	64.1dB	59.7dB	
07:31:34	63.1dB	65.1dB	79.5dB	64.3dB	61.7dB	
07:31:49	61.2dB	62.7dB	77.0dB	62.0dB	60.1dB	
07:32:04	61.3dB	63.2dB	77.4dB	62.0dB	60.4dB	
07:32:19	63.2dB	68.3dB	85.0dB	66.6dB	57.9dB	
07:32:34	70.1dB	82.9dB	98.2dB	74.3dB	56.9dB	
07:32:49	61.2dB	65.7dB	82.1dB	63.3dB	58.9dB	
07:33:04	78.5dB	88.0dB	108.2dB	83.5dB	62.1dB	
07:33:19	80.1dB	88.8dB	106.6dB	84.7dB	65.9dB	
07:33:34	81.4dB	90.3dB	108.5dB	86.3dB	65.8dB	
07:33:49	81.3dB	90.6dB	108.5dB	86.6dB	65.4dB	
07:34:04	82.4dB	90.4dB	107.2dB	88.2dB	64.5dB	
07:34:19	80.2dB	90.1dB	108.7dB	86.6dB	59.3dB	
07:34:34	58.4dB	62.0dB	78.1dB	61.1dB	55.1dB	
07:34:49	61.1dB	65.8dB	77.2dB	63.9dB	56.9dB	
07:35:04	62.4dB	66.3dB	81.3dB	65.0dB	59.3dB	
07:35:19	61.5dB	64.8dB	80.8dB	63.9dB	58.0dB	
07:35:34	61.7dB	66.1dB	81.3dB	63.3dB	59.1dB	
07:35:49	60.5dB	62.6dB	76.1dB	61.5dB	59.1dB	
07:36:04	60.9dB	64.6dB	79.9dB	62.6dB	58.7dB	
07:36:19	60.2dB	62.4dB	78.1dB	61.5dB	58.9dB	
07:36:34	65.8dB	70.7dB	82.7dB	68.4dB	62.6dB	

Study 3

Measuring Parameters

Range: 60 - 120 dB | Weighting: A | Time Constant: Fast
Threshold: Off | Exchange Rate: 3dB | Peak Weighting: A

Study Started: 7/9/99 @ 10:02:05
Study Stopped: 7/9/99 @ 10:09:55
Run Time: 0:07:50
Peak Level: 98.9dB, 7/9/99 @ 10:04:47
Max Level: 79.8dB, 7/9/99 @ 10:05:08
Min Level: 51.6dB, 7/9/99 @ 10:07:11
Overload: 0.00%

LEQ: 64.5dB | SEL(3):91.2dB | TWA: 46.6dB | TAKM3: 71.4dB
LDN: 64.5dB | CNEL: 64.5dB | Pa2Sec: 0.5
L5: 72.9dB | L10: 68.0dB | L50: 55.5dB | L90: 51.6dB

Study 3

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:02:20	63.3dB	78.7dB	96.9dB	64.8dB	55.7dB	
10:02:35	55.0dB	56.4dB	74.8dB	55.8dB	54.4dB	
10:02:50	55.3dB	56.9dB	74.3dB	56.1dB	54.5dB	
10:03:05	55.3dB	57.1dB	75.9dB	56.2dB	54.4dB	
10:03:20	55.7dB	57.2dB	74.6dB	56.4dB	54.6dB	
10:03:35	55.6dB	57.6dB	75.9dB	56.7dB	54.7dB	
10:03:50	55.6dB	57.3dB	74.8dB	56.6dB	54.7dB	
10:04:05	56.0dB	58.8dB	76.6dB	57.1dB	54.9dB	
10:04:20	55.9dB	59.3dB	74.5dB	57.6dB	54.7dB	
10:04:35	72.1dB	79.4dB	95.8dB	76.8dB	59.5dB	
10:04:50	71.6dB	79.6dB	98.9dB	76.0dB	61.5dB	
10:05:05	70.0dB	78.3dB	96.3dB	74.3dB	60.0dB	
10:05:20	70.3dB	79.8dB	96.5dB	74.8dB	58.8dB	
10:05:35	69.3dB	76.4dB	95.1dB	74.1dB	59.3dB	
10:05:50	69.7dB	78.5dB	94.3dB	75.0dB	57.0dB	
10:06:05	56.7dB	61.2dB	75.8dB	57.6dB	55.6dB	
10:06:20	56.3dB	57.8dB	75.6dB	57.2dB	55.5dB	
10:06:35	55.8dB	58.9dB	75.1dB	56.9dB	54.4dB	
10:06:50	67.2dB	75.1dB	90.7dB	72.8dB	57.2dB	
10:07:05	67.4dB	74.7dB	91.6dB	72.8dB	56.4dB	
10:07:20	53.5dB	56.5dB	74.7dB	55.8dB	51.6dB	
10:07:35	53.8dB	59.0dB	74.7dB	56.7dB	51.6dB	
10:07:50	51.7dB	53.3dB	75.8dB	52.0dB	51.6dB	
10:08:05	51.7dB	57.1dB	84.6dB	51.6dB	51.6dB	
10:08:20	51.7dB	53.5dB	75.6dB	51.7dB	51.6dB	
10:08:35	51.8dB	56.8dB	74.1dB	51.6dB	51.6dB	
0:08:50	51.6dB	51.6dB	74.0dB	51.6dB	51.6dB	
10:09:05	51.6dB	53.3dB	74.3dB	51.6dB	51.6dB	
10:09:20	51.7dB	54.3dB	75.3dB	51.6dB	51.6dB	
0:09:35	51.6dB	52.5dB	74.4dB	51.6dB	51.6dB	
.0:09:50	54.5dB	67.3dB	90.9dB	55.5dB	51.6dB	

