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16. Abstract

Noise from railroad operations were measured. Noise level data from freight yard operations were measured at the Argentine Freight Yard of the Santa Fe Railroad in Kansas City, Kansas and on a smaller scale in three facilities of the Boston and Maine Railroad in Boston Massachusetts. In addition, wayside noise data from passenger and line-haul operations were measured on the Penn Central Railroad in New Jersey and Massachusetts, and on the Sante Fe Railroad in Kansas.

This report contains statistical temporal noise data, graphical time history level recordings, and one-third octave frequency spectra of selected data.

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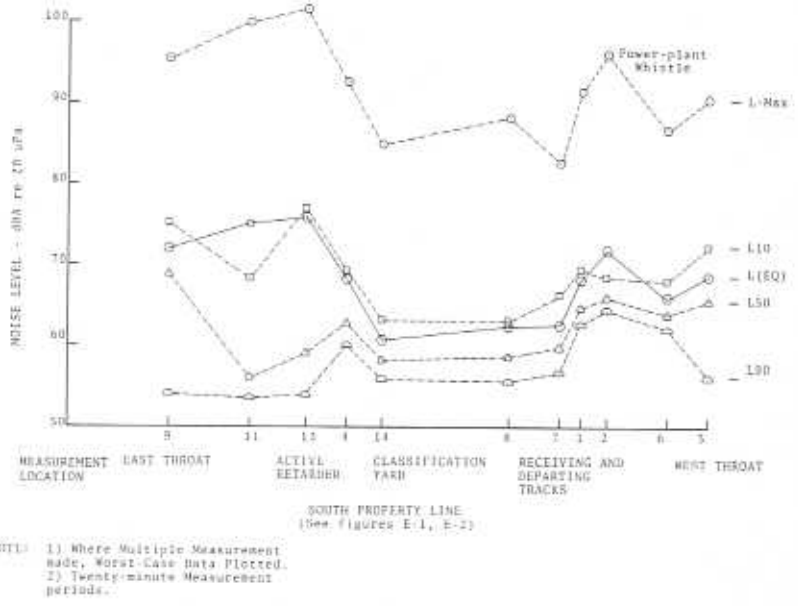
PREFACE

Measurements were made of noise emissions emanating from railroad freight yards and at the wayside from passenger and line-haul operations.

Freight yard measurements were made on 24-26 April 1973 at the Argentine Freight Yards of the Santa Fe Railroad in Kansas City KS and on a smaller scale on 21, 27, and 28 March 1973 at three facilities of the Boston and Maine Railroad in Boston MA.

Wayside passby noise emissions from passenger and line-haul operations were obtained on the Penn Central Railroad in NJ on 23 May, 1972 and in MA on 20 and 26 September 1972; and on the Santa Fe Railroad in KS on 24-26 April 1973.

Included in this report are statistical analyses of recorded data, graphic noise level time history recordings, and one-third octave frequency spectra of selected events. A summary is presented of the statistical data of measurements made along the south boundary of the Argentine yard during 20-minute sampling periods at the locations shown.



Property Line Noise Levels; Argentine Freight Yard, Santa Fe RR, 4/24-26/73

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The following members of the Noise Measurement and Assessment Group, Transportation Systems Center, contributed to the preparation of this report: Messrs. H. Bessler, R. Harzbecker, and F. Sears.

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1. INTRODUCTION

Noise level measurements were made by the U.S. Department of Transportation (DOT), Transportation Systems Center (TSC), Cambridge MA of railroad noise emissions to provide the DOT Office of Noise Abatement and the Environmental Protection Agency (EPA) with baseline data for use in developing railroad noise-emission standards pursuant to the Federal Noise Control Act of 1972.

The Noise Assessment Group at TSC measured both railroad freight yard noise levels, and wayside noise levels of passenger and line-haul (freight) operations. The major portion of the freight yard measurements were made at 21 locations in and around the Argentine Freight Yard of the Atchison, Topeka, and Santa Fe Railroad in Kansas City KS. Freight yard measurements were also made on a smaller scale at the Billerica, Somerville, and Charlestown yards of the Boston and Maine Railroad, Boston MA.

Wayside, passenger and line-haul, noise levels were measured on the Penn Central Railroad in both Plainsboro NJ, and West Mansfield MA, and on the Santa Fe Railroad in Kansas City and Zarah KS.

This report documents the noise level measurements made. Appendixes A and B contain data and analyses of noise level measurements made in the freight yards of the Santa Fe and Boston and Maine Railroads, respectively.

Wayside noise level data of passenger and line-haul service measured in Kansas City and Zarah KS, and in Plainboro NJ; and West Mansfield MA, are contained in appendixes A, C, and D, respectively. Appendixes E through H contain:

E) Measuring station locations and photographs.

F) Noise measurement and data-reduction systems.

G) Meteorological data.

H) Definition of terms and calculated values.

2. DISCUSSION

2.1 NOISE LEVEL MEASUREMENTS, ARGENTINE FREIGHT YARD, SANTA FE RAILROAD, KANSAS CITY, KS

Noise level measurements were made at 21 locations in and around the Argentine Freight Yard of the Santa Fe Railroad on 24-26 April 1973. A simple schematic which depicts the major centers of activity in the yard is shown in figure E-1. Figure E-2 is a reduced reproduction of a detailed map of the Argentine yard as supplied by Santa Fe officials. (Note: because of the overall size of the map (approximately 60 inches) figure E-2 has been cut into 10 contiguous sections for inclusion in this report. Each section has been keyed to facilitate the reconstruction of the map.)

The Argentine yard is one of the larger freight yards in the United States and is operated on a 24-hour, 7 days per week basis. It has a throughput of approximately 100,000 freight cars per month. The main line of the Santa Fe Railroad, which handles through traffic between Morris KS and Kansas City KS and MO, runs through the Argentine yard along the southerly border. Two freight car hump-type classification yards are operated, one fully computerized to handle eastbound traffic, the other manually operated to handle westbound traffic. These are designated as the east and west hump, respectively. A diesel locomotive repair facility is located in the northeast sector of the yard. Here, routine maintenance and the complete overhaul of diesel locomotives is performed. The circular track around the diesel facility (balloon track) is used in place of the now inoperative roundhouse to turn engines around.

Also shown in figures E-1 and E-2 is a 10-million bushel grain elevator and various other smaller car repair facilities.

The major activity in a freight yard is the receiving and rerouting of freight cars. The rerouting process consists of disengaging cars from incoming trains and reassembling them into outgoing trains bound for different destinations. This is

accomplished at the Argentine in the humping classification yards as follows: A switching engine pushes a string of cars up a man-made hill (or hump) on a single lead track. At the crest of the hump, the first car is manually uncoupled and allowed to roll by gravity down the opposite slope of the hump through a series of switches into one of the many tracks in the classification yard. Because railroad freight cars differ in their size, weight, rolling friction, etc., and because each car has a different distance to travel from the crest of the hump into the classification yard where it is to bump gently into and self-couple with a waiting car of its new train, some means must be employed to control its speed. This is accomplished by a mechanical braking device known as a retarder. A retarder is essentially two steel rails, attached to an actuating device, located astride each rail of a section of track. The retarder slows a moving car by squeezing the lower portion of the wheels of the car between the lengths of steel rail with a particular force. The friction between the rail brakes and the carwheel rims opposes the turning of the wheels, thus producing retardation of the forward velocity.

This braking action produces noise emissions known as retarder squeal (noise that is similar, if not identical, to that produced by a steel-wheeled car on steel track negotiating a tight turn at low speed and is common to subway systems).

In a manual-type humping operation such as the west hump of the Argentine Yard, an operator in a control tower has remote manual control of the track switches and the pressure exerted by the retarders. The operator visually observes a car's speed down the hump before its entry into the retarder. He varies the applied pressure to reach a mentally determined exit speed. This speed is determined by the operator's "feel" for the car's rollability and the distance into the classification yard that the car must travel.

A second type of retarder is built into each track at the far end of the west classification yard. These also provide retardation by squeezing the lower portion of the wheels between

steel lengths of rail; however, unlike the actuated or "active" type retarder on the hump, the pressure applied by these "inert" or unactuated retarders is spring-loaded and preset and is not meant to be deactivated in use. The purpose of the inert retarders is to stop the first car down the track from rolling, under its own power, out of the classification yard onto the main section of the yard.

Succeeding cars down that particular track in the classification yard will then gently impact on, and become coupled to, the previous car. When a full train of cars is made up in this manner, a switching engine is coupled to the train and the line of cars is pulled through the inert retarder, with the full pressure of the inert retarder applied, out of the classification yard into one of the departure tracks in the main section of the yard. Since the braking pressure is applied and cannot be released, this forced pull also produces retarder squeal.

The east hump yard in the Argentine operates in essentially the same manner; however, its operations are computer-controlled as follows. The speed of the switch engine pushing the line of cars up the lead track to the hump is radio-controlled by the computer. At the crest of the hump, the first car is manually uncoupled and allowed to roll by gravity down the lead track on the opposite side of the hump where it is automatically weighed, and its rollability and speed measured. This information, coupled with route, yard-grade information, and distance to go into the classification yard, allows the computer to set the proper switches automatically and determine the required exit speed. The pressure exerted by the retarders is automatically set to achieve a speed which will allow the car to travel into the classification yard and gently couple there at a minimum impact velocity (approximately two mph). At the far end of the classification yard, inert retarders are positioned in each track to stop the cars from rolling out into the main yard. The inert retarders used in the east yard of the Argentine are of the weight-balanced variety wherein the amount of retarding pressure exerted on the wheels is a function of the weight of the car going through the retarder

(the heavier the car the more pressure applied). Here, as in the west yard, a line of cars in a newly formed train in the classification yard must be pulled through the inert retarders, with pressure applied according to the cars overall weight, to move the train from the classification yard onto one of the departure tracks in the main section of the yard. Thus here also, inert retarder squeal is produced.

The majority of the noise measurements made at the Argentine Yard were concentrated along the south border of the yard where non-railroad noise was minimal. In general, the land use to the north of the yard was zoned industrial while that to the south was zoned residential. No specific times of the day were deliberately chosen to make measurements because operations were on a 24-hour, 7 days per week basis. The sites measured are located and numbered in figures E-1 and E-2.

For logistical reasons, 20-minute continuous analog magnetic tape recordings were made of the noise data at each of the indicated locations. The reduction of these data included graphical noise level time history recordings with specific noise source information noted, and one-third octave spectral analyses of selected data. These are included in Appendix A, figures A-1 through A-33.

To obtain a statistical measure of the temporal nature of the noise measured at each site, the data were statistically analyzed for each 20-minute measurement period. Data recorded from non-railroad noise intrusions were excluded from the statistical analysis. However these data have not been deleted from the graphical time histories presented.

Table 2-1 is a summary tabulation of the statistical noise data. The complete probability distribution and histogram charts of the data are included in Appendix A, figures A-34 through A-61.

Table 2-2 briefly describes the measurement locations, gives microphone positions, and identifies appendixes where detailed data may be found.

TABLE 2-1. SUMMARY TABULATION: THE STATISTICAL NOISE LEVEL DATA ARGENTINE FREIGHT YARD SANTA FE RR, KANSAS CITY, KS, 4/24-26/73.

LOCATION	DATE APRIL 73	TIME FROM	TO	STD. DEV. dBA	L(EQ) dBA	NPL dB	L1 dBA	L10 dBA	L50 dBA	L90 dBA	L99 dBA	RANGE dBA	MAX dBA	REMARKS
1	24	0950	1010	3.6	64.3	68.4	70.7	65.9	64.1	62.8	62.0	18	77	Activity on westbound receiving track shielded by standing line of cars
1	24	1050	1110	2.5	64.3	70.7	72.1	67.1	65.3	61.4	59.2	25	82	Normal activity of receiving and departure tracks
1	24	1151	1211	3.2	67.9	76.1	80.6	69.2	64.5	62.6	61.4	31	91	Normal activity on receiving and departure tracks. Max level caused by noon whistle
1A	24	2345	0005	5.2	69.1	82.4	82.3	70.4	65.2	57.3	56.3	54	89	Normal activity on receiving and departure tracks including passage of passenger train
1A	25	0745	0805	4.5	68.9	80.2	85.2	67.7	58.3	56.5	55.3	55	89	Normal activity on receiving and departure tracks including passage of passenger train
1A	26	0543	0605	4.9	67.1	80.0	82.4	68.8	60.6	57.4	56.3	52	87	Normal activity of receiving and departure tracks including passage of passenger train
1A	26	0725	0745	5.4	70.3	84.3	85.8	68.8	60.4	57.9	56.4	57	92	Normal activity on receiving and departure track including passage of passenger train
2	24	0950	1010	1.5	65.7	69.0	70.7	67.4	65.8	64.4	63.3	16	78	Activity on westbound receiving track shielded by standing line of cars
2	24	1050	1110	2.2	65.5	71.3	72.5	67.7	65.4	62.9	60.3	20	78	Normal activity on receiving and departure track
2	24	1151	1211	3.0	71.8	79.5	84.6	68.4	66.0	64.5	63.2	34	94	Normal activity on receiving and departure track. Max level caused by noon whistle
3	24	1527	1547	3.7	60.9	70.4	72.0	62.8	57.0	55.1	53.9	30	82	Normal west classification yard activity plus 3 minutes on humping activity
3 Special	24	1528	1531	4.8	63.6	75.9	74.7	68.1	58.3	55.6	54.2	26	79	3 minutes of humping activity in west hump
4	25	0916	0950	4.4	68.2	78.3	80.1	69.1	62.8	60.0	57.9	33	92	Max levels from inert retarder
5	25	1138	1158	2.9	60.8	68.2	69.9	63.3	58.7	56.7	55.4	31	84	East throat of yard, very little activity
5	25	1216	1236	5.3	68.3	81.9	79.4	71.9	65.5	58.5	56.3	56	90	East throat of yard, almost constant in and outbound activity
6	25	1500	1520	2.7	65.7	72.6	74.9	67.5	63.8	62.1	60.8	27	86	Light activity of receiving and departure tracks
7	25	1547	1607	3.9	62.5	72.3	72.0	66.1	59.7	56.5	55.0	28	82	Normal activity of receiving and departure tracks plus hump engine driving west hump
8	25	1648	1708	3.5	62.6	71.6	71.9	65.1	58.6	55.6	54.1	35	88	Normal activity shielded by standing line of freight cars
9	25	2251	2311	7.6	71.8	92.3	80.8	75.0	68.7	54.1	51.6	41	95	West throat of yard, almost constant activity
10	26	1045	1105	-	-	-	68.1	66.6	-	-	-	-	104	Approx. 10 miles west of freight yard. Data includes passby of 1- 3-engine 76-car train. 50 feet offset.
11	25	2232	2252	1.6	56.8	60.9	61.1	59.0	56.8	55.0	53.5	16	87	Light activity, no activity on east hump
11	25	2302	2322	7.7	74.6	94.5	89.0	68.0	56.1	53.5	52.2	49	100	Normal east classification yard activity plus 5 minutes of humping activity
11 Special	25	2306	2311	11.0	80.4	108.6	93.5	83.9	62.1	55.8	53.8	47	100	5 minutes of humping activity in east hump
12	24	1054	1114	1.8	69.5	74.1	75.2	71.1	68.0	67.5	66.5	25	90	Normal Activity outside diesel repair shop
13	26	0952	1012	8.5	75.0	97.6	89.6	76.5	58.0	55.8	54.0	49	101	Max east classification yard. Approx. 50 cars humped
14	26	1036	1056	5.1	60.3	68.2	68.8	62.8	58.1	55.8	54.5	31	84	Normal activity shielded by line on standing freight cars
15	25	0926	0943	15.8	99.5	150.9	113.0	102.8	72.0	60.6	58.2	69	125	East hump microphone offset 25 ft from group retarder 3. Approx. 40 cars humped
16	24	1631	1646	12.4	87.4	129.1	113.0	87.5	67.1	59.7	58.1	65	121	West hump microphone offset 25 ft from intermediate retarder 1. Approx. 30 cars humped
17	25	1630	1645	5.0	72.1	84.9	81.1	55.9	53.1	51.8	51.0	40	96	One, three engine unit around balloon track
18	25	1400	-	-	-	-	-	-	-	-	-	-	93	Piggyback operation. Drott diesel-powered hydraulic travel lift.
19	25	1500	-	-	-	-	-	-	-	-	-	-	92	Impact noise from grain hopper cars (peak impulse 12b dB)
20	25	1100	-	-	-	-	-	-	-	-	-	-	124	West classification yard. Spring loaded inert retarders
21	25	1000	-	-	-	-	-	-	-	-	-	-	116	East classification yard. Weight-balanced inert retarder

Specials are statistical data from a selected portion of the measurement period
See table 2 for microphone positional data

TABLE 2-2. MICROPHONE POSITIONAL DATA: ARGENTINE FREIGHT YARD, SANTA FE RR, KANSAS CITY KS, 4/24-26/73.

Location	General	Specific	Photographs in Appendix	Noise-Level Time History in Appendix	Statistical Analyses in Appendix
1	South border, 2400 feet east of milepost 5, southwest of diesel shop	25 feet offset from mainline track, 5 feet above level grade	E-3	A-1a	A-34, A-35, A-36
1A	Same location 1	60 feet offset from mainline track, 5 feet above level grade	-	A-2 A-3 through A-6	A-40, A-41, A-42, A-43
2	South border, 500 feet east of measurement location 1	25 feet offset from mainline track, 5 feet above level grade	E-4	A-1b	A-37, A-38, A-39
3	North border, east of west classification yard, 1200 feet northwest of measurement location 16	500 feet offset from center of west classification yard, 4.5 feet above level grade	E-5	A-7	A-44, A-45
4	South border, at milepost 6 next to east classification yard	On enbankment, 75 feet offset from mainline track, 30 feet above level of rails	E-6	A-8	A-46
5	South border, 625 feet east of milepost 4, at east throat of yard	On enbankment, 64 feet offset from rear track, 15 feet above level of rails	E-7	A-9	A-47, A-48
6	South border, 340 feet west of 18th street expressway overpass	50 feet offset from mainline track, 4.5 feet above level grade	E-8	A-10	A-49
7	South border, 360 feet west of Goddard Ave. overpass	31 feet offset from mainline track, 4 feet above level of rails	E-9	A-11	A-50
8	South border, 400 feet west of milepost 5	50 feet offset from mainline track, 4.5 feet above level grade	E-10	A-12	A-51
9	South border, 500 feet west of milepost 7	25 feet offset from mainline track, 4 feet above level of rails	E-11	A-13	A-52

TABLE 2-2. (Cont.)

Location	General	Specific	Photographs in Appendix	Noise-Level Time History in Appendix	Statistical Analyses in Appendix
10	Mainline track, Zarah, KS 1150 feet west of milepost 16	Two microphones offset 50 and 100 feet from westbound track, 5 feet above level grade	E-12	A-14, A-15, A-16, A-17	-
11	South border, southwest of east hump, 950 feet southwest of measurement location 15	Offset 775 feet from center of master retarder, 4.5 feet above level grade	E-13	A-18	A-53, A-54
12	Northeast border, 325 feet from rear doors of diesel shop	On enbankment, 25 feet offset from near track, 25 feet above level of rails	E-14	A-19	A-56
13	South border, southeast of east hump, 1100 feet west of milepost 6	On enbankment, 70 feet offset from mainline track, 20 feet above level of rails	E-15	A-20	A-57
14	South border, opposite ladder track at far end of east classification yard, 1100 feet east of milepost 6	100 feet offset from mainline track, 4.5 feet above level grade	E-16	A-21	A-58
15	On down slope of east hump within set of six "group retarders"	25 feet offset from center of group retarder 2, 4.5 feet above level grade and 1.5 feet above level of rails of retarder 2	E-17	A-22, A-23*	A-59
16	On down slope of west hump within set of three "intermediate retarder"	25 feet offset from center of retarder 1, 4.5 feet above level grade and 2.5 feet above level of rails of retarder 1	E-18	A-24, A-26*	A-60
17	Within "balloon track" 200 feet from front of diesel shop	60 feet offset from track, 4.5 feet off level grade	E-19	A-25	A-61
18	North border (piggyback operation)	50 feet offset from flatcar, 4.5 feet off level grade	E-20	A-27, A-28*	-

TABLE 2-2. (Cont.)

Location	General	Specific	Photographs in Appendix	Noise-Level Time History in Appendix	Statistical Analyses in Appendix
19	Center of yard near grain elevator	40 feet offset from track, 4 feet above level of rails	E-21	A-29	-
20	Far end of west classification yard near spring-loaded inert retarder	45 feet offset from center of retarder, 4 feet above level of rails	E-22	A-30, A-32*	-
21	Far end of east classification yard near weight-balanced inert retarder	55 feet offset from center of retarder, 4 feet above level of rails	E-23	A-31, A-33*	-

*One-third octave frequency spectra of selected events.

2.1.1 Locations 1, 1A, and 2

Measurement location 1 was situated on the south boundary of the Argentine Yard, southwest of the diesel shop area, 2400 feet east of milepost 5. The microphone was offset 25 feet from the near mainline track and placed at a height of 5 feet off the level grade. Figure E-3 contains photographs of four views of the measurement site.

Because of its close proximity to the surrounding residential district, this area was selected for measurements during seven different 20-minute time periods. Measurements were made at 1000,1100, and 1200 hours on 24 April 1973. During these periods, no through traffic was expected on the mainline track. In addition, measurements were made at 2400, 0800, 0600, and 0730 hours on 24, 25 and 26 April 1973 when through traffic was expected on the mainline track. For these measurements, the microphone was offset 60 feet from the near mainline track. This location was designated 1A.

Measurement location 2 was situated 500 feet east of location 1 with the microphone offset 25 feet from the near mainline track at a height of 5 feet above the level grade (see photographs figure E-4). Measurements were made at this location simultaneously with those made at 1000,1100, and 1200 hours on 24 April 1973 at location 1.

Figure A-1 contains coincident noise level time histories of the data measured simultaneously at locations 1 and 2 on 24 April 1973 between 1151 and 1211 hours. The bulk of the activity occurred on the far tracks from the microphones which were shielded by a line of freight cars standing on the seventh track over from the microphone. The maximum sound recorded was the noon whistle from the railroad yard powerplant and the whistle from a local steel company located on the south boundary of the yard to the east of locations 1 and 2. Activity on the receiving and departure tracks in this area was similar during the above measurement period and the 1000- and 1100-hour period (except for the noon whistle). Time history recordings during the latter two

periods have not been presented. In general, the background noise at locations 1 and 2 during the above three measurement periods was dominated by engine noise including noise from diesel engines used in mechanical refrigeration cars which were intermingled in the line of standing freight cars. The northerly photograph in figure E-4 of location 2 shows the first of three consecutive refrigeration cars in the upper left-hand corner of the picture. The proximity of these three cars to the microphone at location 2 raised the ambient noise level at location 2 by approximately 2dBA over the level measured at location 1 during the periods measured, see figure A-1.

Figure A-2 contains time histories of data measured during two time periods at location 1A beginning at 2345 hours on 24 April 1973 and 0725 hours on 26 April 1973. Note the passage of through passenger trains on the mainline and the unshielded general activity on the receiving and departure tracks during both measurement periods. Activity of a similar nature occurred during the measurements at 0600 and 0800 hours at this location. Time history recordings for these two periods are not presented.

Figures A-34 through A-43 contain probability distributions and histograms of the measured data for each of the 20-minute measurements made at locations 1, 1A, and 2. The statistical data are summarized in Table 2-1 for these and for all the measurement locations.

Figures A-3 through A-6 contain wayside noise level time histories on an expanded time scale of the passby on the main line through the yard of four passenger trains as measured at location 1A. See section 2.3 for comparison with passenger train noise level signatures recorded in NJ and MA on the Penn Central Railroad.