Study 4

Measuring Parameters

Range: 60 - 120 dB
Weighting: A
Time Constant: Fast
Threshold: Off
Exchange Rate: 3dB
Peak Weighting: A

Study Started: 7/9/99 @ 10:20:54
Study Stopped: 7/9/99 @ 10:33:23
Run Time: 0:12:28
Peak Level: 99.9dB, 7/9/99 @ 10:30:07
Max Level: 80.4dB, 7/9/99 @ 10:29:58
Min Level: 51.6dB, 7/9/99 @ 10:23:41
Overload: 0.00%

LEQ: 62.8dB	SEL(3):91.6dB	TWA: 47.0dB	TAKM3: 69.8dB
LDN: 62.8dB	CNEL: 62.8dB	Pa2Sec: 0.6	
L5: 70.1dB	L10: 63.5dB	L50: 54.8dB	L90: 52.7dB

Study 4

Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:21:09	62.4dB	78.5dB	95.8dB	64.3dB	54.8dB	
10:21:24	67.6dB	75.2dB	82.5dB	72.9dB	54.7dB	
10:21:39	55.6dB	59.7dB	75.8dB	57.1dB	54.3dB	
10:21:54	55.3dB	57.3dB	74.9dB	56.3dB	54.2dB	
10:22:09	55.6dB	57.8dB	75.5dB	56.8dB	54.8dB	
10:22:24	56.7dB	60.1dB	74.7dB	58.5dB	55.3dB	
10:22:39	55.6dB	57.5dB	76.3dB	56.2dB	55.2dB	
10:22:54	57.0dB	59.5dB	77.5dB	59.0dB	54.5dB	
10:23:09	55.0dB	57.3dB	75.0dB	56.2dB	53.4dB	
10:23:24	54.2dB	55.8dB	75.8dB	54.9dB	53.5dB	
10:23:39	54.2dB	55.6dB	74.5dB	54.9dB	53.5dB	
10:23:54	54.7dB	56.8dB	74.9dB	55.8dB	52.7dB	
10:24:09	54.2dB	56.3dB	76.0dB	55.3dB	53.1dB	
10:24:24	54.8dB	57.0dB	74.5dB	55.8dB	53.8dB	
0:24:39	54.6dB	56.2dB	74.9dB	55.5dB	53.7dB	
10:24:54	56.2dB	61.9dB	76.0dB	57.5dB	54.5dB	
10:25:09	59.2dB	62.9dB	74.7dB	61.5dB	55.4dB	
0:25:24	54.7dB	55.7dB	75.0dB	55.3dB	54.0dB	
10:25:39	54.5dB	56.3dB	75.6dB	55.6dB	53.5dB	
10:25:54	59.8dB	66.5dB	82.3dB	62.2dB	56.6dB	
0:26:09	54.3dB	58.9dB	74.5dB	55.4dB	53.0dB	
10:26:24	54.1dB	55.6dB	74.9dB	54.9dB	53.2dB	
10:26:39	53.9dB	55.7dB	75.1dB	55.0dB	52.9dB	
0:26:54	54.0dB	55.8dB	74.5dB	54.8dB	53.0dB	
10:27:09	54.1dB	56.2dB	75.6dB	55.2dB	53.1dB	
10:27:24	53.9dB	58.5dB	74.6dB	54.7dB	53.1dB	
0:27:39	53.0dB	54.3dB	74.7dB	53.5dB	52.5dB	
10:27:54	61.7dB	76.4dB	92.7dB	63.3dB	52.5dB	
10:28:09	68.5dB	77.6dB	93.3dB	73.7dB	54.9dB	
0:28:24	60.6dB	76.3dB	92.9dB	59.1dB	52.0dB	
10:28:39	53.4dB	54.9dB	75.4dB	54.3dB	52.5dB	