2.1.2 Location 3

Measurement location 3 was situated on the northern boundary of the Argentine Yard to the east of the west classification yard, 1200 feet northwest of measurement location 16 which was situated

on the down slope of the west hump (see paragraph 2.1.15). The microphone was placed 4.5 feet off the level grade and offset approximately 500 feet from the centerline of the west classification yard. Figure E-5 contains photographs of four views of the measurement site.

Figure A-7 is a noise level time history of data recorded on 24 April 1973 from 1527 to 1547 hours. It shows the noise emissions from operations within the classification yard and a period of approximately three minutes of noise intrusions from the humping operation (retarder squeal). The background noise at this boundary location was equally contributed to by railroad operations and by the local industrial facility to the north of the microphone.

Figure A-44 contains a probability distribution and histogram of the data for the 20-minute measurement period. To obtain a statistical measure of the temporal noise in this area from the retarders, the three-minute period during which the west hump was active was analyzed separately. The probability distribution and histogram of the three minutes of data are contained in figure A-45. Summary data for the 20-minute and special 3-minute periods are contained inTable 2-1.

2.1.3 Location 4

Measurement location 4 was situated on the south boundary of the Argentine Yard at milepost 6 next to the east classification yard. The microphone was placed at the crest of an embankment 75 feet offset from the near mainline track and 30 feet above the level of the rails. Figure E-6 contains photographs of four views of the measurement site.

Figure A-8 is a noise level time history of the data recorded on 25 April 1973 from 0936 to 0956 hours. It shows the noise emission from classification yard operations, active retarder noise (squeal) from the east hump operations, train movements on the receiving tracks, movement within the classification yard, and inert retarder squeal resulting from a line of cars being pulled through the inert-type retarders in the east classification yard.

(see discussion location 21, paragraph 2.1.17).

Figure A-46 contains a probability distribution and histogram of the noise data for the 20-minute measurement period. The statistical results are summarized in Table 2-1.

2.1.4 Location 5

Measurement location 5 was situated on the south boundary at the east throat of the Argentine Yard, 625 feet east of milepost 4. The microphone was placed on an embankment offset 64 feet from the near track and 15 feet above the level of the rails. Figure E-7 contains photographs of four views of the measurement site.

Measurements were made over two consecutive 20-minute periods at this location on 25 April 1973. Figure A-9 contains graphic recordings of the noise level time histories of both periods measured. During the first period beginning at 1138 (lunch time) (figure A-9a), note light railroad activity in the area. Traffic noise to the south of the microphone was clearly audible. The measurement period beginning at 1216 (figure A-9b) shows a marked increase in railroad activity with the resultant increase in the measured noise levels.

Figures A-47 through A-48 contain probability distributions and histograms for each of the two 20-minute measurement periods individually. The statistical results are summarized in Table 2-1.

2.1.5 Location 6

Measurement location 6 was situated on the south boundary of the Argentine Yard 340 feet west of the 18th Street expressway which runs on an overpass over the yard. The microphone was placed 4.5 feet off the level grade and offset 50 feet from the near mainline track. Figure E-8 contains photographs of four views of the measurement site.

Figure A-10 is a graphic time history recording of the noise levels recorded on 25 April 1973 from 1500 to 1520 hours. Light

freight yard activity was noted during the period. Background noise was mainly from diesel locomotive engines idling in the diesel shop area to the north and in line of sight with the microphone. High-level intrusive sounds recorded and identified on the level-history recording were caused by the local steel company's switching equipment moving in close proximity to the microphone on the spur track approximately 25 feet south of the microphone. Since these intrusions were not freight-yard-generated noise emissions, the data were excluded from the 20-minute analysis period for which statistical data are presented in figure A-49 and summarized in Table 2-1.

2.1.6 Location 7

Measurement location 7 was situated on the south border of the Argentine Yard, 360 feet west of the Goddard Avenue overpass. The microphone was placed 31 feet offset from the near mainline track at a height of 4 feet above the level of the rails. Figure E-9 contains photographs of four views of the measurement site.

Figure A-11 is a noise level time history of the data recorded on 25 April 1973 from 1547 to 1607 hours. Major activity in this area at this time was a result of humping operations on the west hump. In this case, the noise generated was not retarder squeal because of distance and shielding from the retarders but resulted from a single switching locomotive with booster engine which steadily pushed a line of 56 freight cars on the lead track in question.

Automobile and truck passby noise noted on the time history were movements in the freight yard, and these data are included in the statistical data.

Figure A-50 contains a probability distribution and histogram of the noise data for the 20-minute measurement period. The statistical results are summarized in Table 2-1.

2.1.7 Location 8

Measurement location 8 was situated on the south border of the Argentine Yard, 400 feet west of milepost 5. The microphone was placed 4.5 feet above the level grade and offset 50 feet from the near mainline track. Figure E-10 contains photographs of four views of the measurement site.

Figure A-12 is a noise level time history of the data recorded on 25 April 1973 from 1648 to 1708. A 39-car freight train was being moved into position on a receiving track 130 feet offset from the microphone at the start of the measurement period. It stopped and remained there for the entire measurement period along with a second line of standing cars one track over. Both lines of cars provided shielding to the microphone from activity occurring on the west hump.

A two-minute period of switching activity on a spur track leading to a local transportation company, and noise data from an aircraft flyover were not included in the statistical analysis of the data presented in figure A-51 since the intrusions were not freight yard noise emissions.

Table 2-1 contains a summary of the statistical noise data.

2.1.8 Location 9

Measurement location 9 was situated on the south border at the west throat of the Argentine Yard, 500 feet west of milepost 7. The microphone was located 25 feet offset from the near mainline track at a height of 4 feet above the level of the rails. Measurements were made in the late evening on 25 April 1973 to avoid noise generated by construction equipment in the area. Photographs of the measurement site shown in figure E-11 were taken after the fact and shows this equipment.

Figure A-13 contains a noise level time history of the data recorded on 25 April 1973 from 2251 to 2311. Activity in the area during the period included slowly moving freight trains arriving and departing, movement of diesel locomotives back and forth,

distant squealing sounds from the direction of the east hump, and distant truck noise from Key Road to the west of the microphone.

Figure A-52 contains a probability distribution and histogram of the noise data for the 20-minute measurement period. The statistical results are summarized in Table 2-1.

2.1.9 Location 10

Measurement location 10 was situated 9 miles west of the Argentine Yard in Zarah KS, 1150 feet west of milepost 16. Two microphone systems were set up 5 feet off the level grade at offset distances of 50 and 100 feet from the centerline of the westbound track. The centerline of the eastbound track was offset 63 and 113 feet from the microphone. Figure E-12 contains four views of the measurement site.

The two tracks in this area were made up of a combination of welded and jointed rail construction with wood ties in stone ballast. The welded sections of rail were approximately 1500 feet in length with each section being joined with standard jointed construction. The closest joints to the microphone were 80 feet to the west of the microphones.

Figures A-14 through A-17 contain time histories of the wayside noise levels, recorded on 26 April 1973, of the passby of four freight trains driven by multiple diesel locomotives. Note in each case the train whistle which was sounded as the train approached the unattended crossroad.

No statistical data are presented since data were recorded only during the four periods of line-haul activity on the rail line.

See section 2.3 for comparison with line-haul noise level signatures recorded in NJ and MA on the Penn Central Railroad.

2.1.10 Location 11

Measurement location 11 was located on the south border of the Argentine Yard to the southwest of the east hump. The

microphone was set up at a height of 4.5 feet off the level grade and offset approximately 775 feet from the master retarder and 950 feet from measurement location 15 which was situated within the area of the group retarders on the east hump (see paragraph 2.1.14). Measurements were made in the late evening of 25 April 1973, and photographs of the site, shown in figure E-13, were taken after the fact.

Figure A-18 contains noise level time histories of two consecutive 20-minute measurement periods. The first measurement, started at 2032 hours, figure A-18a, shows little intrusive activity from the freight yard operations. General background sounds were of idling diesel engines, an occasional locomotive passby, and distant squealing sounds.

A second recording was started at 2102 hours when it was noted that a line of freight cars was about to be driven up the hump for processing in the classification yard. Figure A-18b shows 5 minutes of retarder squeal intrusions resulting from approximately 15 freight cars being processed over the hump. It also shows classification yard emissions, including impact sounds from the self-coupling of cars being processed and impact sounds from the trimming operation. (Trimming is similar to flat-switching, in that those cars which fail to self-couple as a result of not rolling far enough into the classification yard, or impact too gently, are pushed into position by the switch engine after all the cars being processed have been driven over the hump.) Background noise, as in the previous measurement period, included idling diesel engines.

Figures A-53 through A-54 contain probability distributions and histograms of both 20-minute measurement periods individually. To obtain a statistical measure of the temporal noise from the retarder operation during the processing period recorded, the five-minute period of activity of the east hump was analyzed separately. These special statistical data are contained in figure A-55 and are summarized in Table 2-1 along with the summary data of the two full 20-minute periods.

2.1.11 Location 12

Measurement location 12 was situated on the northeast border of the Argentine Yard to the east of the diesel shop. The microphone was set up on an embankment 25 feet above the level of the rails and offset 25 feet from the centerline of the near track and 325 feet back from the diesel shop building. Figure E-14 contains photographs of three views of the measurement site.

Figure A-19 is a noise level time history of the data recorded on 24 April 1973 from 1054 to 1114 hours. The background noise in this area, was in general, from the diesel locomotives (approximately 12) which were parked with their engines idling in the area behind the diesel shop. Two rebuilt locomotives were tied into load boxes just outside the diesel shop; however, these engines were not run up for testing during the measurement period.

A histogram and probability distribution of the 20-minute measurement period are included in figure A-56 with summary statistical data included in Table 2-1.

2.1.12 Location 13

Measurement site 13 was situated on the south border of the Argentine Yard to the south of the east hump. The microphone was set up on an embankment 20 feet above the level of the rails and offset 70 feet from the centerline of the near mainline track and 1100 feet west of milepost 6. Figure E-15 contains photographs of four views of the measurement site. These were taken after the fact since the original photographs were of poor quality and not reproducible.

Figure A-20 is a noise level time history of the data measured on 26 April 1973 from 0952 to 1012 hours. During the entire measurement period, the computerized east hump was operational with approximately 50 cars being processed over the hump during the 20-minute measurement period.

The maximum levels recorded were retarder squeal intrusions from both the master and group retarders on the east hump. These

were in line of sight and approximately 1300 and 1000 feet, respectively, from the microphone. In addition, impact sounds from the self-coupling of cars in the classification yard were recorded.

Figure A-57 contains a probability distribution and histogram of the 20 minutes of noise data. Summary statistical data are included in Table 2-1.

2.1.13 Location 14

Measurement location 14 was situated on the south border of the Argentine Yard opposite the ladder tracks at the far end of the east classification yard, 1100 feet east of milepost 6. The microphone was placed 4.5 feet above the level grade 100 feet offset from the centerline of the near mainline track. Figure E-16 contains photographs of four views of the measurement site taken after the fact.

Figure A-21 contains a noise-level time history of the data recorded on 26 April 1973 from 1036 to 1056 hours. At the beginning of the measurement period, a long inbound train at 4 to 5 mph was received on track 2 (one track beyond the mainline). It stopped in front of the microphone and its full line of cars provided shielding from classification yard activity for the entire measurement period. Note the coupling impacts caused by the braking action. Noise emission noted included whistle blasts from a locomotive on the balloon track in the diesel shop area (see paragraph 2.1.16, location 17), and retarder squeal from cars being pulled through the inert retarders from both the east and west classification yards. (See paragraph 2.1.17 for measurements made on inert retarders at locations 20 and 21 in the west and east classification yards). The new highway over the freight yard 400 feet east of the microphone although completed at this point was unused and did not contribute to the measured noise levels.

Figure A-58 contains a probability distribution and histogram of the data measured. Table 2-1 contains a summary of the statistical data.

2.1.14 Location 15

Measurement location 15 was situated on the down slope of the computerized east hump in the Argentine Yard. In this humping operation, the first retarder down the slope of the hump on the lead track is termed the "master retarder." The lead track then fans out through switches into six tracks, each of which is equipped with retarders termed "group retarders." These six tracks in turn fan out through switches to 8 tracks each and make up a 48-track classification yard. The microphone was placed within the set of 6 group retarders between retarders 2 and 3 (numbered from south to north) at a height of 4.5 feet above the level grade, 1.5 feet above the level of the rails of retarder no. 2. The microphone was positioned midway down the length and offset 25 feet from the centerline of retarder 2. Approximate distances to the midpoint of the 5 remaining retarders were 65, 65, 95, 106, and 150 feet from retarders 1, 3, 4, 5, and 6, respectively, and 525 feet from the centerline of the master retarder.

Photographs of the measurement site and the computer display are included in figure E-17.

Figure A-22 is a noise level time history of data recorded on 25 April 1973 from 0926 to 0943 hours. The maximum levels noted occurred during retardation of the cars by the group retarders. The time history has been labeled to indicate the retarder in question and, as obtained from the computer console, the weight of the car and the computer-controlled exit speed. The noise level generated as a result of retardation by the master retarder was at a lower level primarily because of its distance from the microphone. The computer-controlled exit speed from the master retarder was 10 mph for each of the cars measured. Forty-two cars were processed over the hump during the 17-minute measurement period.

Also identified on the time history (notes 1, 2, and 3) are noise emissions from three freight cars for which one-third octave spectral analyses are presented in figure A-23. Note the

high-pitched tonal quality (squealing) of the retardation emission.

A probability distribution and histogram of the 17-minute measurement period are included in figure A-59. Summary statistical data are included in Table 2-1.

2.1.15 Location 16

Measurement location 16 was situated on the down slope of the manually operated west hump in the Argentine Yard. In this humping operation, the master retarder is also the first retarder in the lead track on the down slope of the hump. The lead track fans out through switches into three tracks each with retarders which are termed "intermediate retarders". These three tracks in turn fan out through switches into eight tracks, each with a retarder; these are known in this yard as the "group retarders." The 8 tracks finally fan through switches into a 56-track classification yard. The microphone was placed within the group of three intermediate retarders between retarders 1 and 2 (numbered from south to north) at a height of 4.5 feet above the level grade and 2.5 feet above the level of the rails of retarder 1. The microphone was positioned midway down the length and offset 25 feet from the centerline of retarder 1. Approximate distances to the remaining retarder were 100 and 125 from intermediate retarders 2 and 3 and 350 feet from the master retarder. The nearest group of group retarders was 175 feet from the microphone.

Figure E-18 contains photographs of the measurement site.

Figure A-24 is a noise level time history of data recorded on 24 April 1973 from 1631 to 1646 hours. The time history has been labeled to indicate the retarder from which the noise emanated and the estimated entrance and exit speed of the car through the retarder. Unlike the computerized humping operation where cars are processed on an individual basis, in a manual operation, consecutive cars in a string bound for the same destination are processed in tandem without uncoupling. One such three-car tandem of grain cars is identified going through intermediate retarder 1 and then through one of the group retarders (see also photograph, figure E-18b).

Also identified in figure A-24 (Notes 1, 2, 3) are the emissions from three freight cars for which one-third octave spectral analyses are presented in figure A-26. Note that the high-pitched tonal quality (squealing) of the retardation emissions are similar to those measured in the east hump yard (figure A-23).

A probability distribution and histogram of the 15-minute measuring period are contained in figure A-60. Table 2-1 contains summarized statistical data.

2.1.16 Location 17

Measurement location 17 was situated within the balloon track at the front of the diesel shop.

The balloon track around the diesel shop building is used in place of the no longer used "roundhouse" to turn locomotive engines around. As the locomotive comes from behind the diesel shop, the engineer is required to sound warning blasts of the locomotive horn as he negotiates the balloon track because of pedestrian and vehicular traffic in the area.

The microphone was set up inside the balloon track, 200 feet from the diesel shop building and 60 feet offset from the center of the track at a height of 4.5 feet off the level grade. Figure E-19 contains photographs of two views of the measurement site.

Figure A-25 contains a noise level time history of the data recorded on 25 April 1973 from 1630 to 1645. A three-engine Amtrak locomotive negotiated the balloon during the measurement period at approximately four to six mph. Little if any vehicular traffic was noted on the nearby roadways during the measurement period.

Figure A-61 contains a histogram and probability distribution of the temporal noise measured during the 15-minute measurement period. Note that the noise intrusion from the aircraft noted in figure A-25 was excluded from this statistical description.

Summary statistical data are included in Table 2-1.

2.1.17 Locations 18, 19, 20, and 21

Measurements were made of singular noise sources at locations 18, 19, 20, and 21 in the Argentine yard.

At site 18 (north border), measurements were made of a "Drott" diesel-powered hydraulic travel-lift used in the railroad "piggy back" operation. The travel-lift was recorded lifting a loaded trailer box and placing it on a railroad flat car. See photographs in figure E-20 of travel-lift moving into position and lifting the box.

The microphone, placed at a height of 4.5 feet, was centered on the travel-lift and offset 50 feet from the centerline of the flat car on which the box was to be placed.

Figures A-27 and A-28 contain a time history of the noise level data recorded and a one-third octave spectral analysis of noise emissions recorded of an eight-second period during the lifting of the trailer box.

At site 19 (center of yard near 10-million-bushel grain elevator), measurements were made of several coupling impacts of loaded grain carriers (200,000 pounds). After loading of the grain cars, the car is pushed out of the dumper shed and allowed to roll under its own power down the gently sloped track until it impacts and couples with the other cars on the track.

The microphone was offset 40 feet from the centerline of the track at a height of 4 feet above the level of the rails and placed directly opposite the point of impending impact. Figure A-29 contains noise level time histories of three impacts recorded. Presented are both the A-weighted and flat-unweighted level histories for each event. The graphic recorder was adjusted for a writing speed of 200 dB per second for these recordings. Included on the time histories is the unweighted peak impulse measurement value for each recorded impact.

The first impact recorded (figure A-29a) is of a loaded grain car impacting on a long line of loaded cars at approximately eight mph. Point of impact was shielded from the microphone by a standing

line of empty freight cars 13 feet closer to the microphone. The second impact at seven mph (figure A-29b) was of a single grain carrier impacting on a single standing grain carrier with no obstruction between point of impact and microphone. The third impact at two or three mph (figure A-29c) (brakeman riding car) was of a single grain carrier impacting on two standing carriers. All three cars were loaded, and there was no obstruction between point of impact and the microphone.

Photographs of the measurement area are included in figure E-21.

At site 20 (far end of the west classification yard), measurements were made of the noise emissions resulting from a "pull" through the inert retarders. Photographs of the retarder and of the site are contained in figure E-22.

The inert retarders (braking system) built into the tracks at the far end of the west classification yard are of the spring-loaded variety. Their purpose is to stop the first car in the train being assembled from rolling under its own power out of the classification yard into the freight yard proper. Unlike the active retarders on the hump whose braking pressure is controlled either by computer or by an operator and can be completely disengaged, the braking pressure exerted by these spring-loaded inert retarders is preset to a specific pressure and cannot be disengaged. To move a train of cars out of the classification yard, a switching engine must physically "pull" the entire line of cars through an inert retarder which has its braking pressure applied. This results in the characteristic high level tonal noise emissions from the retarder braking action.

Figure A-30 is a noise level time history recorded on 25 April 1973 of a line of cars being pulled through the spring-loaded inert retarders. The microphone was offset 45 feet from the centerline of the track midway between the ends of the retarder at a height of 4.5 feet of the level grade and 4 feet above the level of the rails.

Figure A-32 contains one-third octave spectral analyses of the recorded emissions of three different-type railroad cars being pulled through the retarder; i.e., a grain carrier, a tank car, and an empty autoveyor. As with the active retarders a high-pitch tonal characteristic of the emissions (squealing) is noted.

At site 21 (far end of the east classification yard), measurements were made of the noise emissions resulting from a "pull" through the weight-balanced-type inert retarders built into the tracks. Photographs of the retarder and the measuring site are included in figure E-23.

The purpose of the weight-balanced inert retarder is the same as the spring-loaded type used in the west classification yard; however, its operation is different in that the braking pressure exerted is variable and is a function of the weight of the car impinging upon the retarder mechanism; therefore, the heavier the car, the greater is the pressure exerted. As with the spring-loaded inert retarders, these also cannot be disengaged, and a switching engine must physically pull the made-up train through the retarder with the braking pressure applied to get the train of cars into the yard proper.

Figure A-31 is a noise level time history recorded on 25 April 1973 of a line of cars being pulled through the weight-balanced inert retarder in the east classification yard. The microphone was placed at a height of 4 feet above the level of the rails, and centered on an offset 55 feet from the centerline of the retarder.

Figure A-33 contains one-third octave spectral analyses of the noise emissions generated as two heavy tank cars and a mechanical refrigeration car were pulled through the weight-balanced inert retarder. Note here, also, the high-pitch tonal characteristic of the emission. It was noted during the measurement that lightweight cars generated lower noise levels on the weight-balanced inert retarder than did the heavier cars. The reverse was noted of the spring-loaded variety of inert retarder found in the west classification yard.

Also noted on site, but not recorded on magnetic tape, was that, as the switching engine moved through the inert retarder, little if any squealing resulted despite the heavy weight of the engine. This was perhaps caused by the buildup of grease and oil on the wheels of the locomotive which in turn lubricated the retarder (braking) mechanism. As succeeding cars were pulled through the retarder, they also benefited from the lubrication (squealing far less) until the lubricants were finally worn away. This effect was also noted with the spring-loaded retarders in the west hump.

2.2 NOISE LEVEL MEASUREMENTS, BOSTON AND MAINE RAILROAD, BOSTON MA

Noise measurements were made on 21, 27, and 28 March 1973 at three facilities of the Boston and Maine (B&M) Railroad, Boston MA: The diesel locomotive repair facility at Iron Horse Park, Billerica MA; the Somerville Hump Yard, Somerville MA; and Piggyback Yard Seven, Charlestown MA.

Data were obtained of individual noise sources at these facilities. No data were obtained to statistically characterize the temporal noise of any of the areas as had been done at the Argentine Yard of the Santa Fe Railroad (see section 2.1).

Included in Appendix B are graphic noise level time history recordings and one-third octave spectral analyses, where applicable, of the data recorded.

2.2.1 Diesel Locomotive Static Measurements

Measurements were made on 21 March 1973 in Iron Horse Park, Billerica MA at the B&M diesel locomotive repair facility on Locomotive 1563. This is a 1550-horsepower General Motors locomotive Model GP-7 with a Model 16-567B engine. See figure B-1 for physical dimensions and general equipment layout of the locomotive.

The locomotive was completely overhauled (rebuilt) at the facility, and was in the process of being "run in" under static

conditions. In actual operation of the locomotive, the diesel engine drives an electric generator which in turn supplies power to the traction motors. The speed or throttle setting is variable through eight fixed steps from the idle setting (notch 1) to full throttle (notch 8). When static-tested, the electric power generated (normally furnished to the traction motors) is dissipated in an external resistive load (known as a load box).

The measurements made were of static conditions with simulated load as above, and also under unloaded conditions, wherein the electrical circuit to the load box was opened and, although the generator was being driven, no power was being generated and the loading on the engine was minimal.

Three microphones centered on the locomotive and offset 25, 50, and 100 feet from its center-line, were set up at a height of 5- 1/2 feet above the level grade (see figure E-24). In addition to recording data with the microphones thus placed, microphone 1 at 25 feet was moved to 12 additional locations in and around the locomotive and data were recorded. The position of microphones 2 and 3 (50 and 100 feet, respectively) were unchanged for all the measurements conducted. Figure E-25 contains photographs showing: (a) the initial microphone locations at 25, 50, and 100 feet; (b) the movable microphone at a point 55 feet to the left-hand side of its initial position (note the load box in the background); and (c) the movable microphone at one of its positions on the catwalk platform six inches from the skin of the engine body.

Figure B-2 contains coincident time histories of the wayside noise level data recorded at the initial three-microphone locations (25, 50, and 100 feet). Approximately 30 seconds of data are presented at each throttle setting from notch 1 to notch 8. For this test, the engine was in the unloaded condition. A one-second period of the data from each microphone, recorded at the eighth notch setting, was spectrally analyzed. The coincident one-third octave spectral analyses of the data for the three

microphone locations are presented in figure B-3.

Figure B-4 contains coincident time histories of the noise level data recorded at the wayside under loaded conditions from notch 2 to notch 8 for the above locomotive.

Figure B-5 contains one-third octave spectral analyses of a coincident one-second period of data measured at the three offset microphone locations. The engine was fully loaded at 1550-horsepower running at the eighth notch.

Figures B-6 and B-7 contain one-third octave spectral analyses of a one-second period of data measured at the initial 25-foot offset location at each notch setting from 2 to 7.

A summary tabulation of the wayside noise levels measured for both loaded and unloaded conditions are included in Table 2-3.

To obtain a more complete picture of the spatial distribution of the noise levels in and around the locomotive, microphone 1 (25 feet offset) was moved to an additional 12 locations (7 positions along a centerline offset 25 feet from the centerline of the locomotive; 3 positions along the catwalk platform 6 inches from the skin of the engine; 1 position in the engineer's cab; and 1 position in the engine compartment). The microphone in the cab was set at a height of 4- 1/2 feet (at ear level to a seated engineer), all the others were at a height of 5- 1/2 feet. For these tests, microphones 2 and 3 (50 and 100 feet respectively) were not moved, and the engine was fully loaded at 1550 horsepower and held at the eighth notch (1900 amperes at 600 volts into the load box). Spatial noise level data are included in figure B-8. Note the position of the 40-foot high brick diesel shop building which was the only major obstruction in the test area.

2.2.2 Freight Yard Data

Measurements were made of specific noise sources at the B&M Somerville Hump Yard, Somerville MA, and Piggyback Yard Seven, Charlestown MA on 27 and 28 March 1973.

TABLE 2-3. WAYSIDE NOISE LEVELS: GM LOCOMOTIVE MODEL GP-7, B&M RR, IRON HORSE PARK, BILLERICA, MA. (STATIC TESTS)

ENGINE THROTTLE NOTCH	Peak RMS Noise Level-dBA re. 20 MP_a at Microphone Offset Locations						REMARKS Microphones 5.5 feet above grade level
	25 Feet		50 Feet		100 Feet		
	Unloaded	Loaded	Unloaded	Loaded	Unloaded	Loaded	
1	78	-	70	-	66	-	
2	78	79	73	74	68	70	
3	85	86	76	80	72	75	
4	85	87	82	82	74	80	
5	86	90	82	86	78	81	All fans & compressor off
6	90	91	83	90	81	86	
7	91	94	84	90	81	87	
8	94	97	88	92	81	88	Fans 3 and 4 ON
1	78		71		67		Fan 1 on
1	78		71		67		Fan 2 on
1	78		71		67		Fan 3 on
1	78		71		66		Fan 4 on
1	78		71		67		All four fans on
1	78		71		67		Compressor on
1	107		106		101		Horn (104 dBA inside of cab)
8		97		91		89	All four fans on
8		97		91		88	Compressor on

Figure E-26 is a photograph from the control tower of the Somerville Hump Yard facing the classification yard. On the left-hand side of the photograph is the master retarder. The group retarders can be seen further down the lead track. The series of tracks to the right-hand side of the photograph are the receiving and departure tracks.

This humping operation is manually controlled, wherein operators in the control towers (one by the master retarder, and one each by the intermediate and group retarders) control the track switches and the amount of pressure exerted by the retarders on the wheels of cars passing through. Inert retarders were not used in this yard. To prevent the first car down the classification yard from rolling under its own power out of the yard, a brakeman rides the car down the hump into the classification yard and manually sets the brakes at the far end of the classification yard. This stops the first car. Succeeding cars down that track couple to it, and are in turn prevented from rolling out of the classification yard.

The noise advantage here over the Argentine operation which uses inert retarders to stop the cars at the end of the track is that when a line of cars is moved out of the yard no retarder noise is generated.

Measurements were made in the classification yard of self-coupling impact sounds. For these tests, a microphone was set up directly opposite the point of impending impact at offset distances as dictated to insure the safety of the measurement team.

Figure B-9 contains graphic time histories (A-weighted and flat-unweighted) of the impact noise emissions recorded when two empty cement cars estimated to be travelling at approximately four mph impacted (point A) upon two standing box cars (also empty). The standing two cars had not traveled far enough on their own into the classification yard to couple with the line of 30 cars standing approximately 50 feet further down the track. Upon impact of the two cement cars the two standing box cars were set into motion by the impact and in turn impacted into the standing line of cars 50

feet away (point B). The two cement cars followed and impacted again at point C.

Also shown on the history are the impact sounds from the secondary impacts and the wave that moved through the full length of the line of cars in the train. For this measurement, the microphone was 3 feet above the level of the rails in line of sight with, and offset 88 feet from the initial point of impact (point A). Remaining impacts were not in line-of-sight with the microphone but were shielded from the microphone by the cars themselves. Included on the history are unweighted peak impulse levels for each impact as measured with a sound level meter in the peak hold mode.

The unweighted sound levels of the impact events above (A, B, and C were also measured with an appropriately calibrated memory oscilloscope. The scope display was photographed and the results included in figure B-10.

Figures B-11 through B-14 are data from four additional impacts. In each case, the microphone was directly opposite and in line-of-sight with the point of impact.

Figure B-15 contains a noise level history and frequency spectra of retarder noise as measured 50 feet offset from the master retarder. The first event in the time history is the noise emission at the master retarder of a single freight car equipped with roller bearings being slowed from an estimated eight to four mph. Note the level of the unmuffled air-release blast from the retarder actuator. A one-half second interval during the period of retarder squeal was analyzed and the one-third octave spectra are included in figure B-15b. Note the tonal characteristics of the squeal.

The second and third events in figure B-15b are of two coupled freight cars moving through the retarder and being slowed from an estimated six to four mph. The first car was equipped with roller bearings, and the second with journal boxes. The retarder squeal can be seen to be equal to the noise from the air-release blast for the first car retarded, and no squeal

emissions were generated with retardation pressure applied to the second car of the set.

Figure B-16 is a time history level recording and one-third octave spectral analysis of data recorded of noise emissions of the diesel engine on a mechanical refrigeration freight car. The microphone was set up at a height of 5 feet above the level of the rails and offset 50 feet from the car's centerline. The microphone was set up directly opposite to the open grille behind which the diesel engine was located.

Figure E-27 is a photograph of an FWD Wagner Model P-70 Piggyback Packer (fork-lift truck) lifting a 56,000-pound trailer box and placing it on a railroad flatcar in the B&M Piggyback Yard Seven, Charlestown MA.

Measurements were made in this yard on 28 March 1973. Figures B-17 and B-18 are time histories of the noise measured during two operations of this model fork-lift truck. In the two cases recorded, the microphone was set up at a height of 5.5 feet above the level grade. For the data in figure B-17, the microphone was offset 50 feet from the right-hand side of the Model P-70. For the data in figure B-18, the microphone was placed 50 feet to the rear of Model P-70.

2.3 WAYSIDE NOISE LEVEL MEASUREMENTS, PASSENGER AND LINE-HAUL OPERATIONS

Wayside noise level measurements were made next to the tracks of the Penn Central Railroad (PCRR), New York-to-Washington Line in Plainsboro NJ, 2600 feet north of milepost 46 on 23 May 1972; and next to the Boston -to- New York Line in West Mansfield MA, 1310 feet east of mile post 201 on 4 November 1971 and 20 and 26 September 1972.

Data were recorded at that time of the noise generated during the passby of the high-speed Metroliner and Turbotrains. (See the authors' report DOT-TSC-OST-73-18, "Wayside Noise and Vibration Signatures of High-Speed Trains in the Northeast Corridor", September 1973). Also recorded and included in the

report as a summary tabulation was passby noise data of passenger and line-haul operations.

Because of the present interest in railroad operations, graphic level signatures of both passenger and line-haul data measured then but not included in the earlier report, have been prepared and are presented in this report as Appendixes C and D.

Figures C-1 through C-17 are wayside noise level signatures of trains measured in Plainsboro NJ. The Penn Central Railroad line at this location consists of four tracks with welded rail construction, wood ties and stone ballast. All trains measured obtained power from an overhead catenary system through a pantograph with the exception of a 33-car freight train which was driven by two diesel-powered locomotives, see figure C-8.

Figures E-28 through E-30 contain a schematic of the microphone locations and photographs of the Plainsboro NJ measurement site.

Figures D-1 through D-16 are wayside noise level signatures of trains measured in West Mansfield MA. The Penn Central Railroad line in thsi area consists of two track with standard jointed rail construction, wood ties on stone ballast. Trains were driven by one or more diesel-powered locomotives.

Figures E-31 through E-33 contain a schematic of the microphone locations and photographs of the measurement site.

Wayside noise level signatures of passenger and line-haul operations measured in Kansas City and Zarah KS on the Santa Fe Railroad are included in Appendix A: figures A-4 through A-6 are of passenger trains, and figures A-14 through A-17 are for freight trains.

APPENDIX A

NOISE LEVEL DATA MEASURED AT TWENTY-ONE LOCATIONS OF THE ARGENTINE FREIGHT YARDS, SANTA FE RR, KANSAS CITY KS

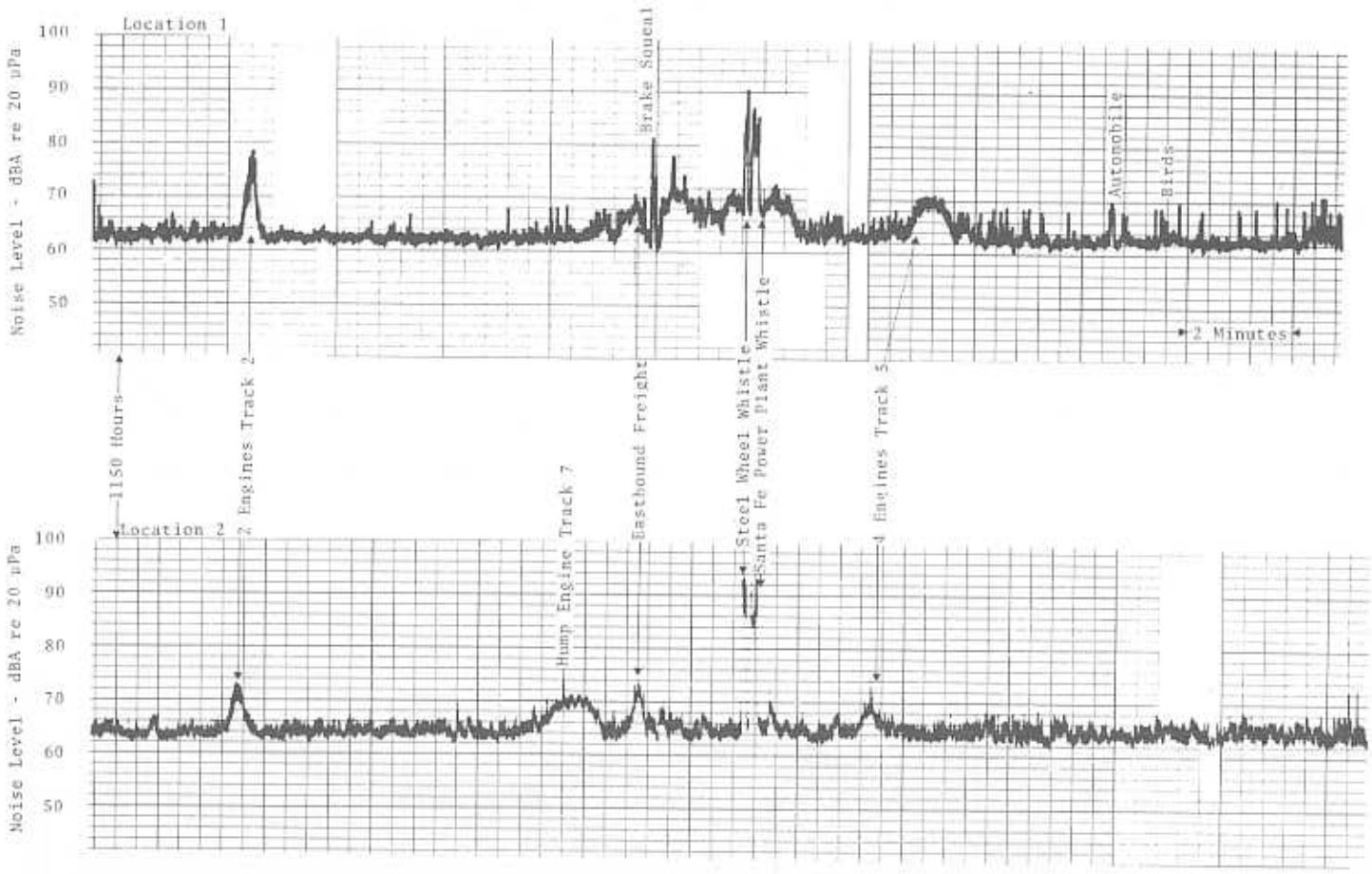


Figure A-1. Coincident Time Histories - Noise-Level Data-Locations 1 and 2 (see figure E-1). Argentine Freight Yard, Santa Fe RR, 4/24/73. Microphone Offset 25 Feet from Mainline Track at a Height of 5 Feet Above Level Grade.

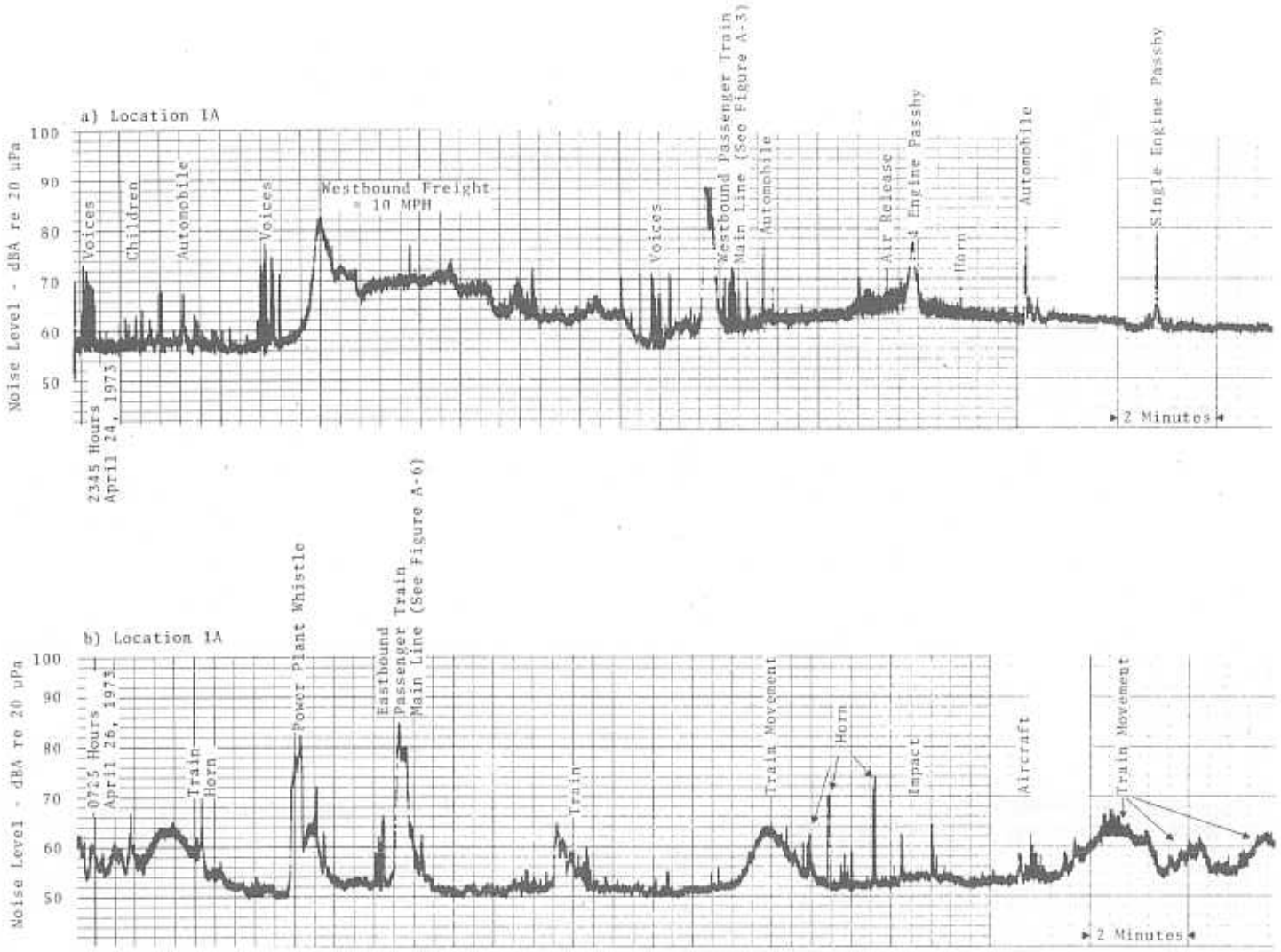


Figure A-2. Time Histories - Noise Level Data Location 1A (see figure E-1). Argentine Freight Yard, Santa Fe RR, 4/24 - 26/73. Microphone Offset 60 Feet from Mainline Track at a Height of 5 Feet Above Level Grade

a) Measurement Period Beginning 2345 Hours
b) Measurement Period Beginning 0725 Hours

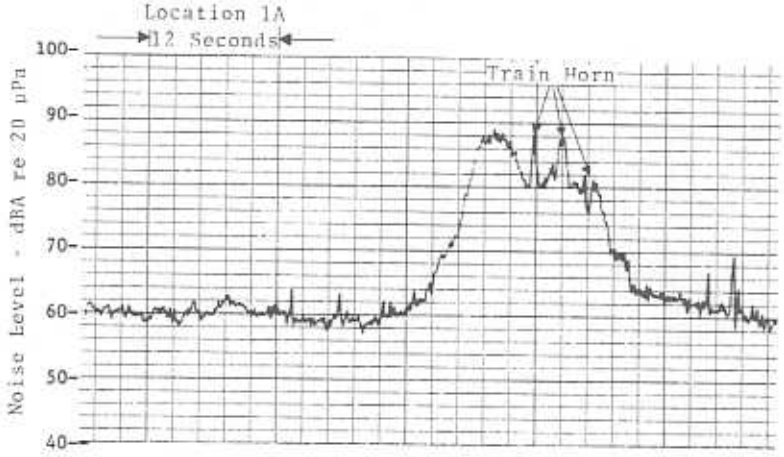


Figure A-3. Time History - Wayside Noise Levels Offset 60 Feet from Track Centerline, Location 1A, Argentine Freight Yards, Santa Fe RR, 4/25/73, 0005 Hours, Passenger Train, 4 Diesel Engines Plus 16 Cars, Westbound 60 mph (see figure A-2a)

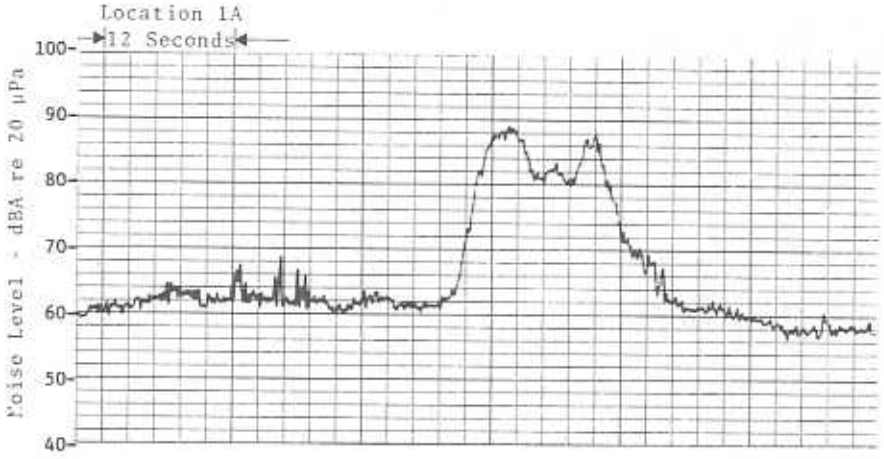


Figure A-4. Time History - Wayside Noise Levels Offset 60 Feet from Track Centerline, Location 1A, Argentine Freight Yards, Santa Fe RR, 4/25/73, 0752 Hours, Passenger Train, 4 Diesel Engines Plus 8 Cars, Eastbound 45 mph

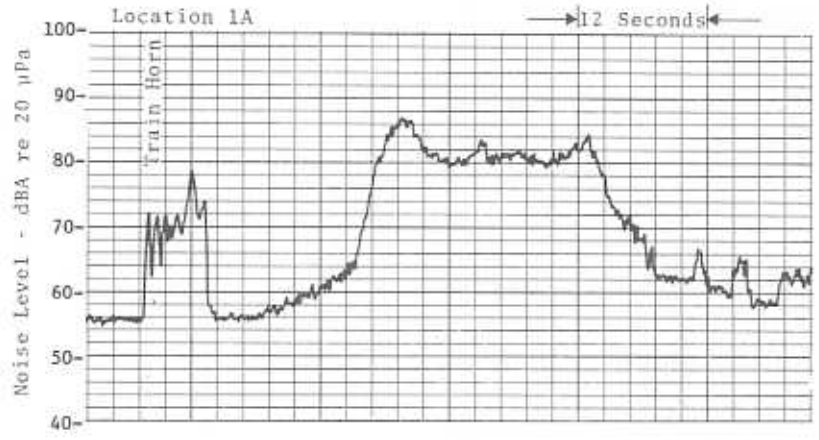


Figure A-5. Time History - Wayside Noise Levels Offset 60 Feet from Track Centerline, Location 1A, Argentine Freight Yard Santa Fe RR, 4/26/73, 0605 Hours, Passenger Train, 3 Diesel Engines Plus 14 Cars, Eastbound 40 mph

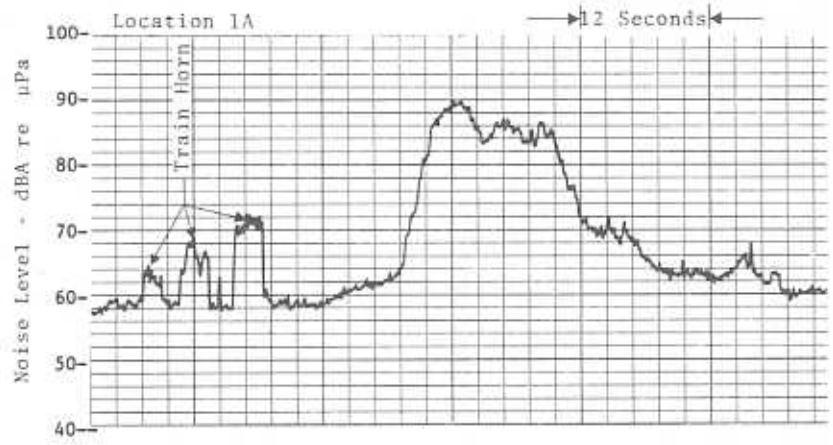


Figure A-6. Time History - Wayside Noise Levels Offset 60 Feet from Track Centerline, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0731 Hours, Passenger Train, 4 Diesel Engines Plus 8 Cars, Eastbound 45 mph (see figure A-26)