Study 4

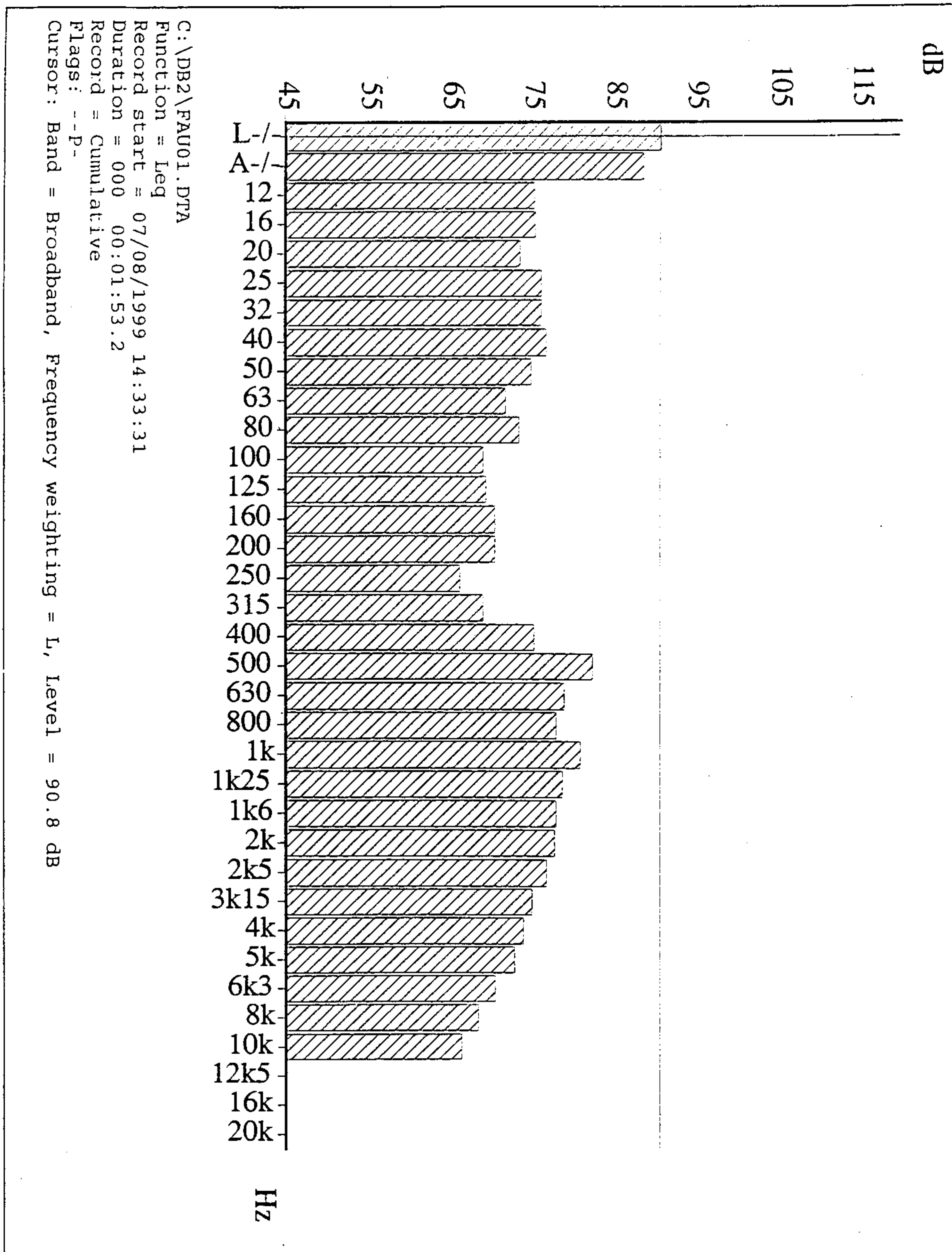
Logging (15 Seconds)	LEQ	LMAX	LPeak	LN10	LN90	Ovl
10:28:54	53.3dB	54.5dB	74.5dB	53.9dB	52.8dB	
10:29:09	54.0dB	56.0dB	76.5dB	54.7dB	53.1dB	
10:29:24	54.3dB	57.0dB	75.1dB	55.0dB	53.6dB	
10:29:39	53.9dB	55.1dB	74.6dB	54.5dB	53.3dB	
10:29:54	69.5dB	79.3dB	96.0dB	75.6dB	54.5dB	
10:30:09	72.2dB	80.4dB	99.9dB	76.8dB	61.7dB	
10:30:24	70.2dB	78.6dB	98.1dB	74.5dB	59.7dB	
10:30:39	68.9dB	76.8dB	92.7dB	73.7dB	56.4dB	
10:30:54	69.5dB	78.0dB	95.5dB	74.6dB	56.4dB	
10:31:09	69.0dB	79.2dB	93.7dB	74.5dB	56.0dB	
10:31:24	56.4dB	60.1dB	76.3dB	57.7dB	54.9dB	
10:31:39	56.5dB	57.9dB	75.0dB	57.4dB	55.3dB	
10:31:54	60.5dB	66.7dB	77.0dB	64.8dB	54.5dB	
10:32:09	52.9dB	55.4dB	75.1dB	53.7dB	51.7dB	
10:32:24	51.6dB	53.2dB	74.6dB	51.6dB	51.6dB	
10:32:39	51.6dB	51.7dB	74.1dB	51.6dB	51.6dB	
10:32:54	52.3dB	58.9dB	75.1dB	52.7dB	51.6dB	
10:33:09	62.4dB	75.3dB	87.6dB	65.7dB	51.6dB	

Octave Band Analyzer Data Sheets

.DB2\FAU01.DTA

.m summary -

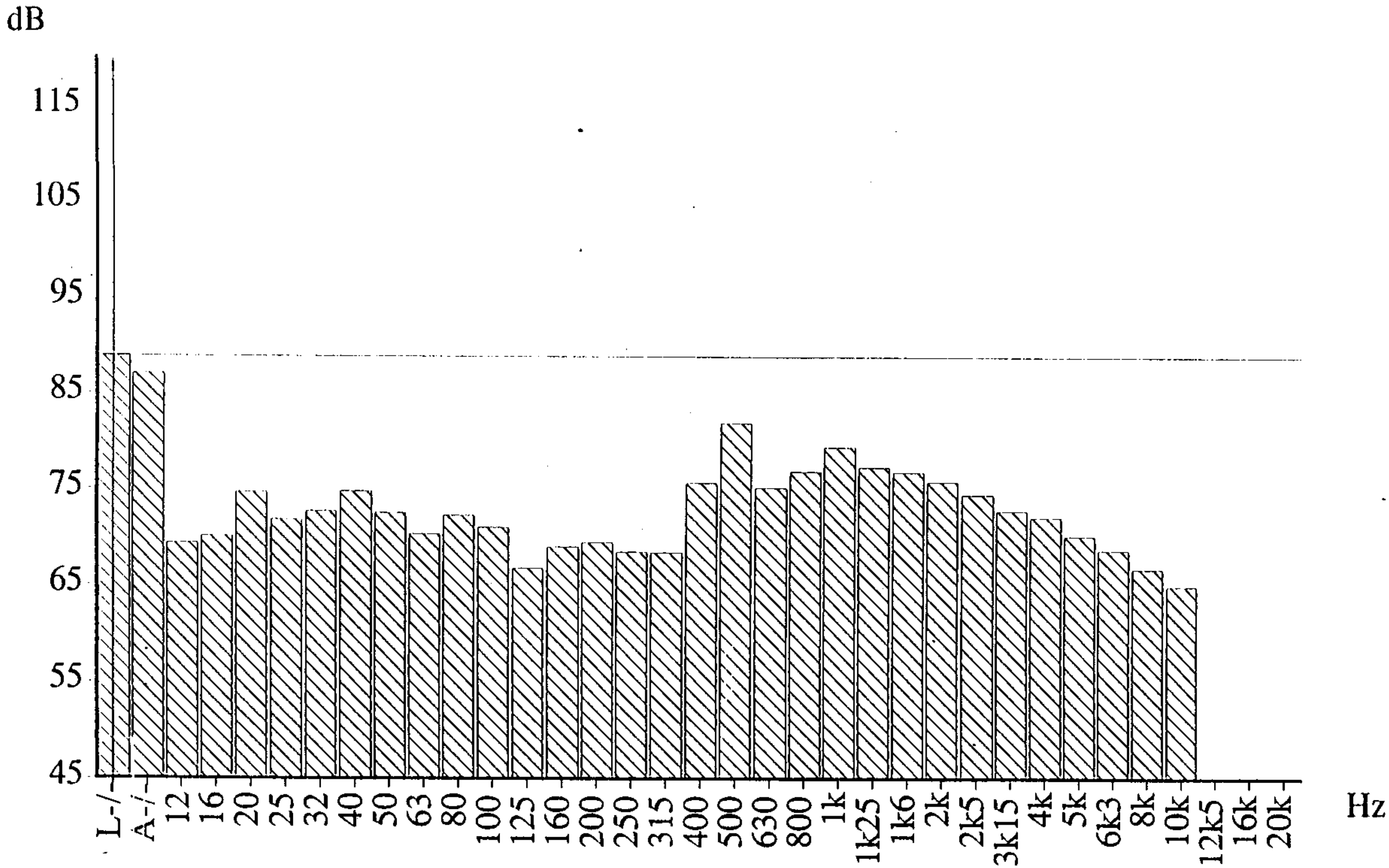
trument	CEL-593.C2 Version 6.3 Type 2
rument ID (DPB)	107331
ı mode	Third-octave band Environmental
n start	07/08/1999 14:33:31
n end	07/08/1999 14:35:24
ı duration	000 00:01:53.18
.t calibration	07/07/1999 14:33:40
asurement range	65 - 140 dB
rophone response	Free Field
ırizing voltage	Off
ıe weighting	F
quency weighting	L, A
hange rate (Q)	3
ıod time	500 ms
iods too short for LNs	Yes
iles recorded	No
ile sample interval	1 s
mber of records	226
ıts enabled	No
erload occurred	No
battery occurred	No
.e was used	Yes