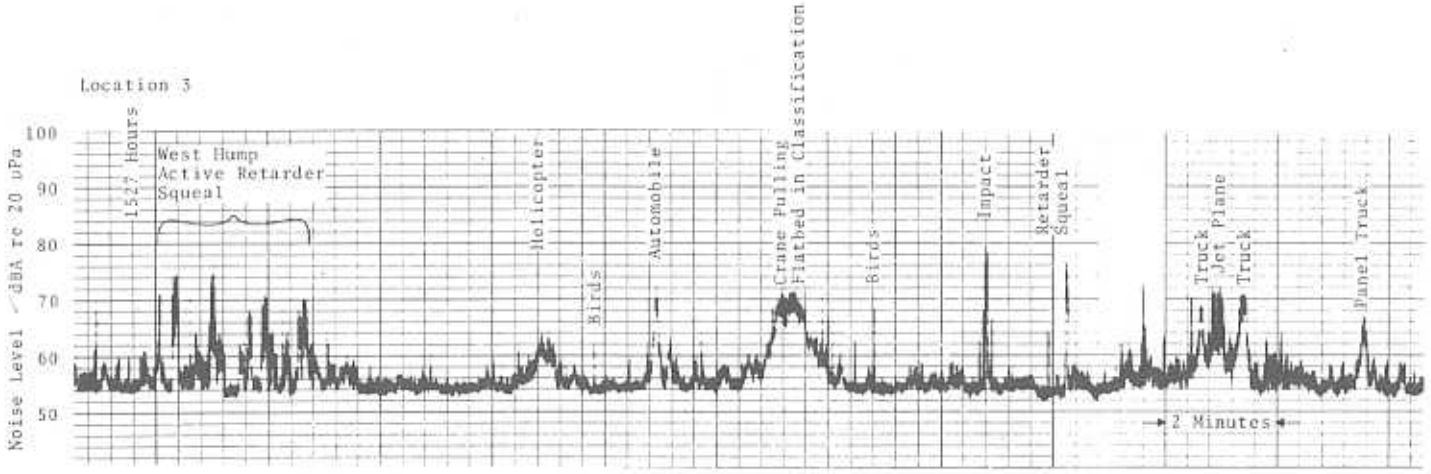


Figure A-7. Time History - Noise Level Data, Location 3 (see figure E-1), Argentine Freight Yard Santa Fe RR, 4/24/73, Microphone Offset approximately 500 feet from the Center of West Classification Yard 4.5 feet above the Level Grade

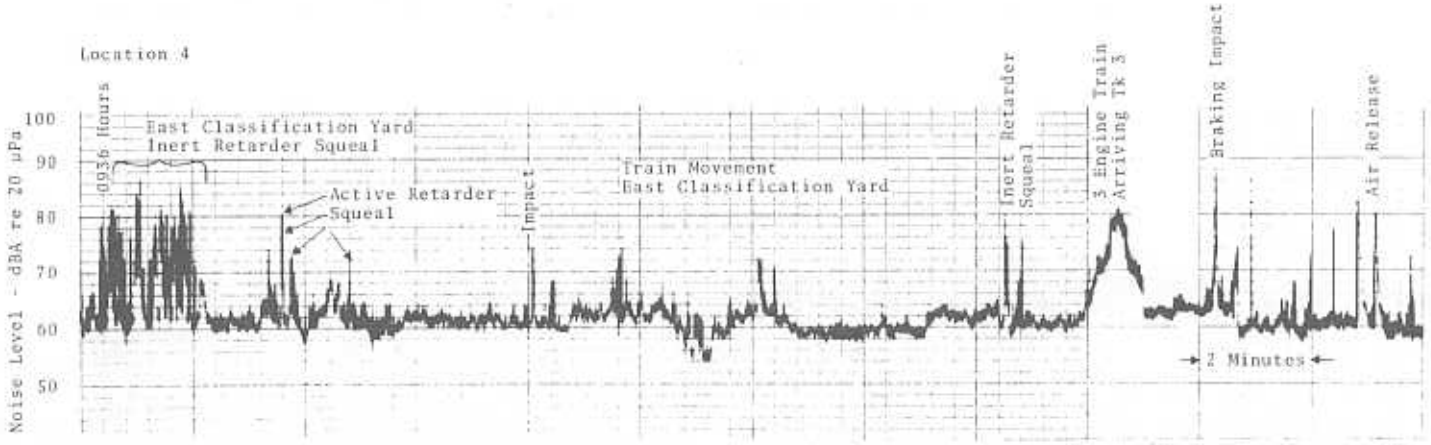


Figure A-8. Time History - Noise Level Data, Location 4 (see Figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone on Embankment 75 Feet Offset from Mainline Track and 30 Feet Above the Level of the Rails

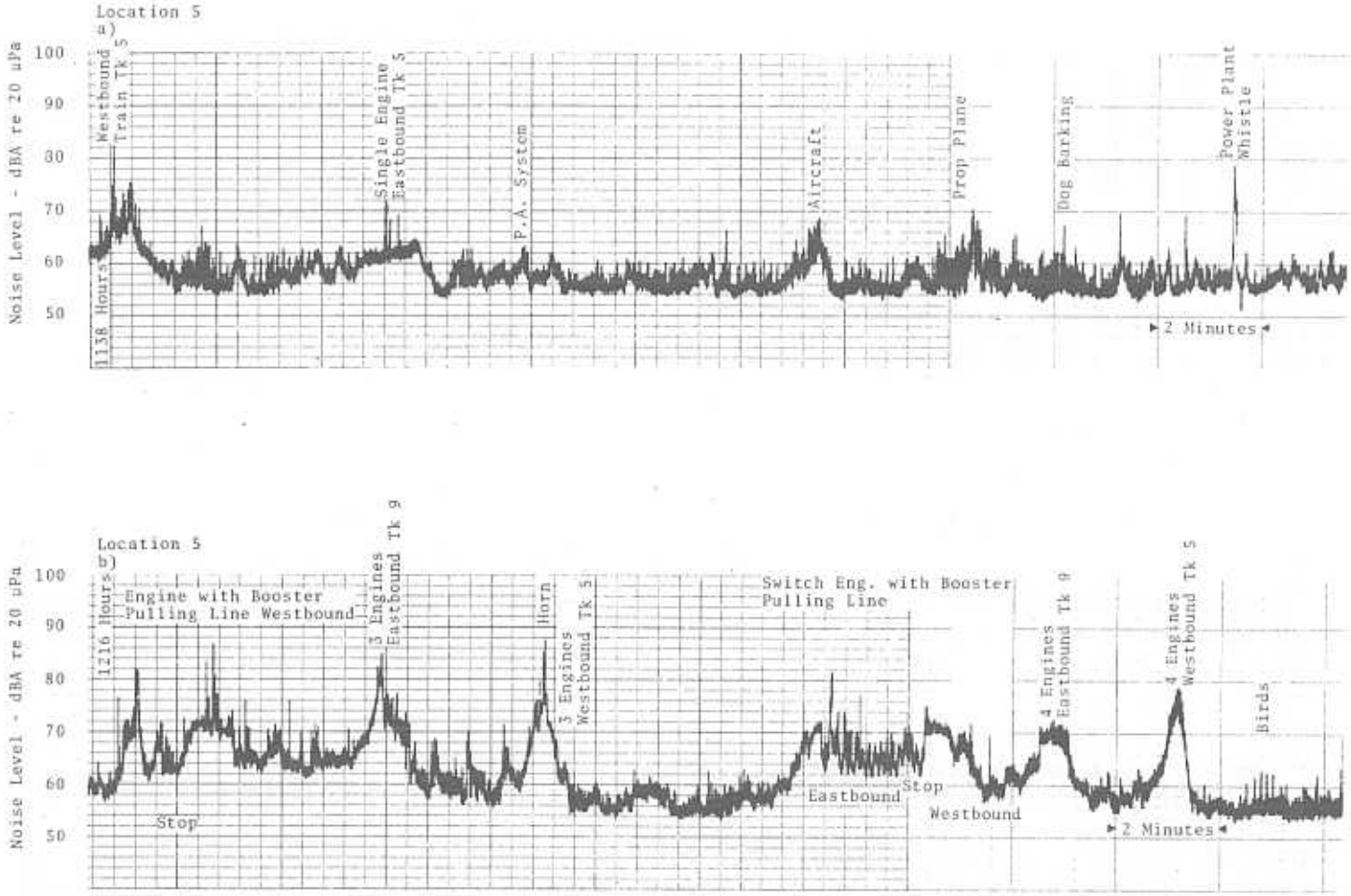


Figure A-9. Time History - Noise Level Data, Location 5 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone on Embankment 64 Feet Offset from Near Track and 15 Feet Above Level of Rails

a. Measurement Period Beginning 1138 Hours
b. Measurement Period Beginning 1216 Hours

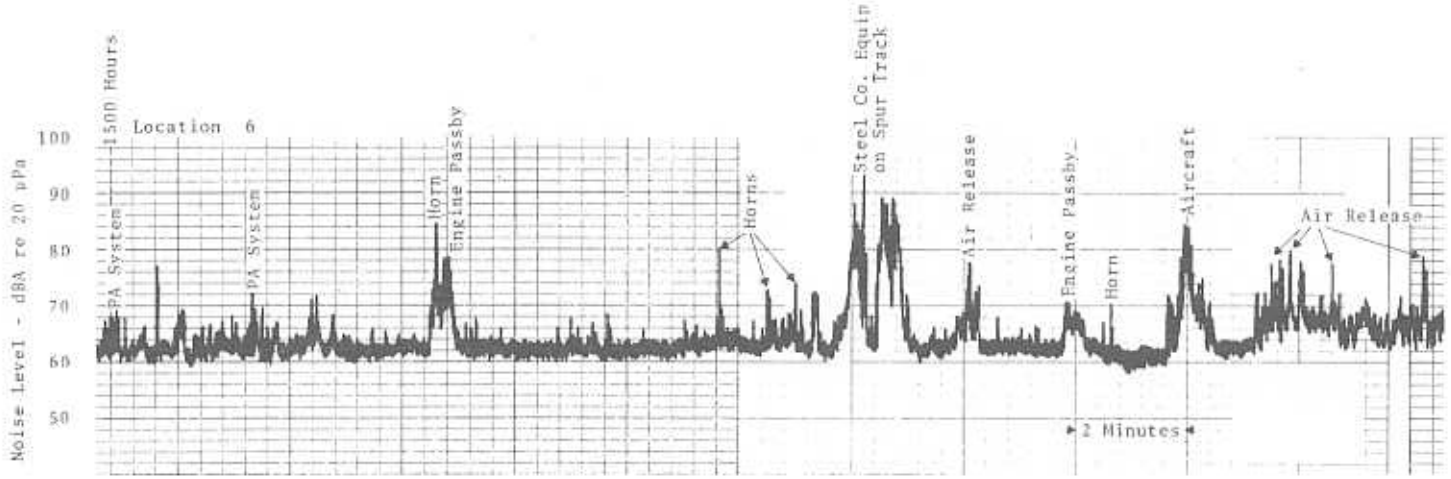


Figure A-10. Time History - Noise Level Data, Location 6 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 50 Feet from Mainline Track and 4.5 Feet Above the Level Grade

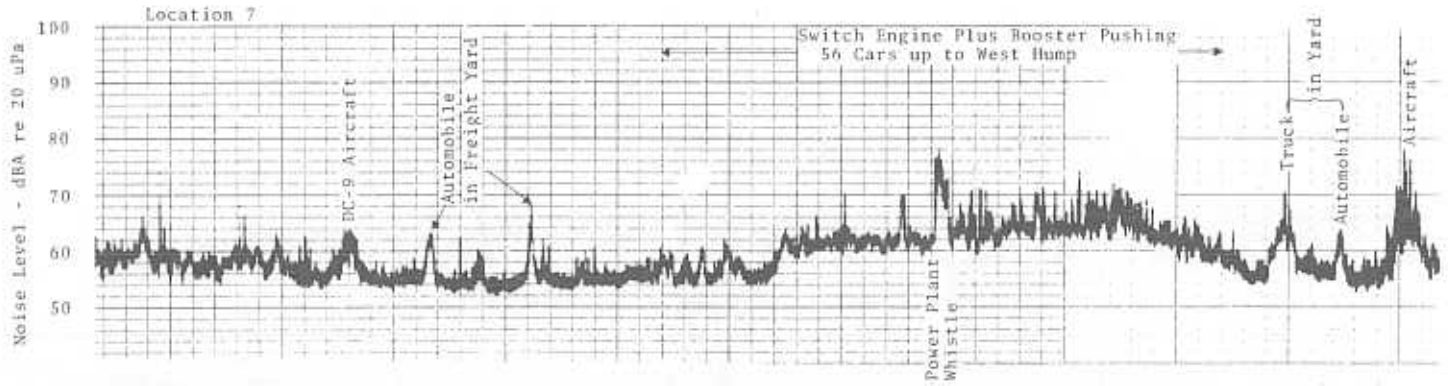


Figure A-11. Time History - Noise Level Data, Location 7 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 31 Feet from Mainline Track and 4 Feet Above the Level of the Rails

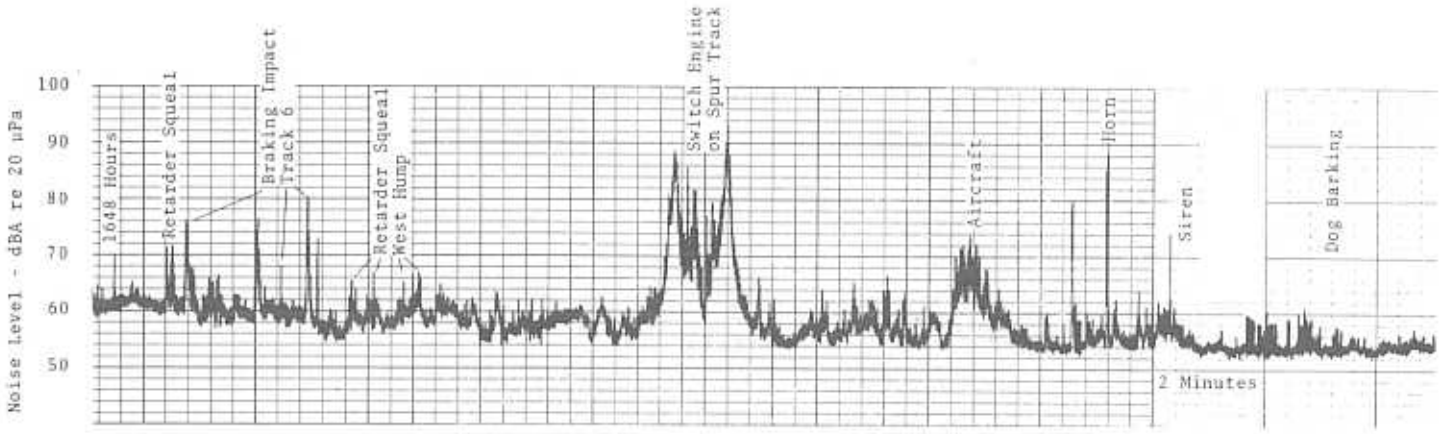


Figure A-12. Time History - Noise Level Data, Location 8 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 50 Feet from Mainline Track and 4.5 Feet Above the Level Grade

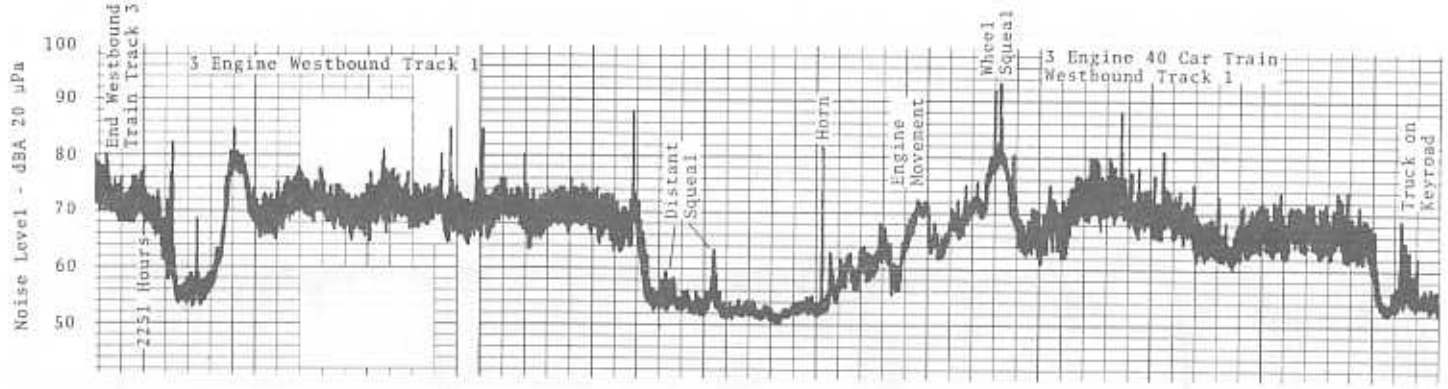


Figure A-13. Time History - Noise Level Data, Location 9 (see figure E-1) Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 25 Feet from Mainline Track and 4 Feet Above Level of Rails

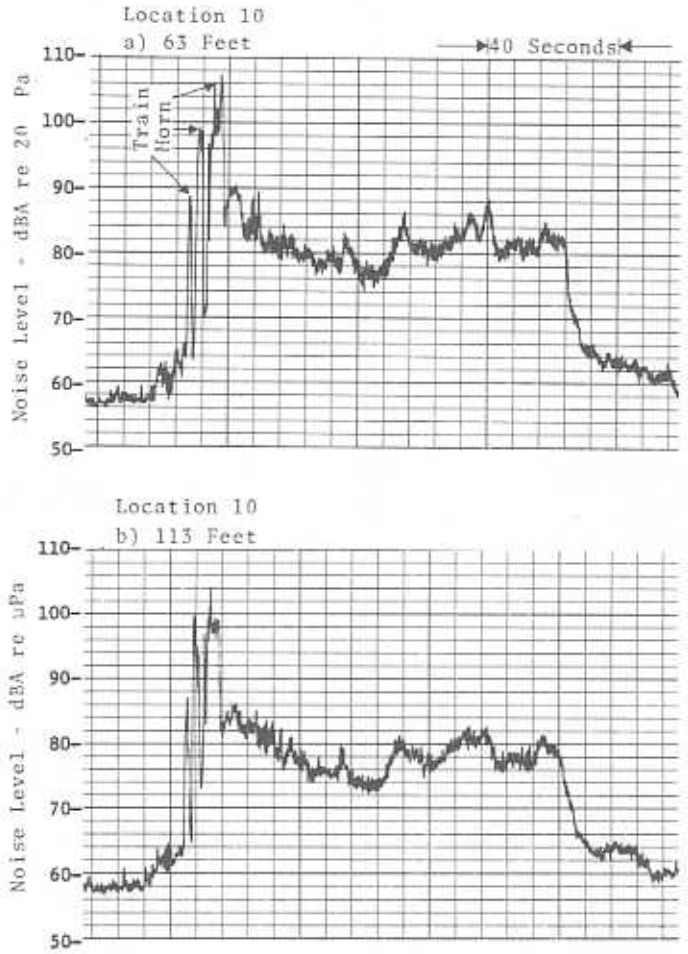


Figure A-14. Coincident Time Histories - Wayside Noise Levels at 63 and 113 Feet, Location 10, Santa Fe RR, Zarah KS, 4/26/73, Freight Train - 2 Diesel Engines Plus 76 Cars, Eastbound 31 mph

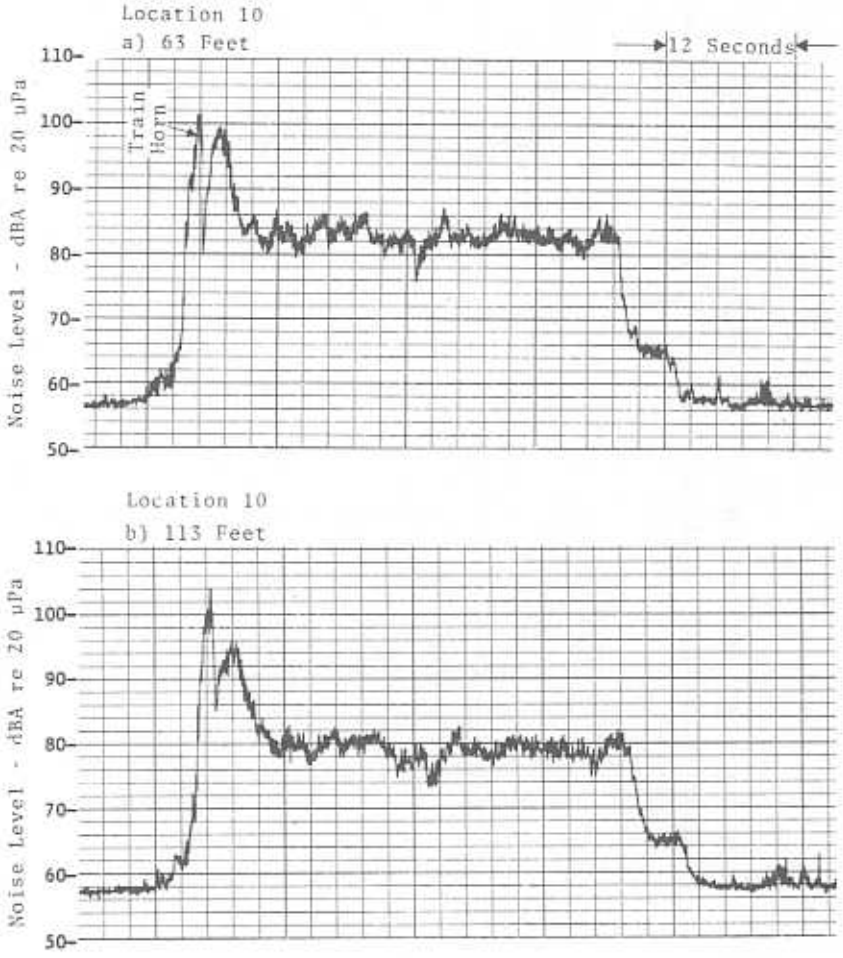


Figure A-15. Coincident Time Histories - Wayside Noise Levels at 63 and 113 Feet, Location 10, Santa Fe RR, Zarah KS, 4/26/73, Freight Train - 6 Diesel Engines Plus 87 Cars, Eastbound 30 mph

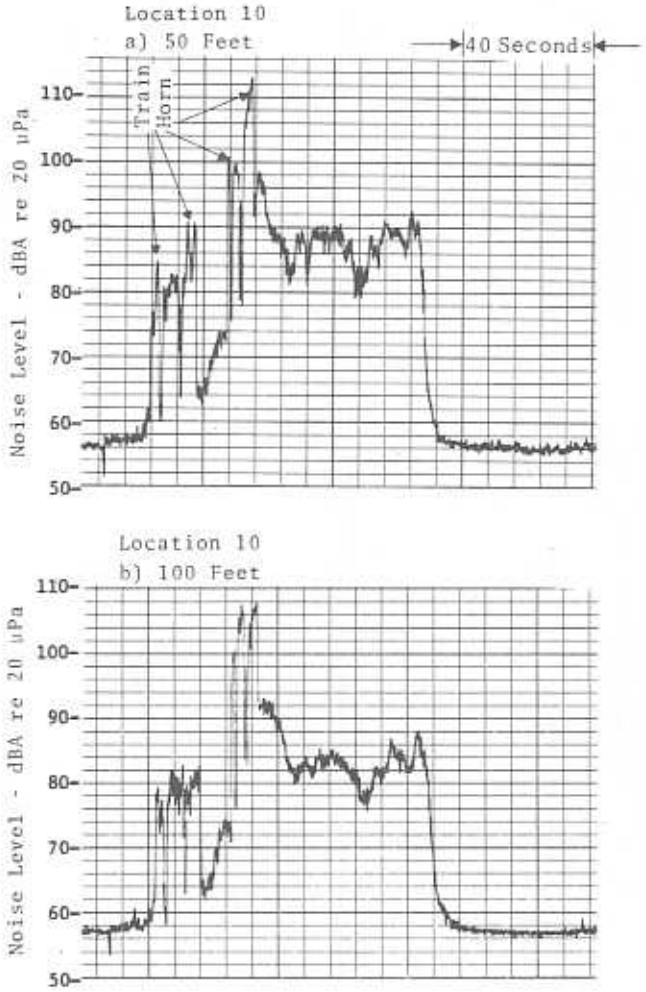


Figure A-16. Coincident Time Histories - Wayside Noise Levels at 50 and 100 Feet, Location 10, Santa Fe RR, Zarah KS, 4/26/73, Freight Train - 3 Diesel Engines Plus 43 Cars, Westbound 36 mph

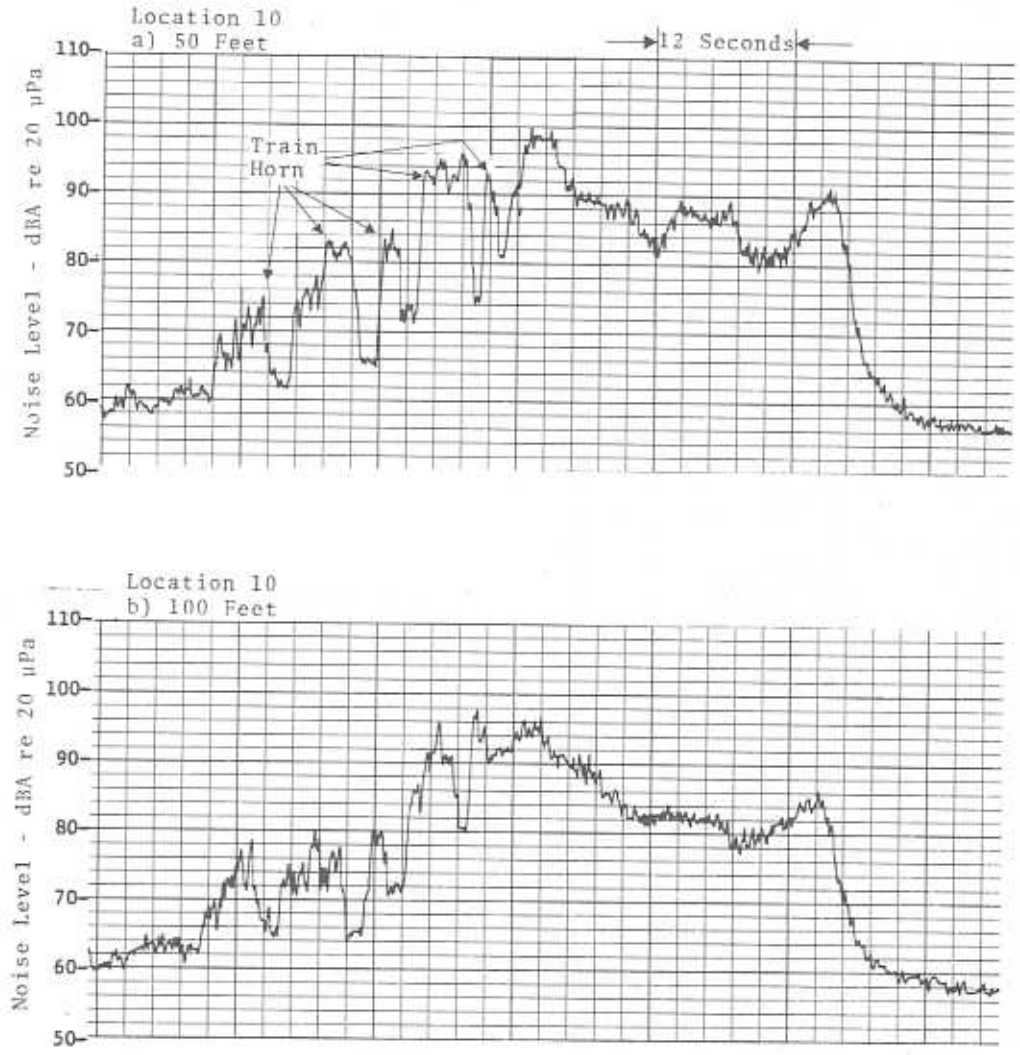


Figure A-17. Coincident Time Histories - Wayside Noise Levels at 50 and 100 Feet, Location 10, Santa Fe RR, Zarah, KS, 4/26/73, Freight Train - 3 Diesel Engines Plus 31 Cars, Westbound 49 mph

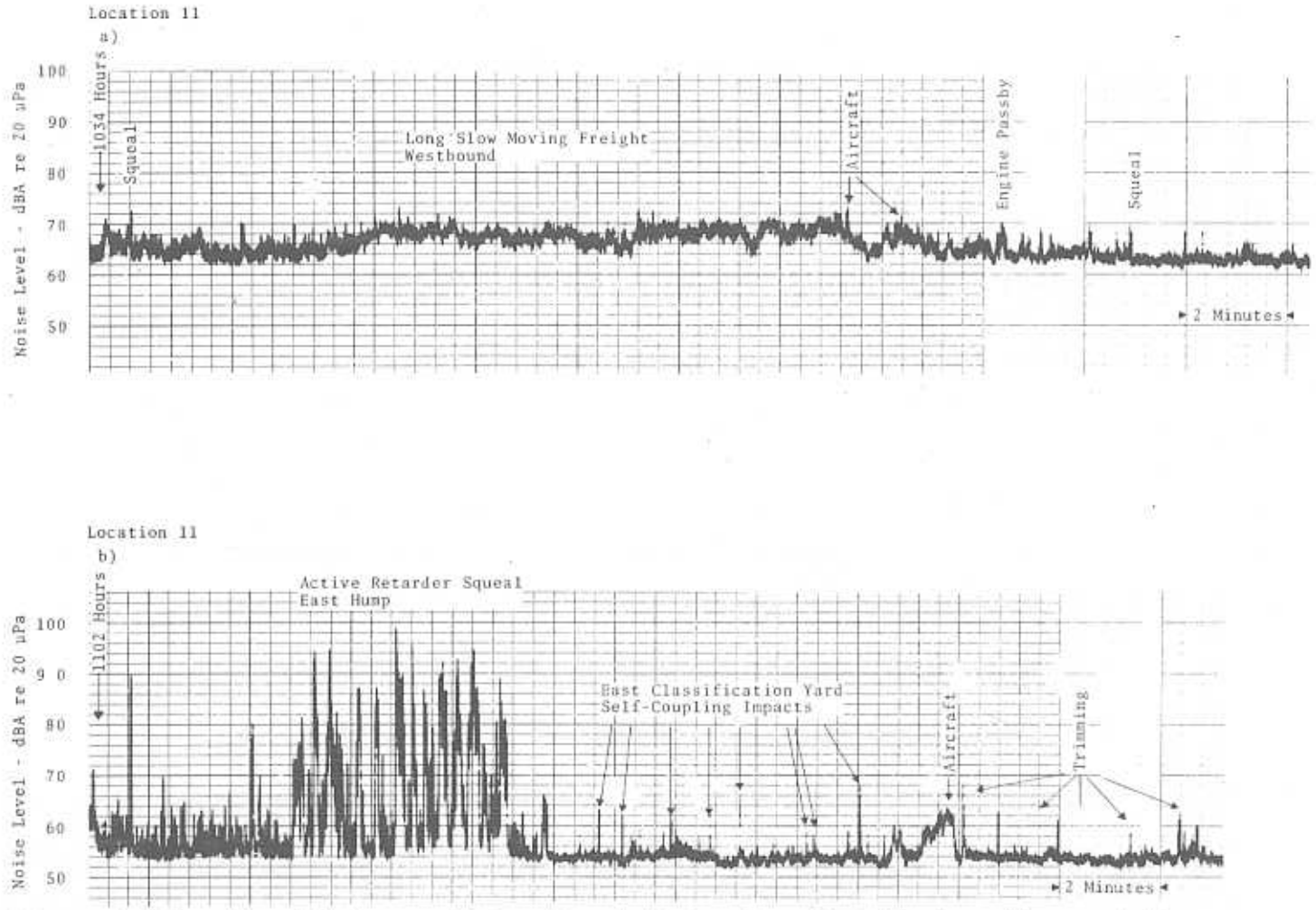


Figure A-18. Time History - Noise Level Data, Location 11 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset Approximately 775 Feet South of Master Retarder and 4.5 Feet Above Level Grade
a) Measurement Period Beginning 1034 Hours
b) Measurement Period Beginning 1102 Hours

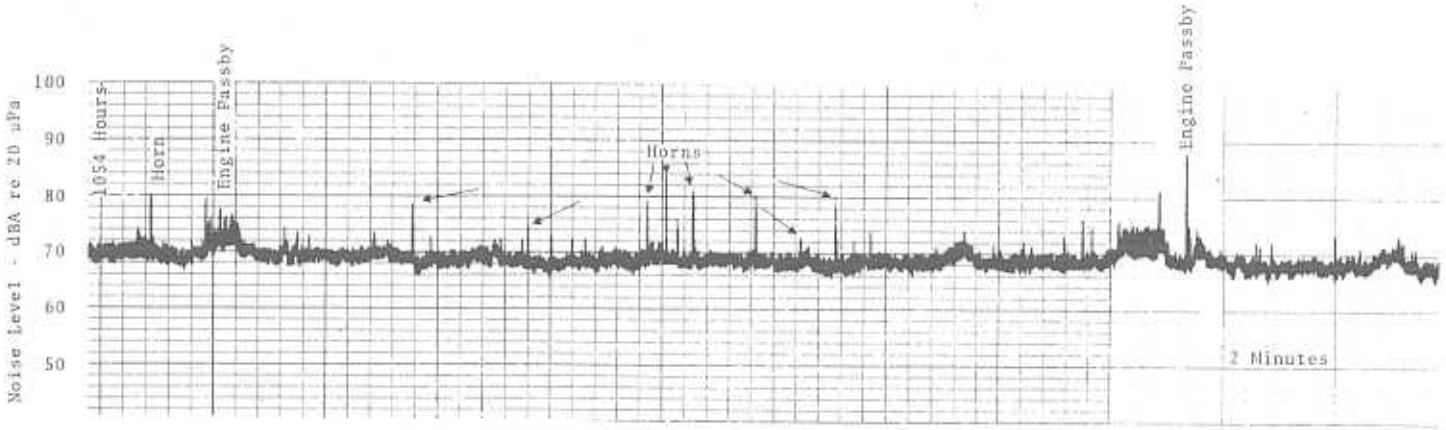


Figure A-19. Time History - Noise Level Data, Location 12 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/24/73, Microphone on Embankment Offset 25 Feet from Near Track and 25 Feet Above Level of Rails

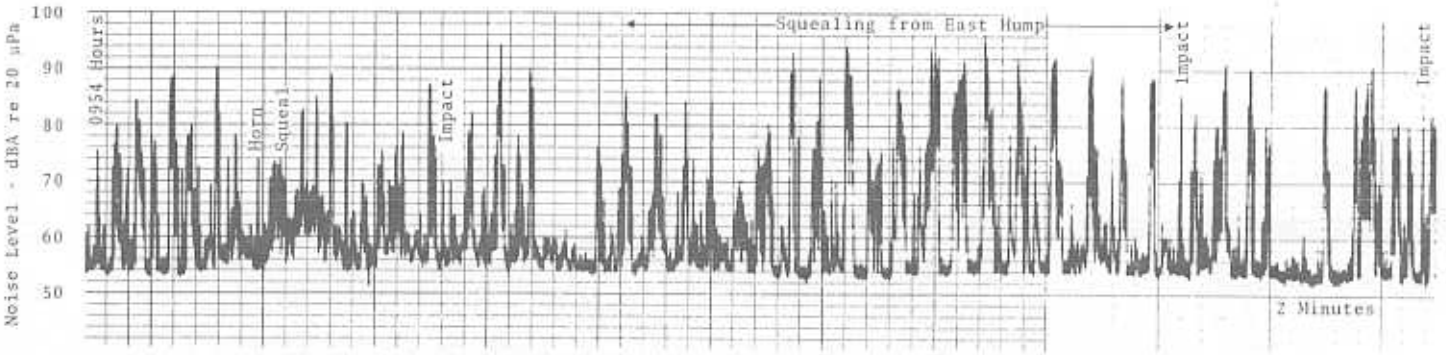


Figure A-20. Time History - Noise Level Data, Location 13 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/26/73, Microphone on Embankment Offset 70 Feet From Mainline Track and 20 Feet Above Level of Rails

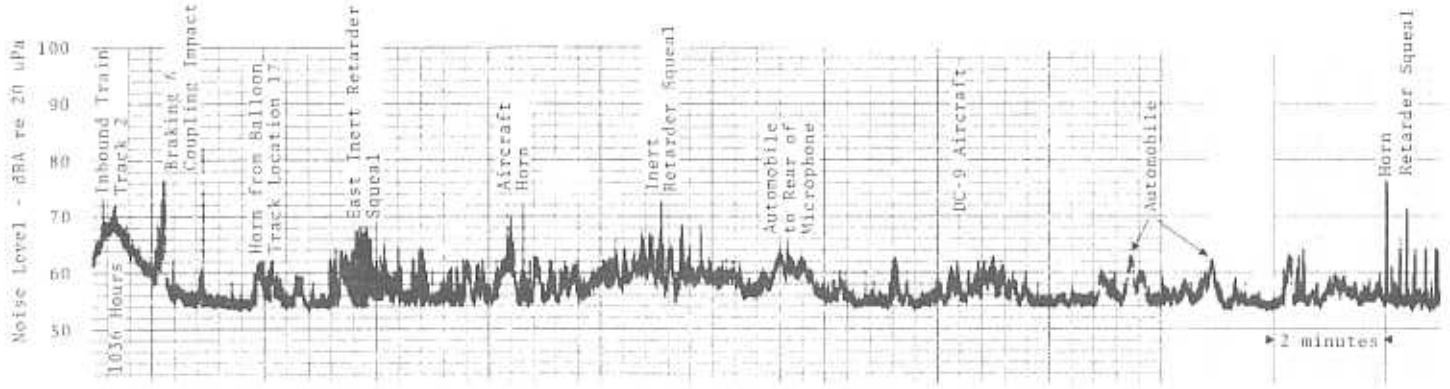


Figure A-21. Time History - Noise Level Data, Location 14 (see figure E-1) Argentine Freight Yard, Santa Fe RR, 4/26/73, Microphone Offset 100 Feet from Mainline Track and 4.5 Feet Above Level Grade

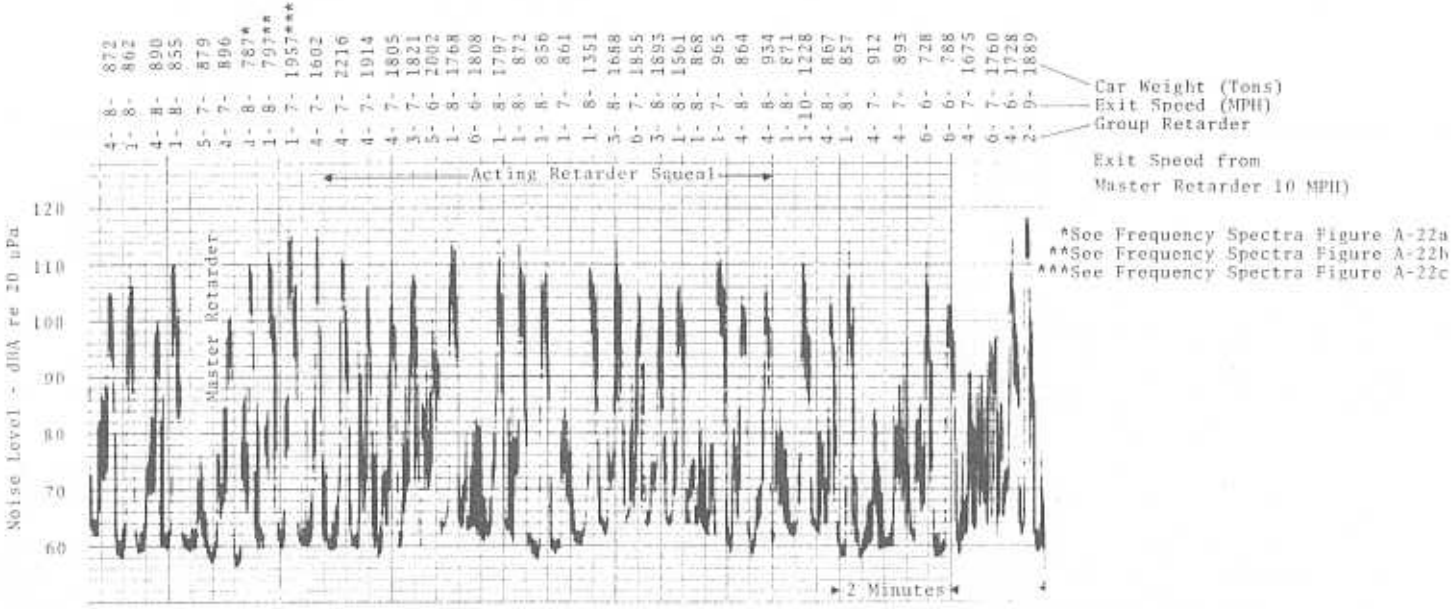


Figure A-22. Time History - Noise Level Data, Location 15 (see figure E-1), East Hump, Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Between Retarders 2 and 3, Offset 25 Feet from 2 at a Height of 4.5 Feet Off Grade and 1.5 Feet Above Level of Rails

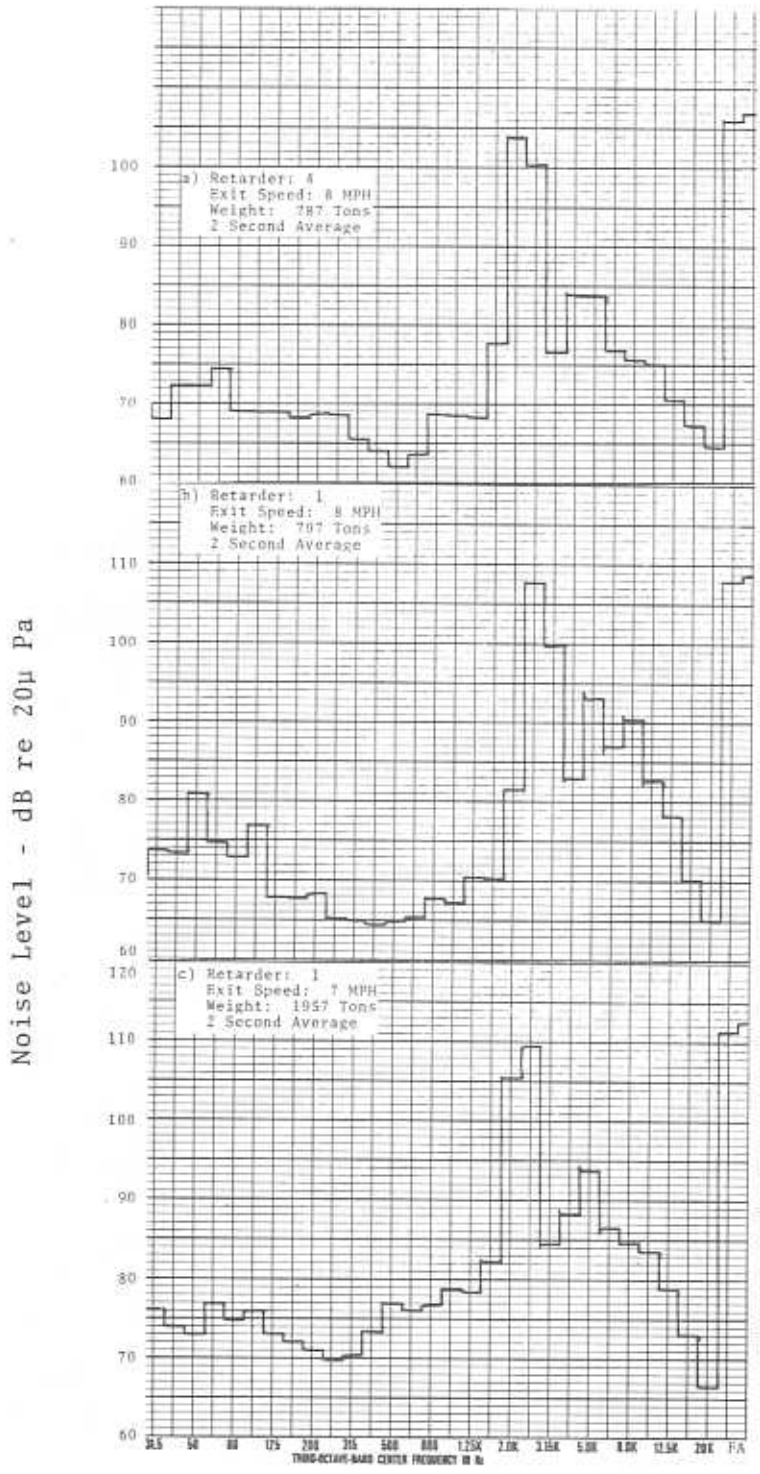


Figure A-23. Frequency Spectra - Active Retarder Noise, Location 15, East Hump, Argentine Freight Yard, Santa Fe RR, 4/25/73 (see figure A-22 for noise level time history)

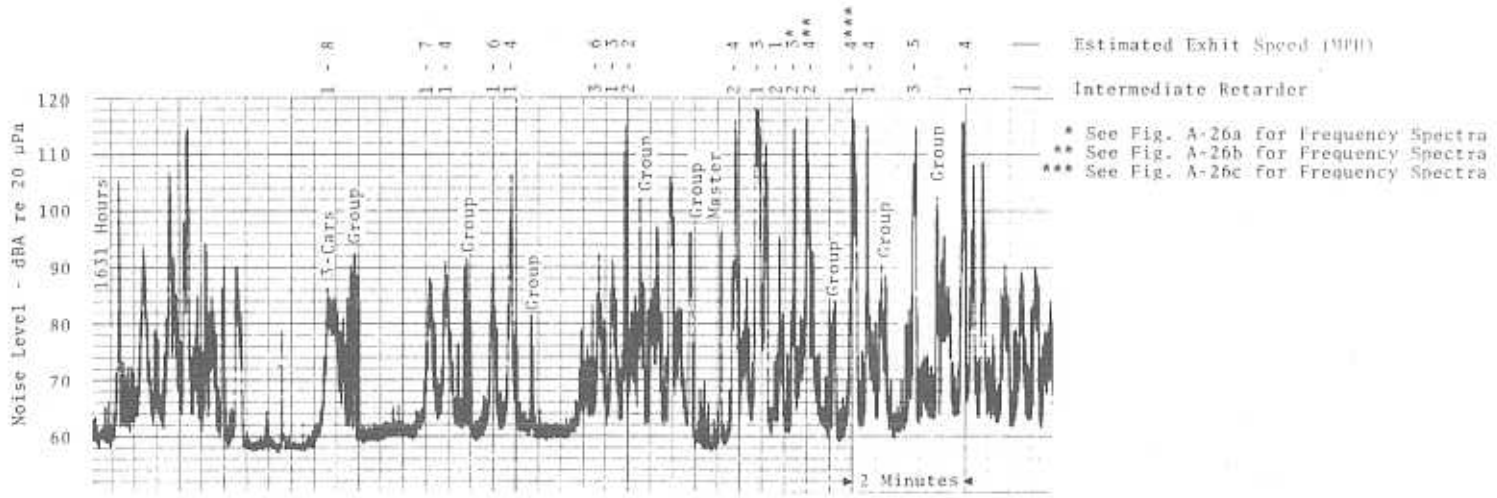


Figure A-24. Time History - Noise Level Data, Location 16 (see figure E-1), West Hump, Argentine Freight Yard, Santa Fe RR, 4/24/73, Microphone Between Retarders 1 and 2, Offset 25 Feet from 1 at a Height of 4.5 Feet Off Grade and 2.5 Feet Above Level of Rails