dB
115
105
95
85
75
65
55
45
L-/-
A-/-
12
16
20
25
32
40
50
63
80
100
125
160
200
250
315
400
500
630
800
1k
1k25
1k6
2k
2k5
3k15
4k
5k
6k3
8k
10k
12k5
16k
20k
Hz
C:\DB2\FAU01.DTA
Function = Leq
Record start = 07/08/1999 14:33:31
Duration = 000 00:01:53.2
Record = Cumulative
Flags: --P-
Cursor: Band = Broadband, Frequency weighting = L, Level = 90.8 dB

.DB2\FAU03.DTA

un summary -

strument	CEL-593.C2 Version 6.3 Type 2
trument ID (DPB)	107331
1 mode	Third-octave band Environmental
n start	07/09/1999 08:43:01
n end	07/09/1999 08:45:43
1 duration	000 00:02:42.42
t calibration	07/07/1999 14:33:40
easurement range	65 - 140 dB
rophone response	Free Field
arizing voltage	Off
ne weighting	F
equency weighting	L, A
hange rate (Q)	3
.od time	500 ms
riods too short for LNs	Yes
iles recorded	No
ile sample interval	1 s
mber of records	324
its enabled	No
erload occurred	No
battery occurred	No
se was used	No

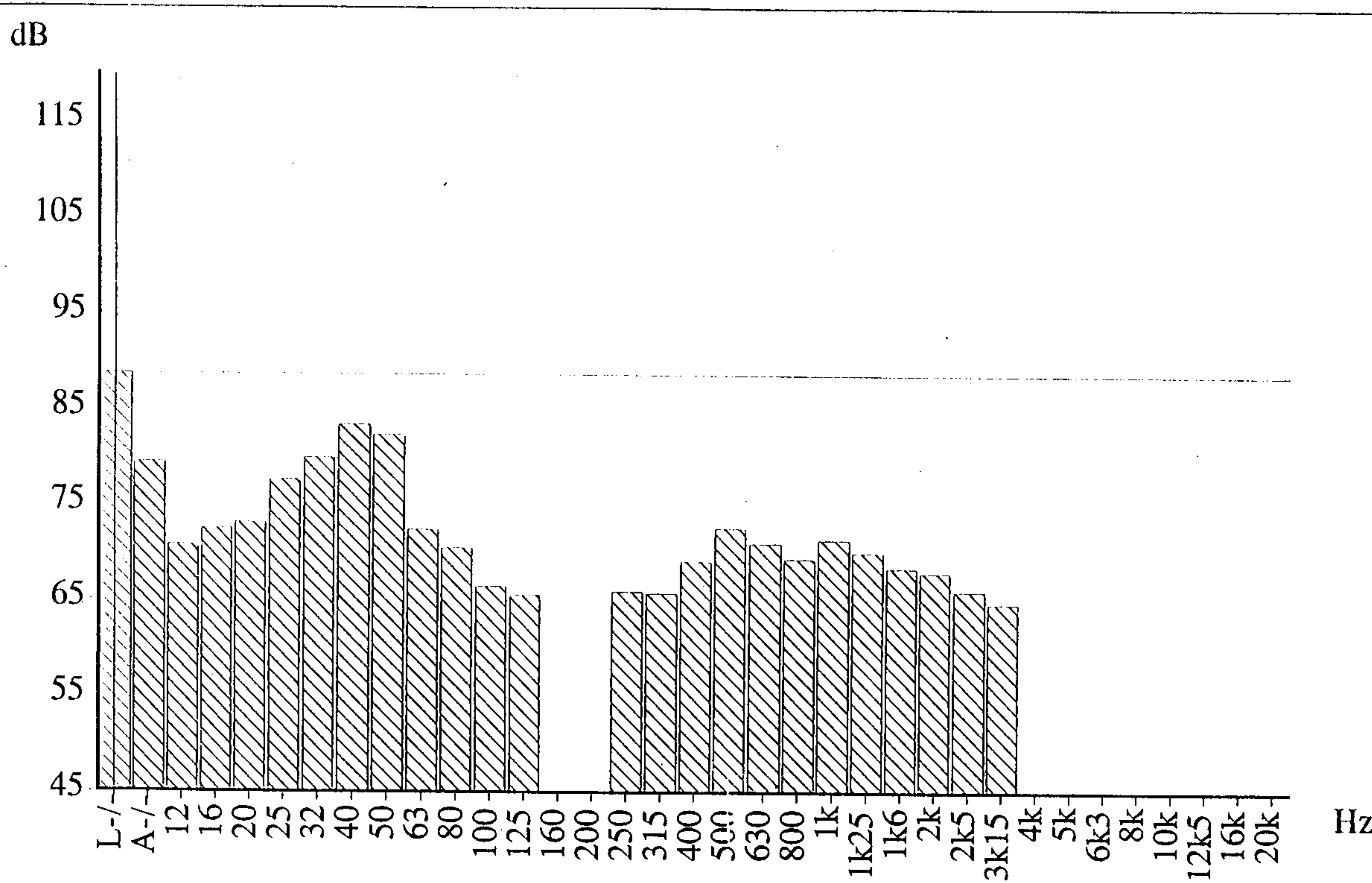


C:\DB2\FAU03.DTA
Function = Leq
Record start = 07/09/1999 08:43:01
Duration = 000 00:02:42.4
Record = Cumulative
Flags: ----
Cursor: Band = Broadband, Frequency weighting = L, Level = 88.9 dB

.\DB2\FAU04.DTA

:un summary -

strument	CEL-593.C2 Version 6.3 Type 2
strument ID (DPB)	107331
n mode	Third-octave band Environmental
in start	07/09/1999 11:15:31
in end	07/09/1999 11:17:16
n duration	000 00:01:45.88
st calibration	07/07/1999 14:33:40
easurement range	65 - 140 dB
crophone response	Free Field
larizing voltage	Off
me weighting	F
equency weighting	L, A
change rate (Q)	3
riod time	500 ms
riods too short for LNs	Yes
ofiles recorded	No
ofile sample interval	1 s
imber of records	211
ents enabled	No
erload occurred	No
w battery occurred	No
use was used	No