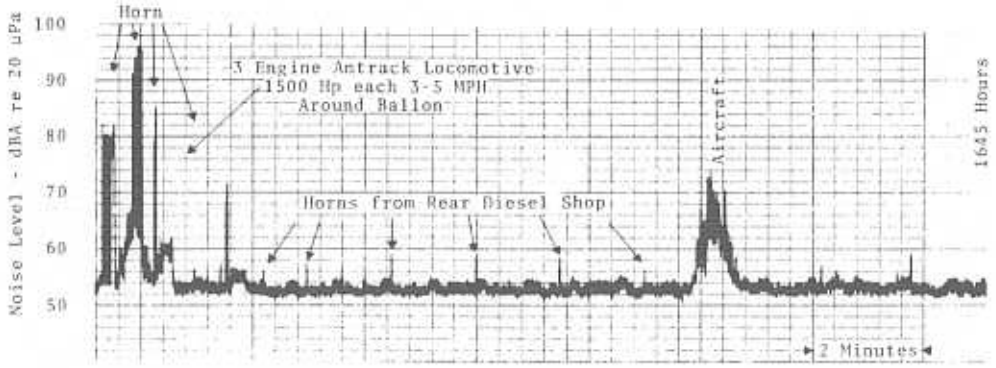


Figure A-25. Time History - Noise Level Data, Location 17 (see figure E-1), Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 60 Feet on Inside of Balloon Track at a Height of 4.5 Feet Above the Level Grade

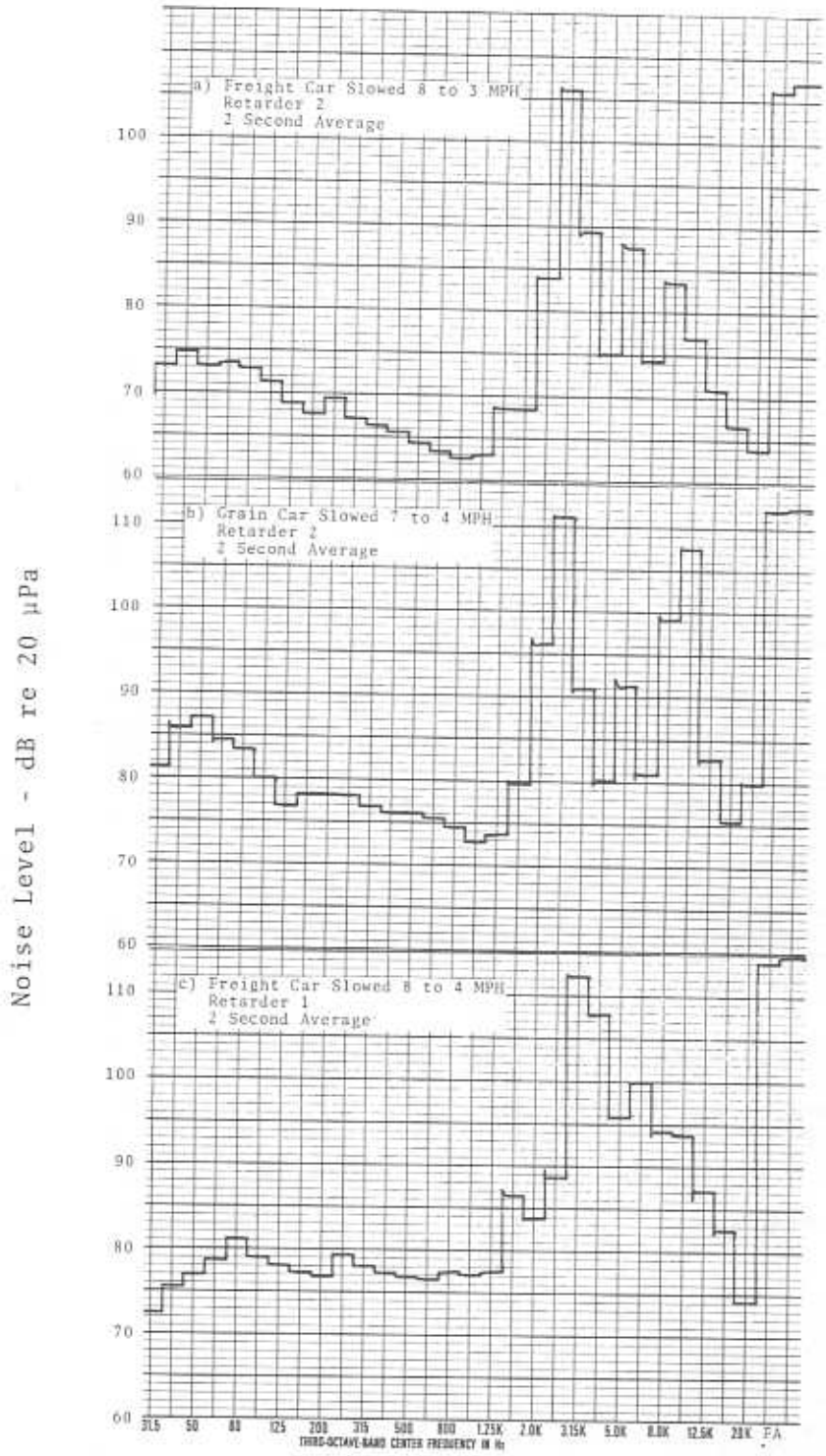


Figure A-26. Frequency Spectra - Active Retarder Noise, Location 16, West Hump, Argentine Freight Yard, Santa Fe RR, 4/24/73 (see figure A-24 for Noise Level Time History)

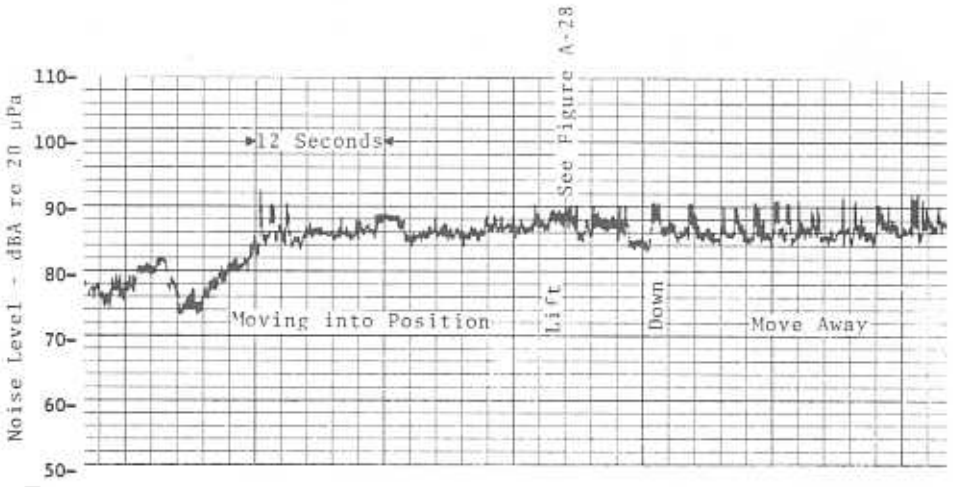


Figure A-27. Time History - Noise Level Data, Drott Diesel-Powered Hydraulic "Travel Lift" Lifting Trailer Box, Location 18, Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 50 Feet from Centerline of Flatcar at a Height of 4.5 Feet

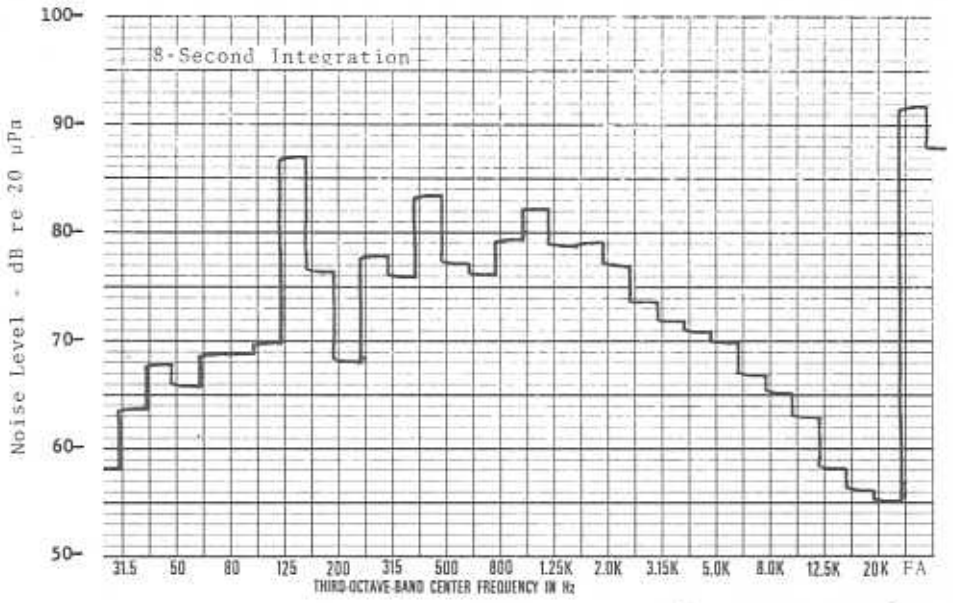


Figure A-28. Frequency Spectra - Drott Diesel-Powered Hydraulic "Travel Lift" Lifting Trailer Box, Location 18, Argentine Freight Yard, Santa Fe RR, 4/25/73 (see figure A-27)

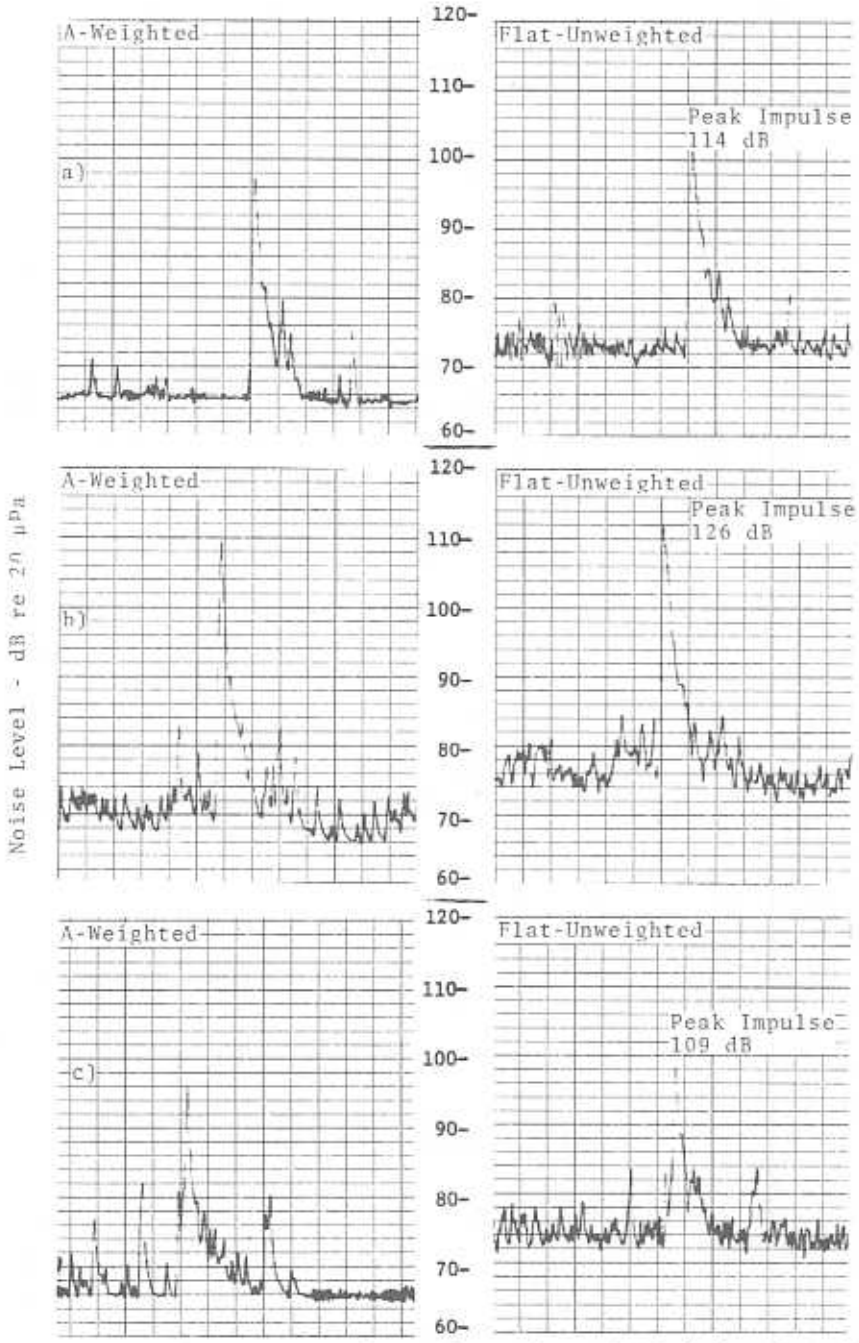


Figure A-29. Noise Level Time Histories (A-Weighted and Flat-Unweighted) Impact Data, Location 19, Microphone Offset 40 Feet from and Directly Opposite Point of Impact at a Height of 4 Feet Above Level of Rails
a) Loaded Grain Carrier at 8-mph Impacting Line of Cars. Impact Shielded by Empty Freight Car
b) Loaded Grain Carrier at 7-mph Impacting on Single Loaded Grain Carrier. No Shielding
c) Loaded Grain Carrier at 2 to 3-mph Impacting on Two Loaded Grain Carriers. No Shielding

Argentine Freight Yard, Santa Fe RR, 4/25/73

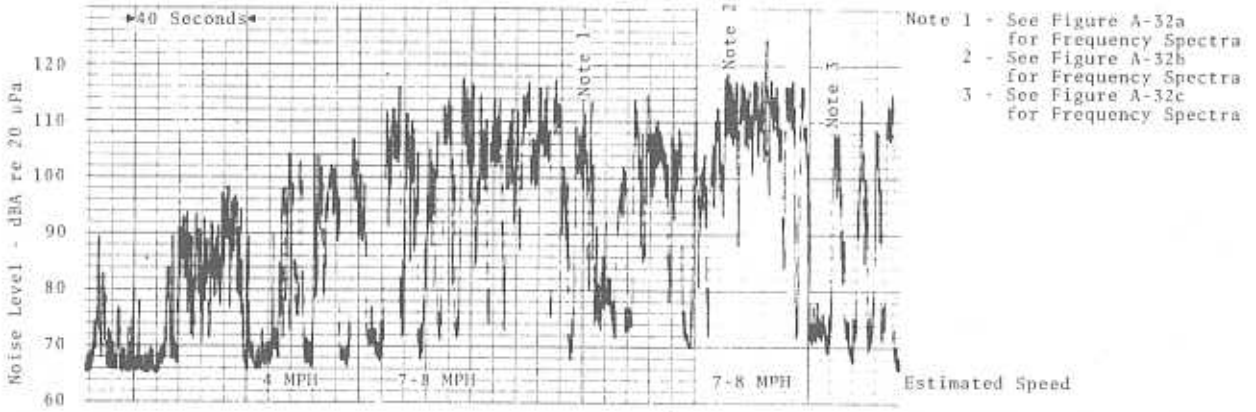


Figure A-30. Time History - Noise Level Data, Location 20 (see figure E-1), West Classification Yard, Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 45 Feet from Inert Retarder, 4 Feet Above Rails (Spring-loaded Inert Retarder)

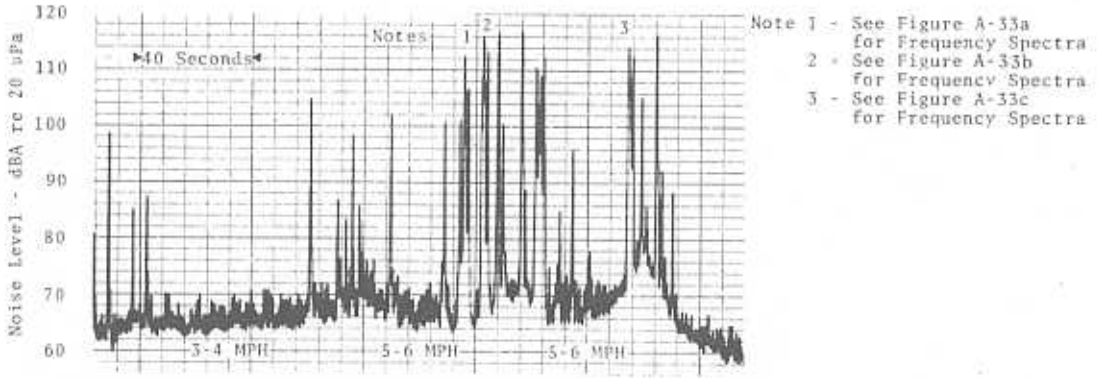


Figure A-31. Time History - Noise Level Data, Location 21 (see figure E-1), East Classification Yard, Argentine Freight Yard, Santa Fe RR, 4/25/73, Microphone Offset 55 Feet from Inert Retarder, 4 Feet Above Rails (Weight-balanced Inert Retarder)

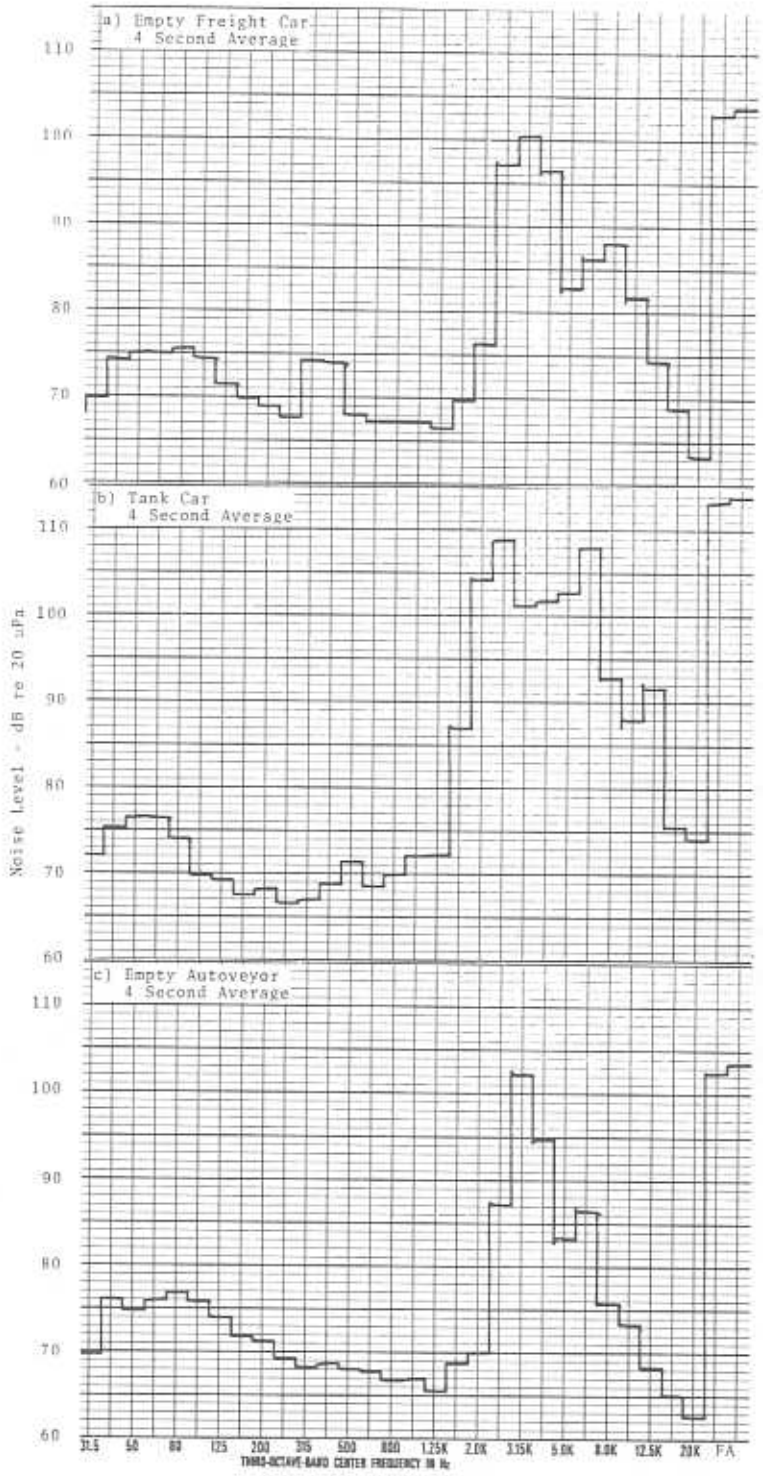


Figure A-32. Frequency Spectra - Inert Retarder Noise, Location 20, West Classification Yard, Argentine Freight Yard, Santa Fe RR, 4/25/73 (Spring-loaded Inert Retarder) (see figure A-30 for Noise Level Time History)

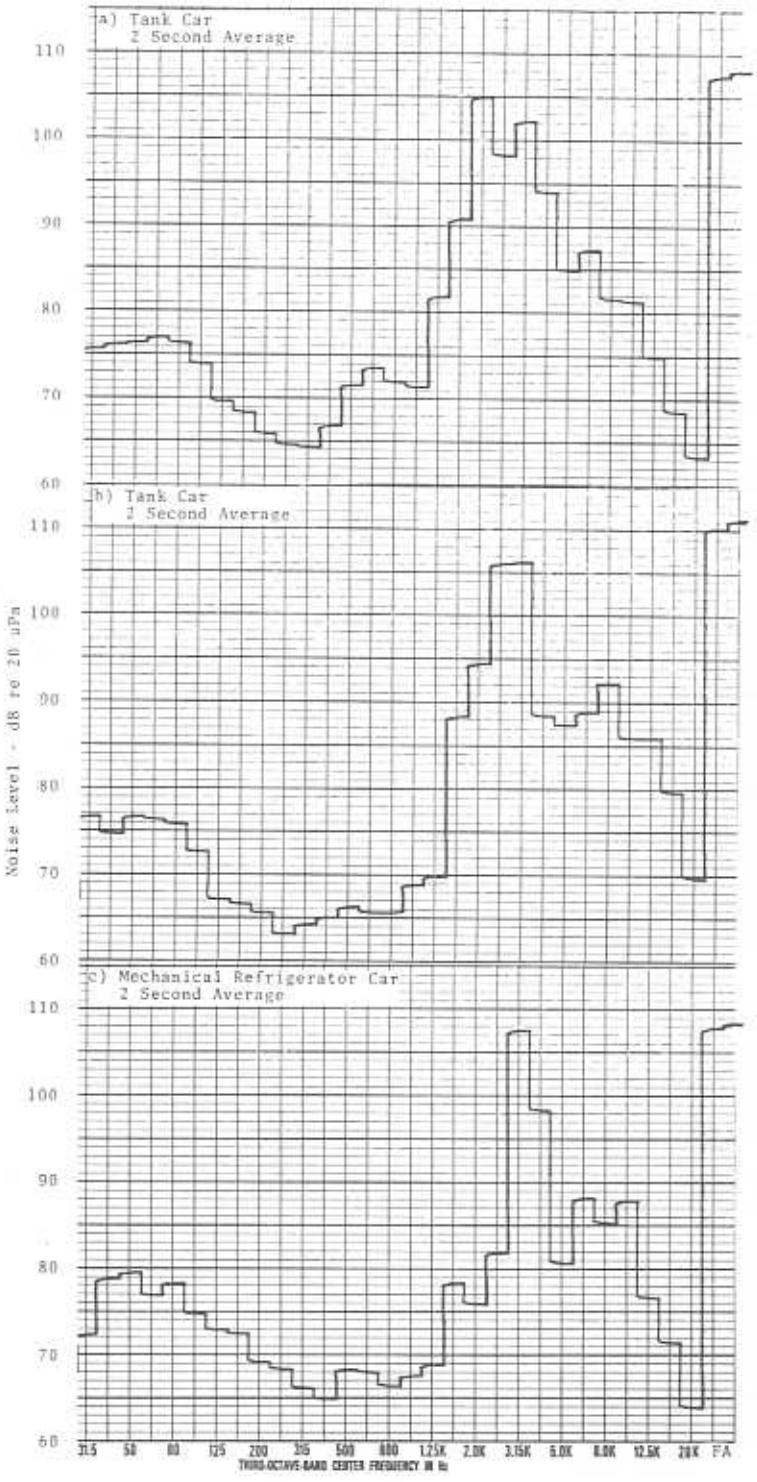


Figure A-33. Frequency Spectra - Inert Retarder Noise, Location 21, East Classification Yard, Argentine Freight Yard, Santa Fe RR, 4/25/73 (Weight-balanced Inert Retarder) (see figure A-31 for noise level time history)