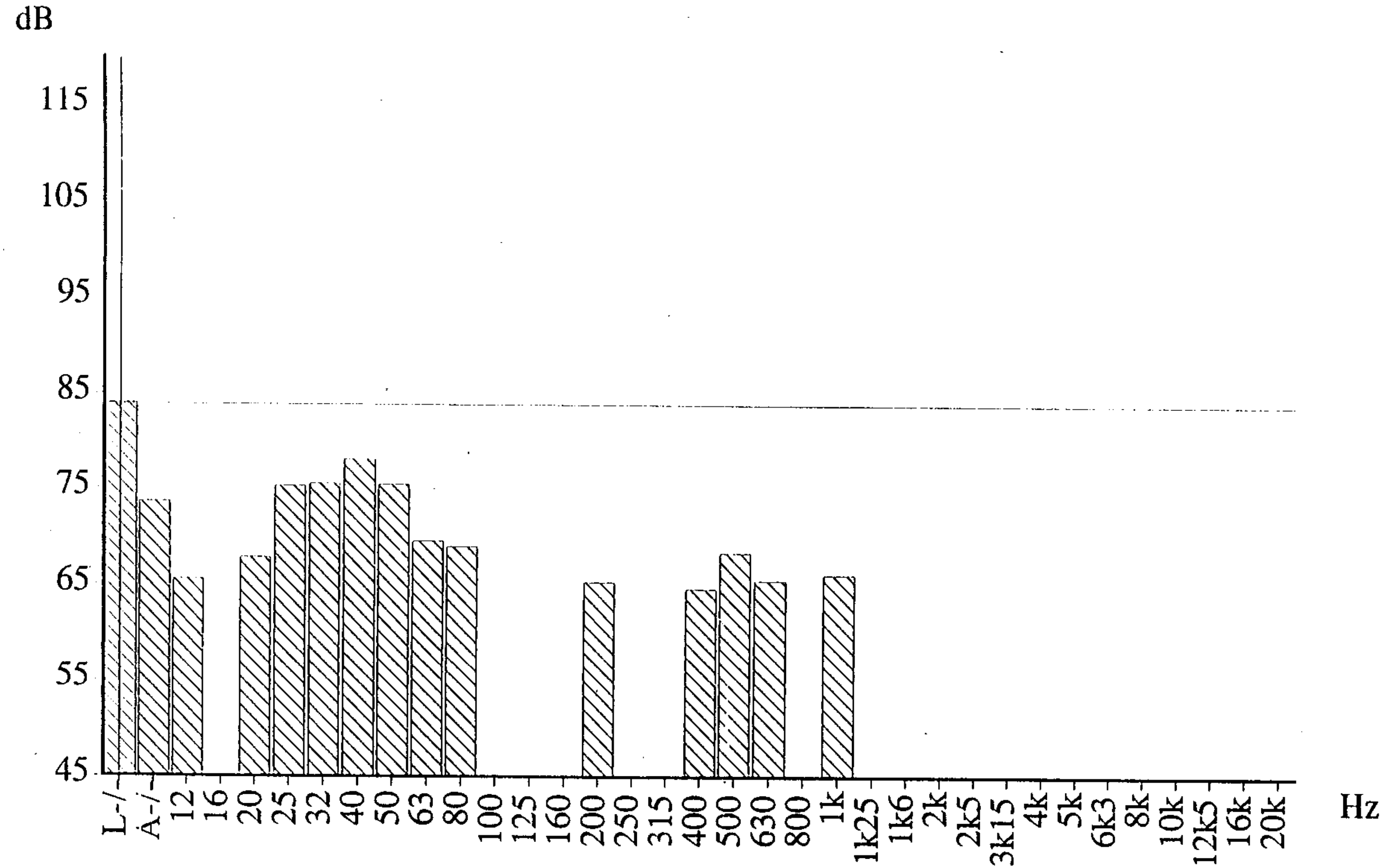


C:\DB2\FAU04.DTA
Function = Leq
Record start = 07/09/1999 11:15:31
Duration = 000 00:01:45.9
Record = Cumulative
Flags: ----
Cursor: Band = Broadband, Frequency weighting = L, Level = 88.7 dB

':\DB2\FAU05.DTA

Run summary -

ıstrument	CEL-593.C2 Version 6.3 Type 2
ıstrument ID (DPB)	107331
un mode	Third-octave band Environmental
ın start	07/09/1999 11:17:29
un end	07/09/1999 11:18:34
ın duration	000 00:01:05.56
ıst calibration	07/07/1999 14:33:40
.easurement range	65 - 140 dB
icrophone response	Free Field
ılarizing voltage	Off
me weighting	F
equency weighting	L, A
change rate (Q)	3
riod time	500 ms
riods too short for LNs	Yes
ofiles recorded	No
›file sample interval	1 s
.mber of records	131
ents enabled	No
erload occurred	No
w battery occurred	No
ıse was used	No