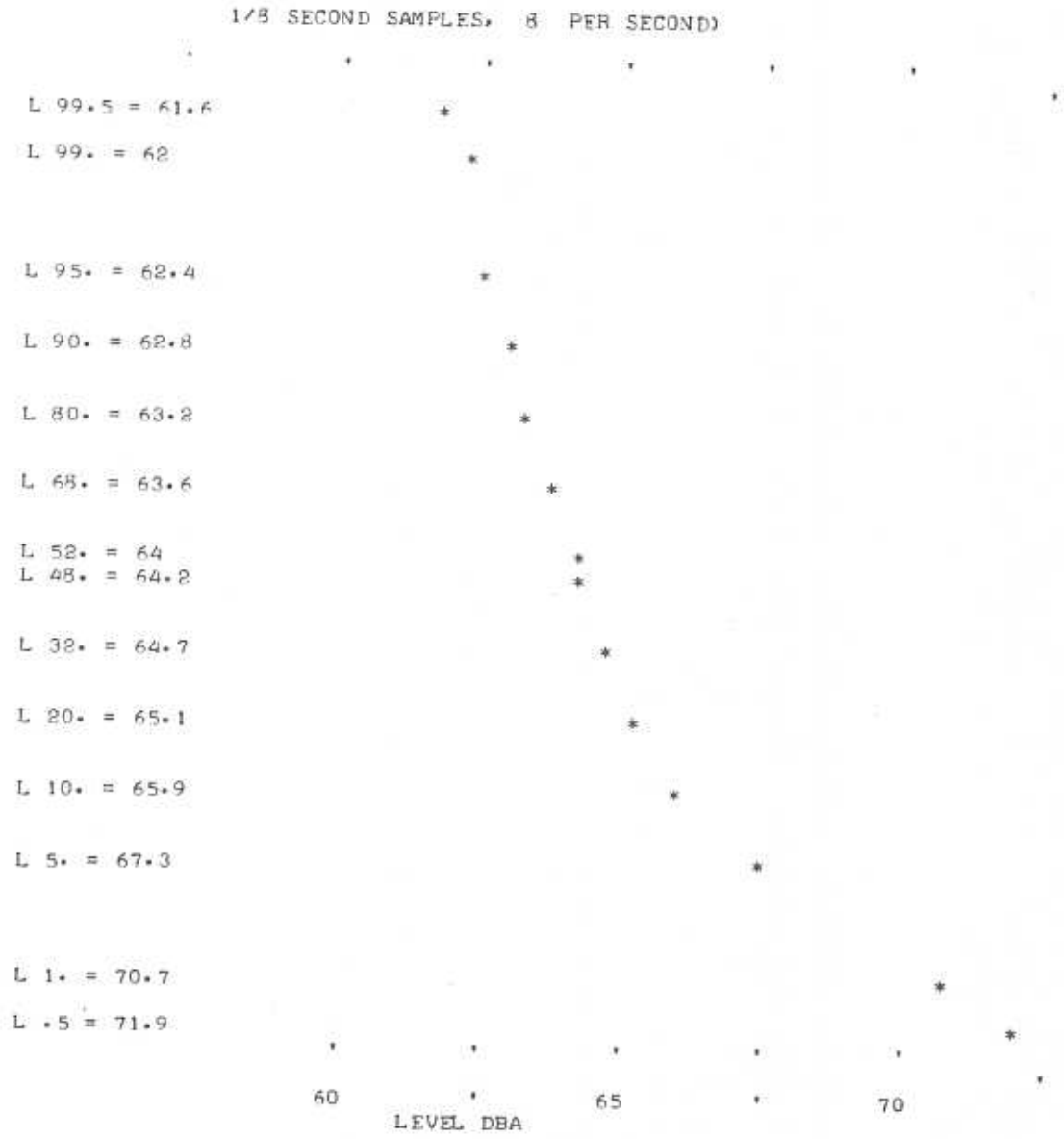
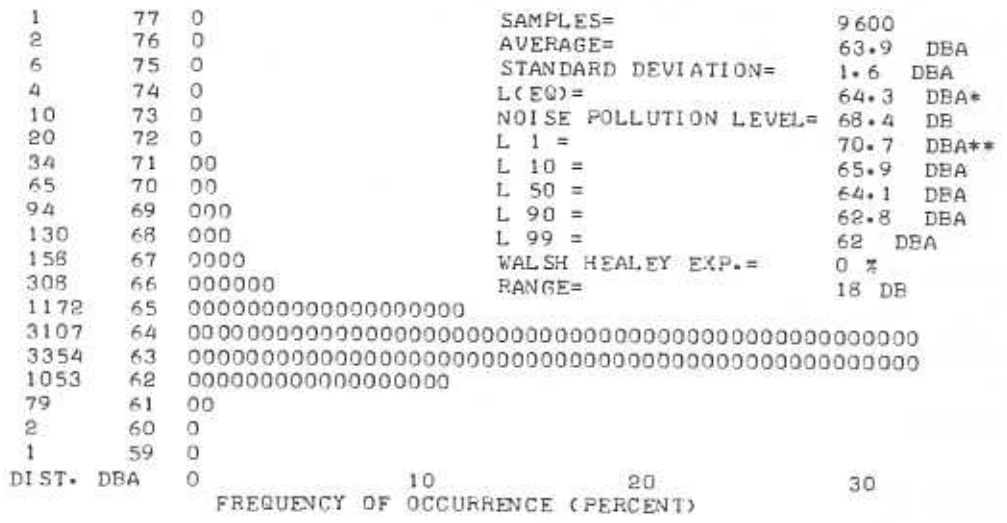


Figure A-34. Statistical Noise Data, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 0950 to 1010 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-34a. Histogram, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 0950 to 1010 Hours

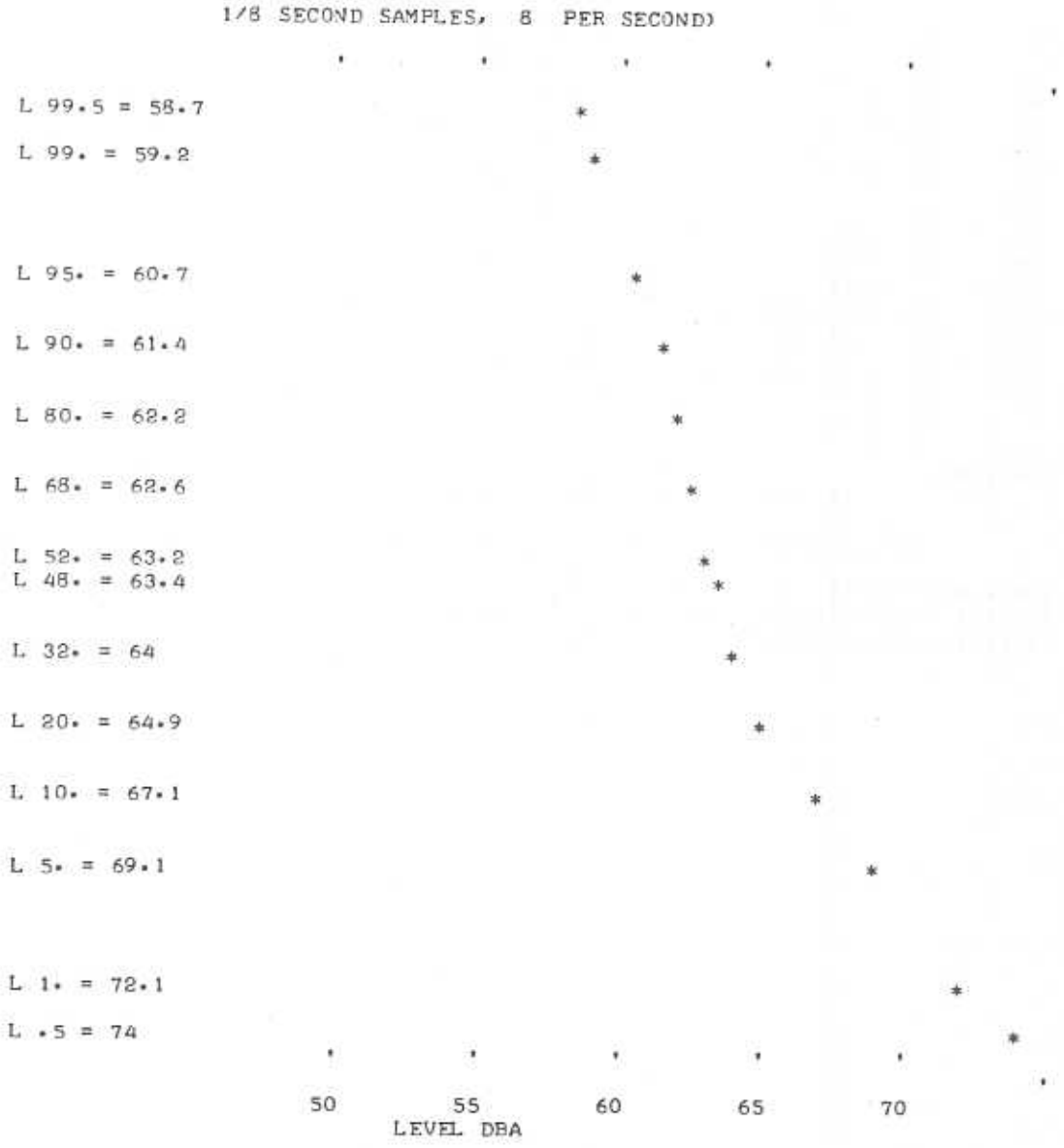
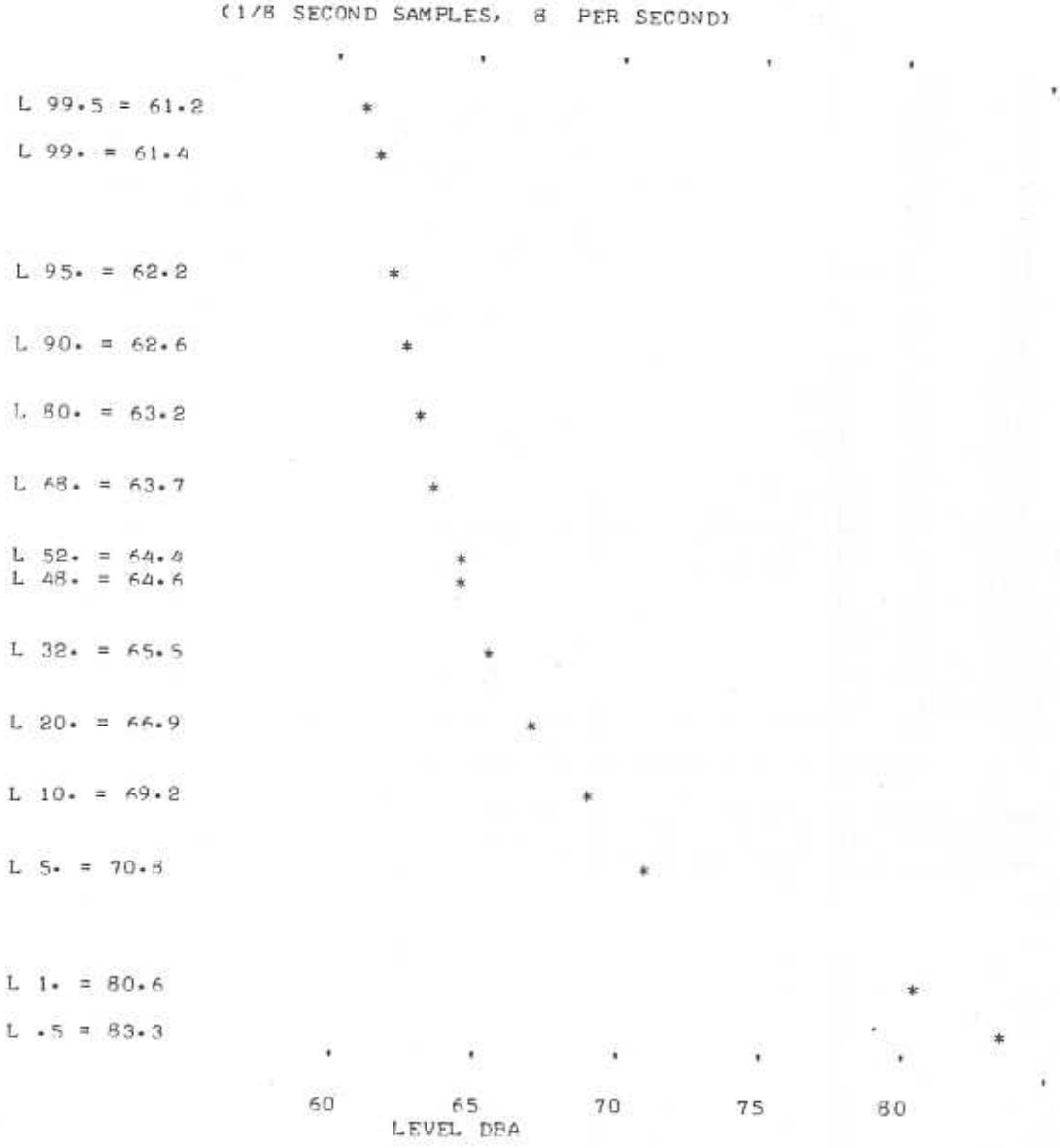


Figure A-35. Statistical Noise Data, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1050 to 1110 Hours

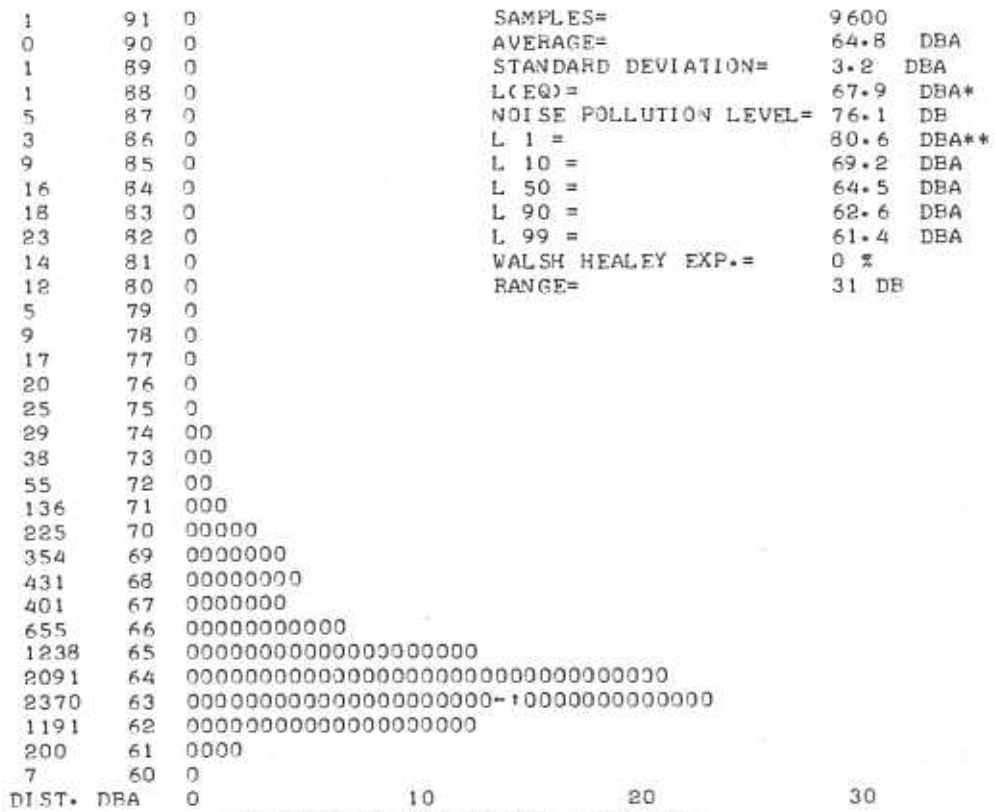
```
 2       82  0                       SAMPLES=                  9600
 0       81  0                       AVERAGE=                  63.3  DBA
 1       80  0                       STANDARD DEVIATION=       2.5   DBA
 0       79  0                       L(EQ)=                    64.3  DBA*
 4       78  0                       NOISE POLLUTION LEVEL=    70.7  DB
 3       77  0                       L 1 =                     72.1  DBA**
 6       76  0                       L 10 =                    67.1  DBA
 16      75  0                       L 50 =                    63.3  DBA
 16      74  0                       L 90 =                    61.4  DBA
 23      73  0                       L 99 =                    59.2  DBA
 28      72  00                      WALSH HEALEY EXP.=        0 %
 49      71  00                      RANGE=                    25 DB
 122     70  000
 223     69  00000
 248     68  00000
 231     67  00000
 265     66  00000
 521     65  000000000
 1210    64  000000000000000000000
 2603    63  0000000000000000000000000000000000000000000000
 2519    62  00000000000000000000000000000000000000000000
 943     61  0000000000000000
 341     60  000000
 158     59  0000
 62      58  00
 6       57  0
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-35a. Histogram, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1050 to 1110 Hours



LEVEL(DBA) VS PERCENT OF TIME LEVEL EXCEEDED
(PROBABILITY DISTRIBUTION)

Figure A-36. Statistical Noise Data, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1151 to 1211 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-36a. Histogram, Location 1, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1151 to 1211 Hours

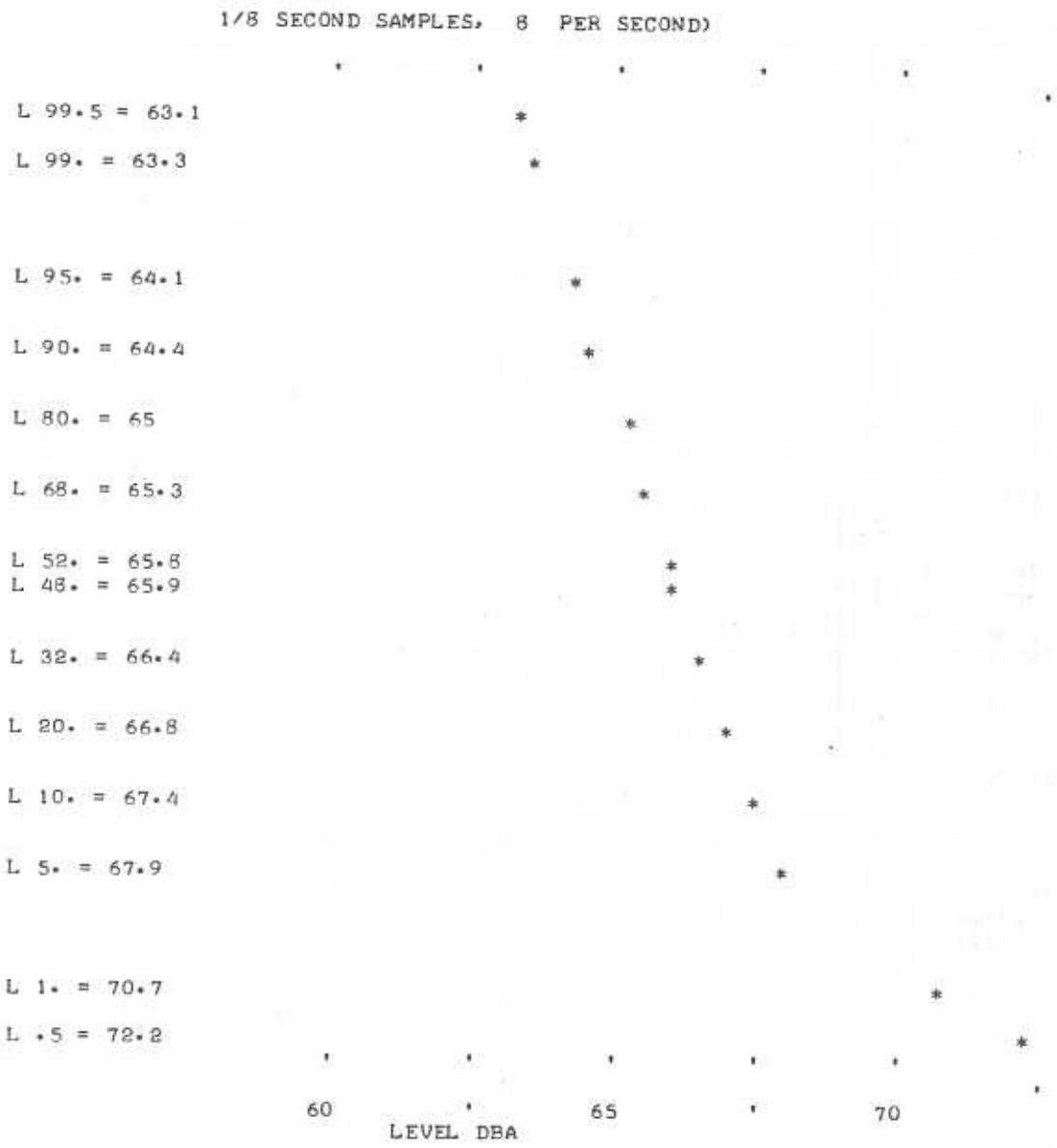
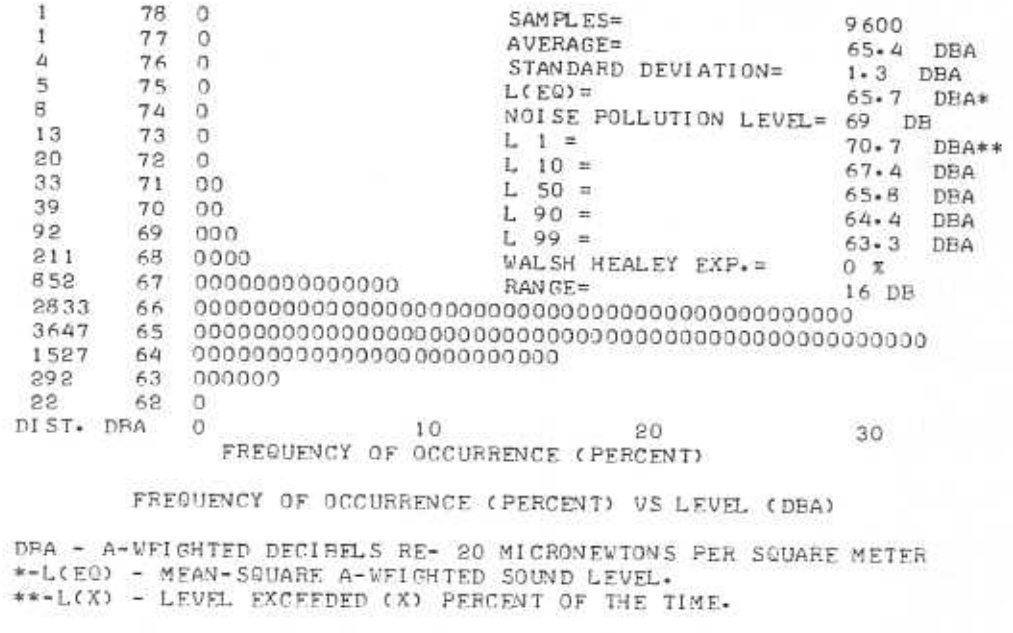


Figure A-37. Statistical Noise Data, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 0950 to 1010 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-37a. Histogram, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 0950 to 1010 Hours

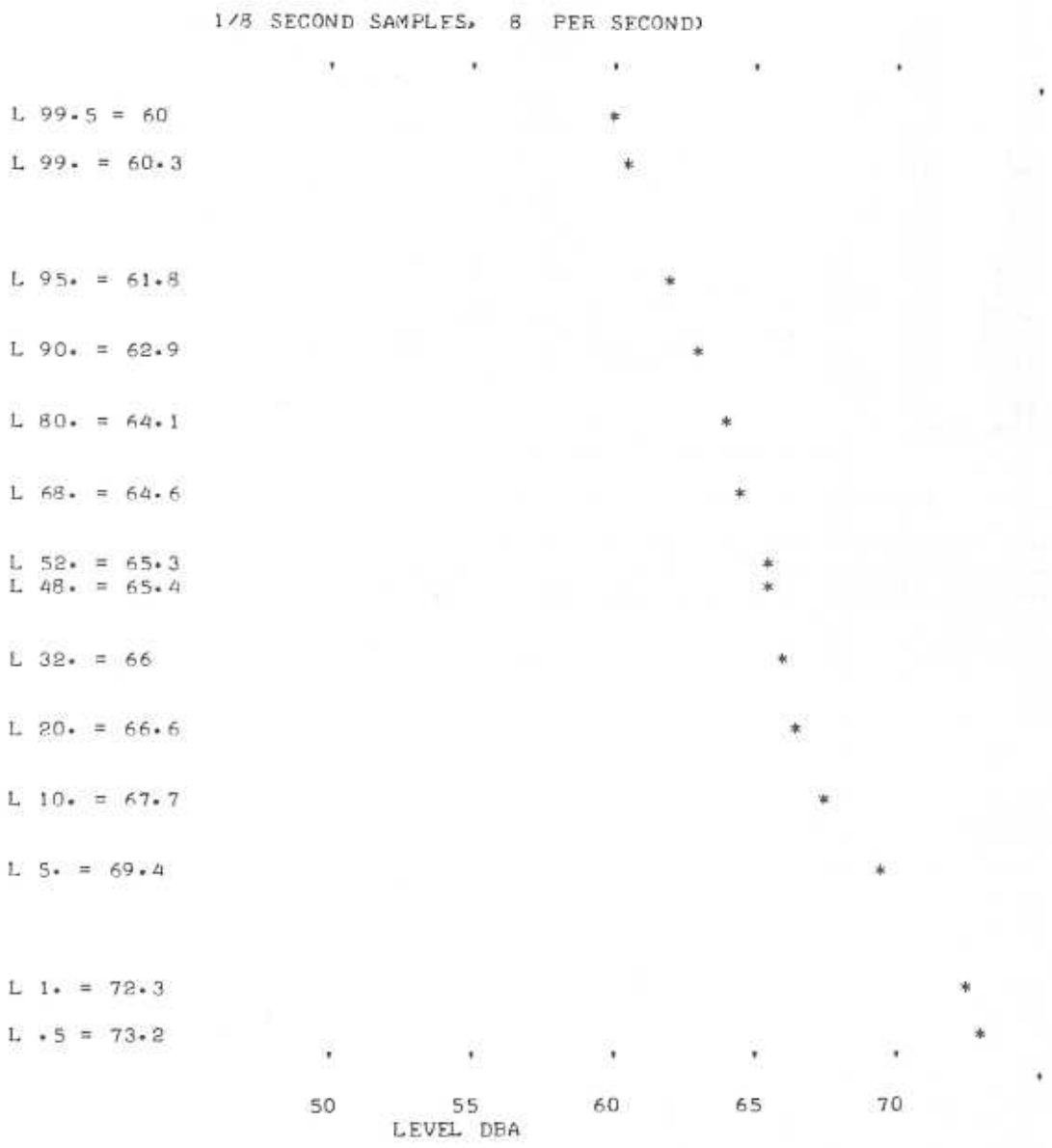


Figure A-38. Statistical Noise Data, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1050 to 1110 Hours