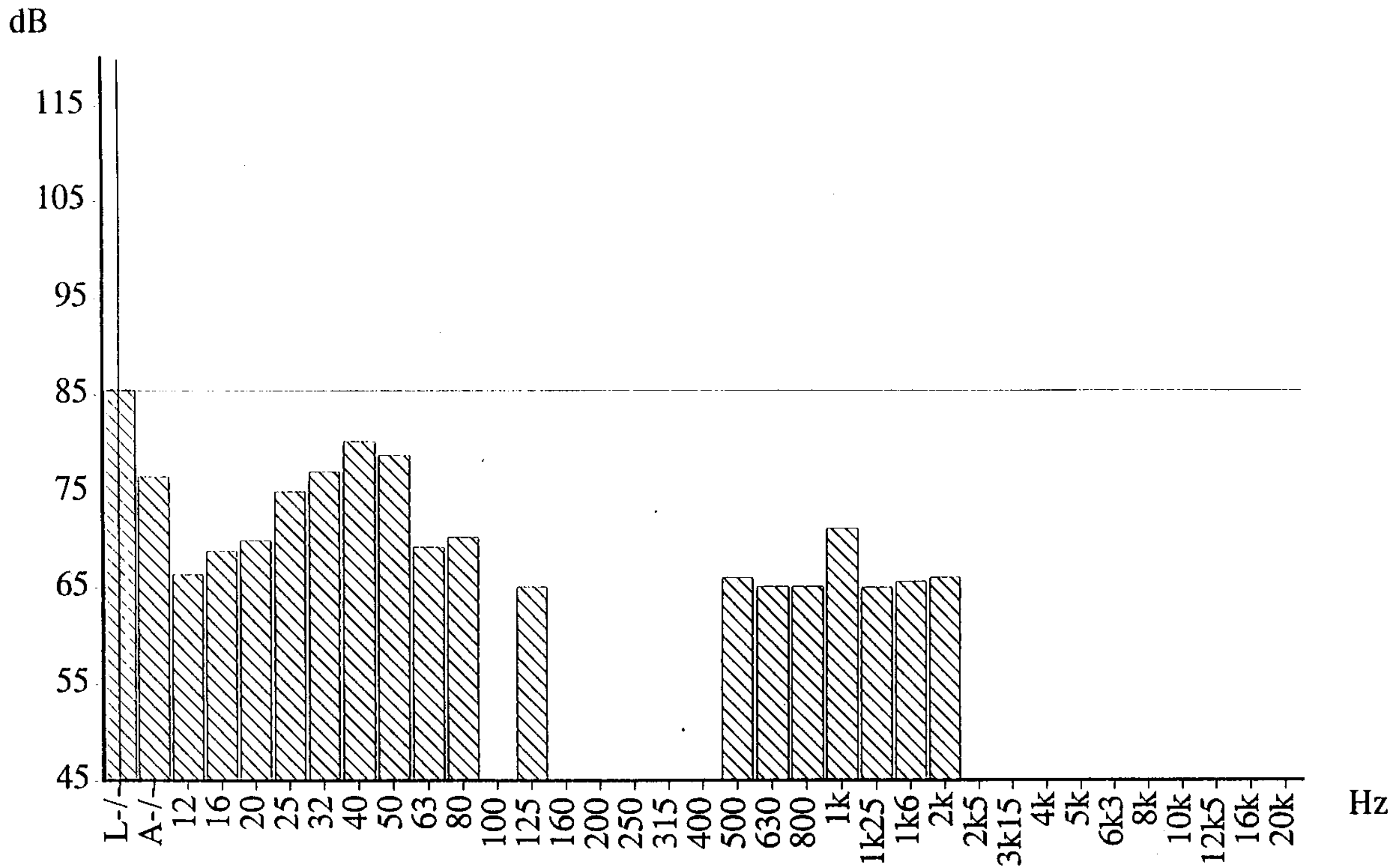


C:\DB2\FAUC5.DTA
Function = Leq
Record start = 07/09/1999 11:17:29
Duration = 000 00:01:05.6
Record = Cumulative
Flags: ----
Cursor: Band = Broadband, Frequency weighting = L, Level = 84.0 dB

\DB2\FAU06.DTA

Run summary -

strument	CEL-593.C2 Version 6.3 Type 2
strument ID (DPB)	107331
in mode	Third-octave band Environmental
in start	07/09/1999 11:38:59
in end	07/09/1999 11:42:36
in duration	000 00:03:37.58
st calibration	07/07/1999 14:33:40
easurement range	65 - 140 dB
crophone response	Free Field
larizing voltage	Off
ne weighting	F
equency weighting	L, A
change rate (Q)	3
riod time	500 ms
riods too short for LNs	Yes
ofiles recorded	No
ofile sample interval	1 s
imber of records	435
ents enabled	No
erload occurred	No
w battery occurred	No
ise was used	No



C:\DB2\FAU06.DTA
Function = Leq
Record start = 07/09/1999 11:38:59
Duration = 000 00:03:37.6
Record = Cumulative
Flags: ----
Cursor: Band = Broadband, Frequency weighting = L, Level = 85.5 dB