```
 3       78  0                    SAMPLES=                  9600
 0       77  0                    AVERAGE=                  64.9  DBA
 3       76  0                    STANDARD DEVIATION=       2.2   DBA
 14      75  0                    L(EQ)=                    65.5  DBA*
 11      74  0                    NOISE POLLUTION LEVEL=    71.1  DB
 22      73  0                    L 1 =                     72.3  DBA**
 64      72  00                   L 10 =                    67.7  DBA
 92      71  000                  L 50 =                    65.4  DBA
 152     70  000                  L 90 =                    62.9  DBA
 215     69  0000                 L 99 =                    60.3  DBA
 251     68  00000                WALSH HEALEY EXP.=        0 %
 530     67  000000000            RANGE=                    20 DB
 1608    66  0000000000000000000000000
 2876    65  00000000000000000000000000000000000000000000000000
 1950    64  0000000000000000000000000000000
 802     63  000000000000000
 449     62  00000000
 347     61  0000000
 168     60  0000
 40      59  00
 3       58  0
DIST. DBA    0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-38a. Histogram, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1050 to 1110 Hours

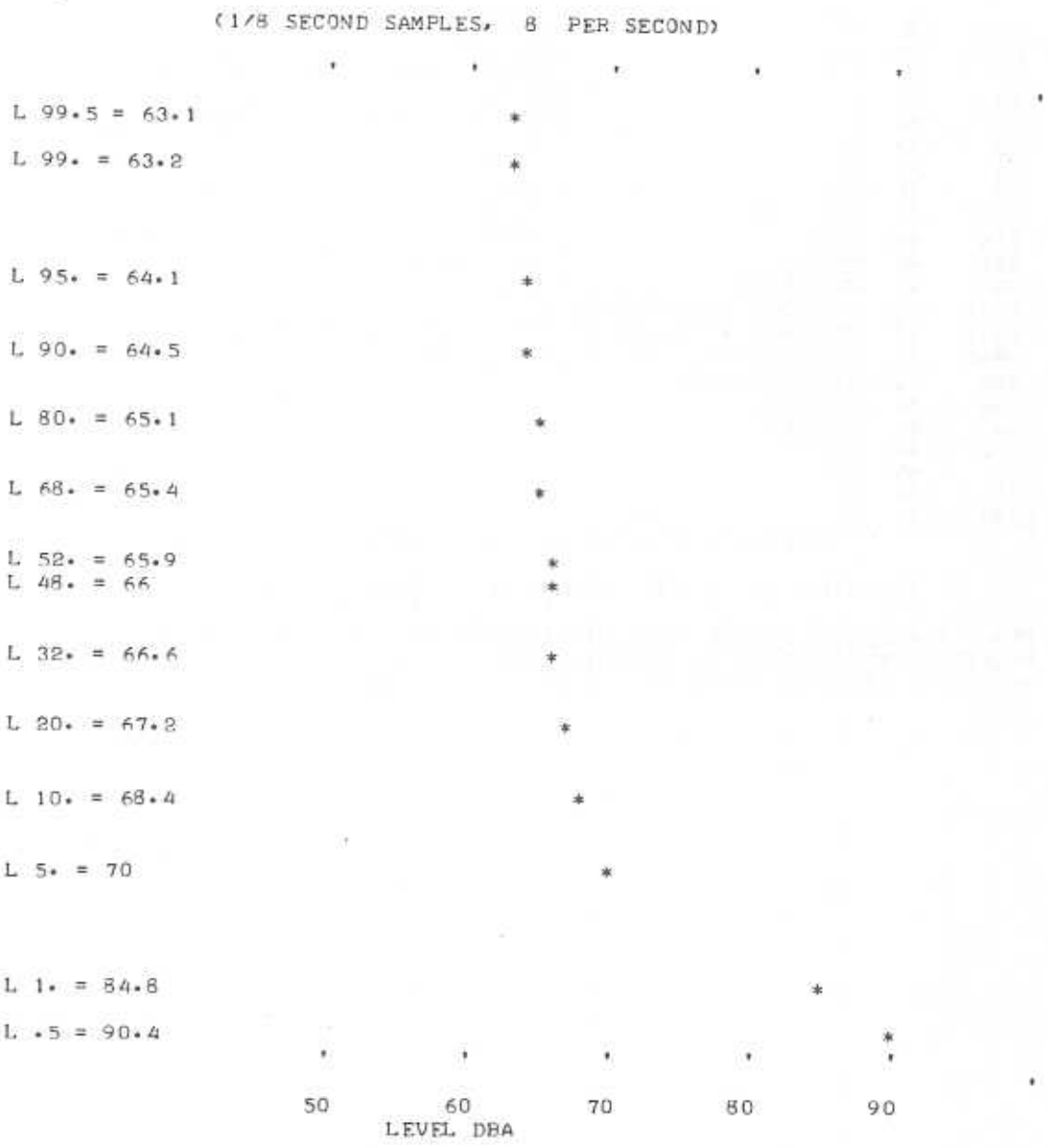


Figure A-39. Statistical Noise Data, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1151 to 1211 Hours

```
 1       96   0                    SAMPLES=                  9600
 0       95   0                    AVERAGE=                  66  DBA
 4       94   0                    STANDARD DEVIATION=       3  DBA
 9       93   0                    L(EQ)=                    71.8  DBA*
 15      92   0                    NOISE POLLUTION LEVEL=    79.5  DB
 12      91   0                    L 1 =                     84.8  DBA**
 12      90   0                    L 10 =                    68.4  DBA
 6       89   0                    L 50 =                    66  DBA
 7       88   0                    L 90 =                    64.5  DBA
 12      87   0                    L 99 =                    63.2  DBA
 6       86   0                    WALSH HEALEY EXP.=        .9 %
 10      85   0                    RANGE=                    34 DB
 10      84   0
 2       83   0
 1       82   0
 1       81   0
 0       80   0
 1       79   0
 1       78   0
 0       77   0
 3       76   0
 5       75   0
 12      74   0
 28      73   00
 56      72   00
 105     71   000
 152     70   000
 259     69   00000
 358     68   0000000
 997     67   0000000000000000
 2593    66   00000000000000000000000000000000000000000000
 3265    65   0000000000000000000000000000000000000000000000000000
00
 1364    64   00000000000000000000
 262     63   00000
 31      62   00
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)
```

FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-39a. Histogram, Location 2, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1151 to 1211 Hours

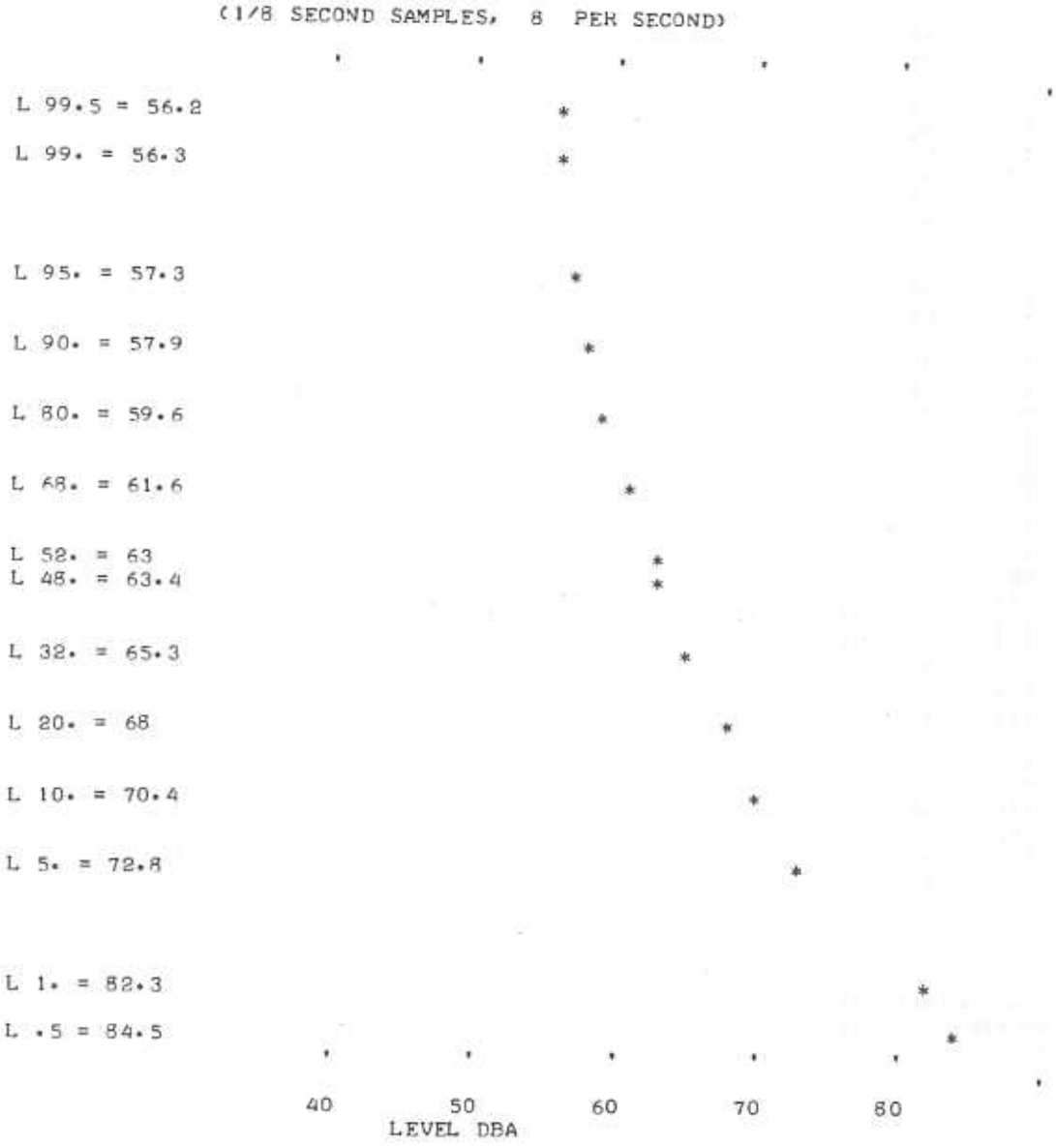


Figure A-40. Statistical Noise Data, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/24-25/73, 2345 to 0005 Hours

```
 3       89   0                    SAMPLES=                  9600
 14      88   0                    AVERAGE=                  63.5  DBA
 12      87   0                    STANDARD DEVIATION=       5.2   DBA
 8       86   0                    L(EQ)=                    69.1  DBA*
 6       85   0                    NOISE POLLUTION LEVEL=    82.4  DB
 11      84   0                    L 1 =                     82.3  DBA**
 16      83   0                    L 10 =                    70.4  DBA
 36      82   00                   L 50 =                    63.2  DBA
 32      81   00                   L 90 =                    57.9  DBA
 20      80   0                    L 99 =                    56.3  DBA
 23      79   0                    WALSH HEALEY EXP.=        0 %
 23      78   0                    RANGE=                    34 DB
 34      77   00
 51      76   00
 44      75   00
 55      74   00
 65      73   00
 122     72   000
 217     71   0000
 294     70   000000
 402     69   0000000
 417     68   00000000
 336     67   000000
 384     66   0000000
 610     65   00000000000
 773     64   000000000000
 1027    63   0000000000000000
 1172    62   00000000000000000000
 811     61   00000000000000
 481     60   000000000
 426     59   00000000
 638     58   00000000000
 772     57   000000000000
 258     56   00000
 7       55   0
DIST. DBA    0              10              20              30
                FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-40a. Histogram, Location 1A, Argentine Freight Yard Santa Fe RR, 4/24-25/73, 2345 to 0005 Hours

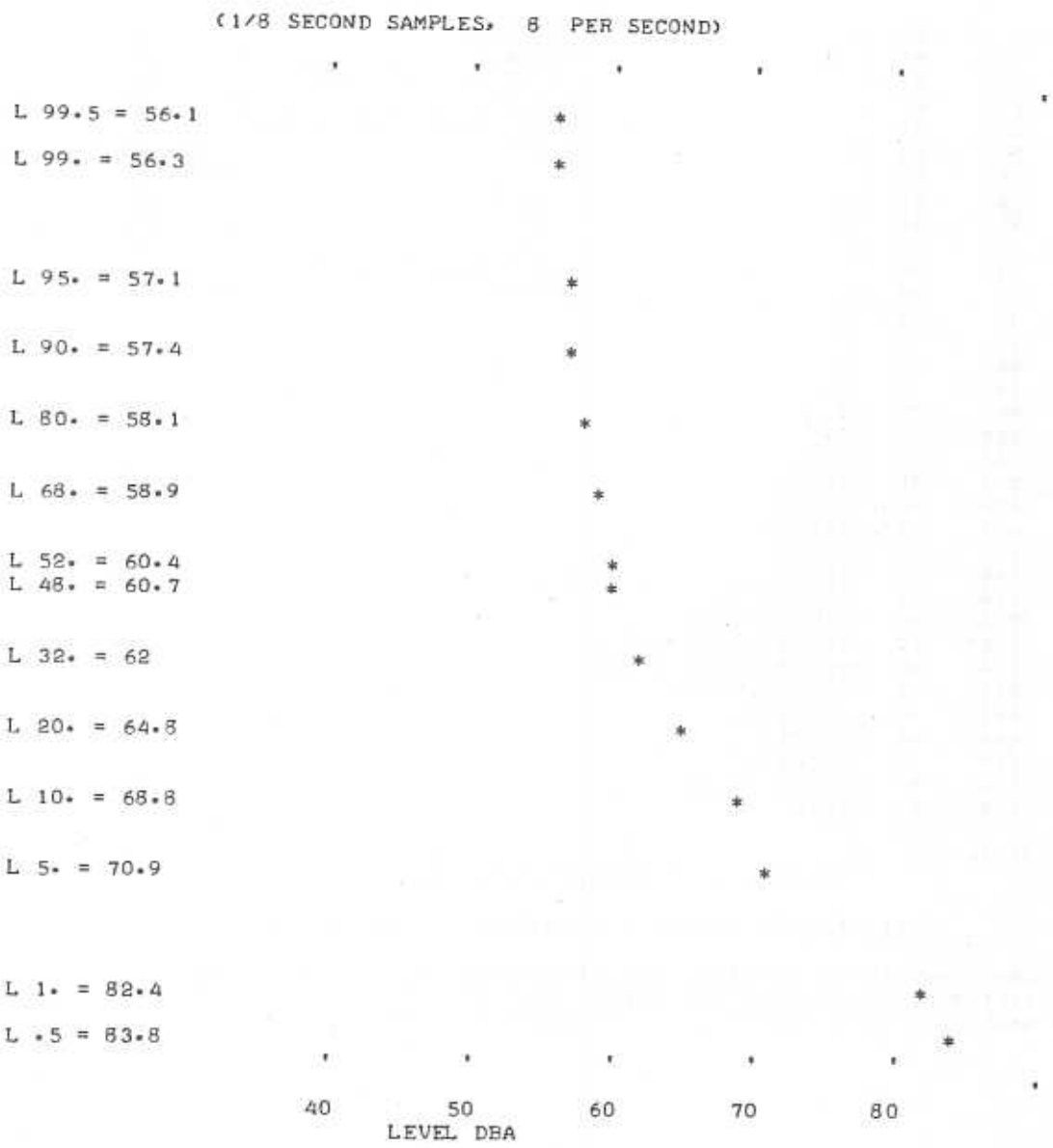


Figure A-41. Statistical Noise Data, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73 0545 to 0605 Hours

```
 5       87  0                      SAMPLES=                  9600
 8       86  0                      AVERAGE=                  61.3  DBA
 12      85  0                      STANDARD DEVIATION=       4.9   DBA
 18      84  0                      L(EQ)=                    67.5  DBA*
 32      83  00                     NOISE POLLUTION LEVEL=    80   DB
 36      82  00                     L 1 =                     82.4  DBA**
 30      81  00                     L 10 =                    68.8  DBA
 25      80  0                      L 50 =                    60.6  DBA
 6       79  0                      L 90 =                    57.4  DBA
 4       78  0                      L 99 =                    56.3  DBA
 7       77  0                      WALSH HEALEY EXP.=        0 %
 7       76  0                      RANGE=                    32 DB
 9       75  0
 9       74  0
 27      73  00
 72      72  00
 141     71  000
 227     70  00000
 243     69  00000
 269     68  00000
 207     67  0000
 211     66  0000
 252     65  00000
 293     64  000000
 382     63  0000000
 539     62  0000000000
 1172    61  00000000000000000000
 1299    60  000000000000000000000
 886     59  00000000000000
 1330    58  0000000000000000000000
 1512    57  00000000000000000000000000
 318     56  000000
 12      55  0
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-41a. Histogram, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0545 to 0605 Hours

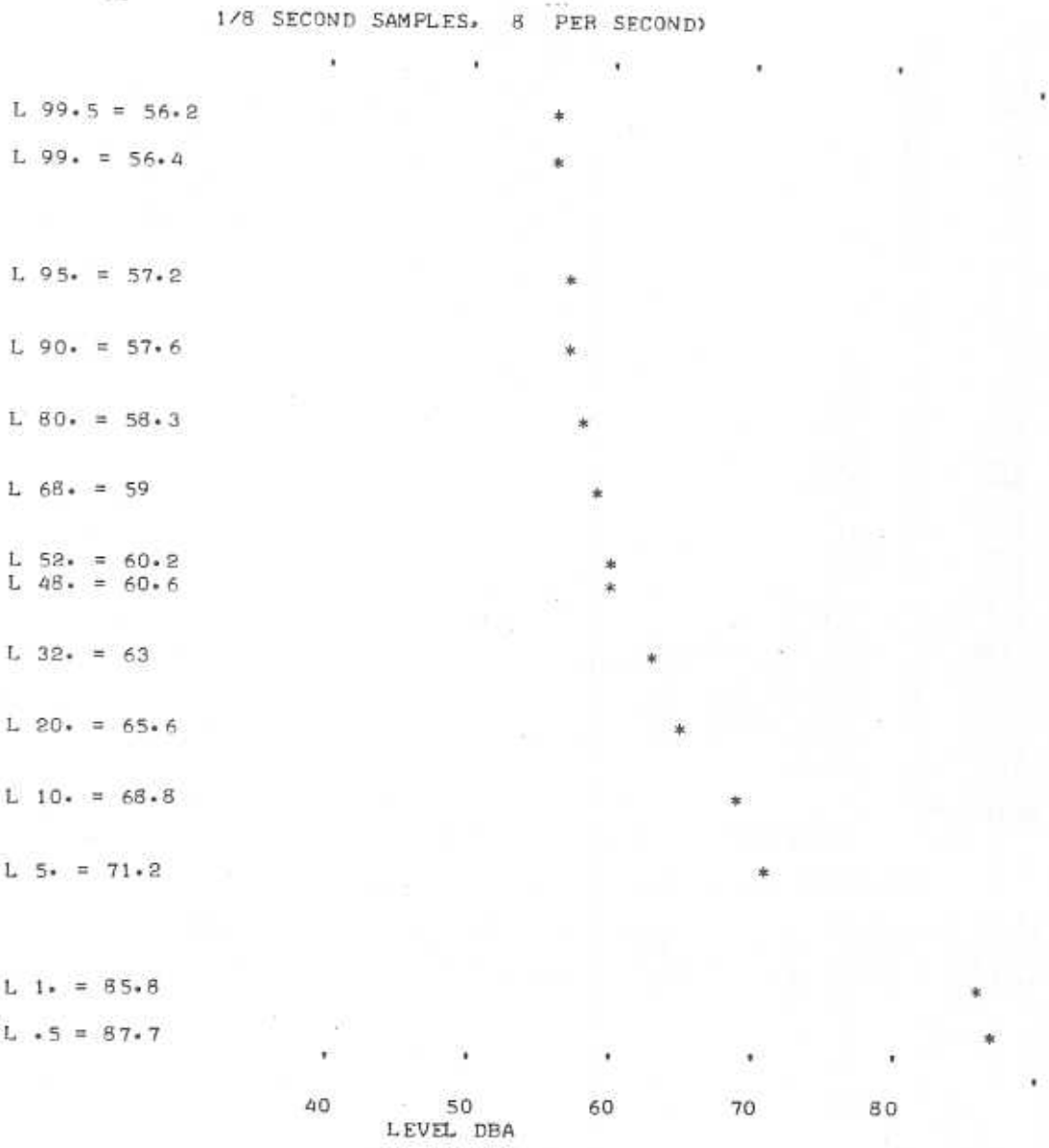
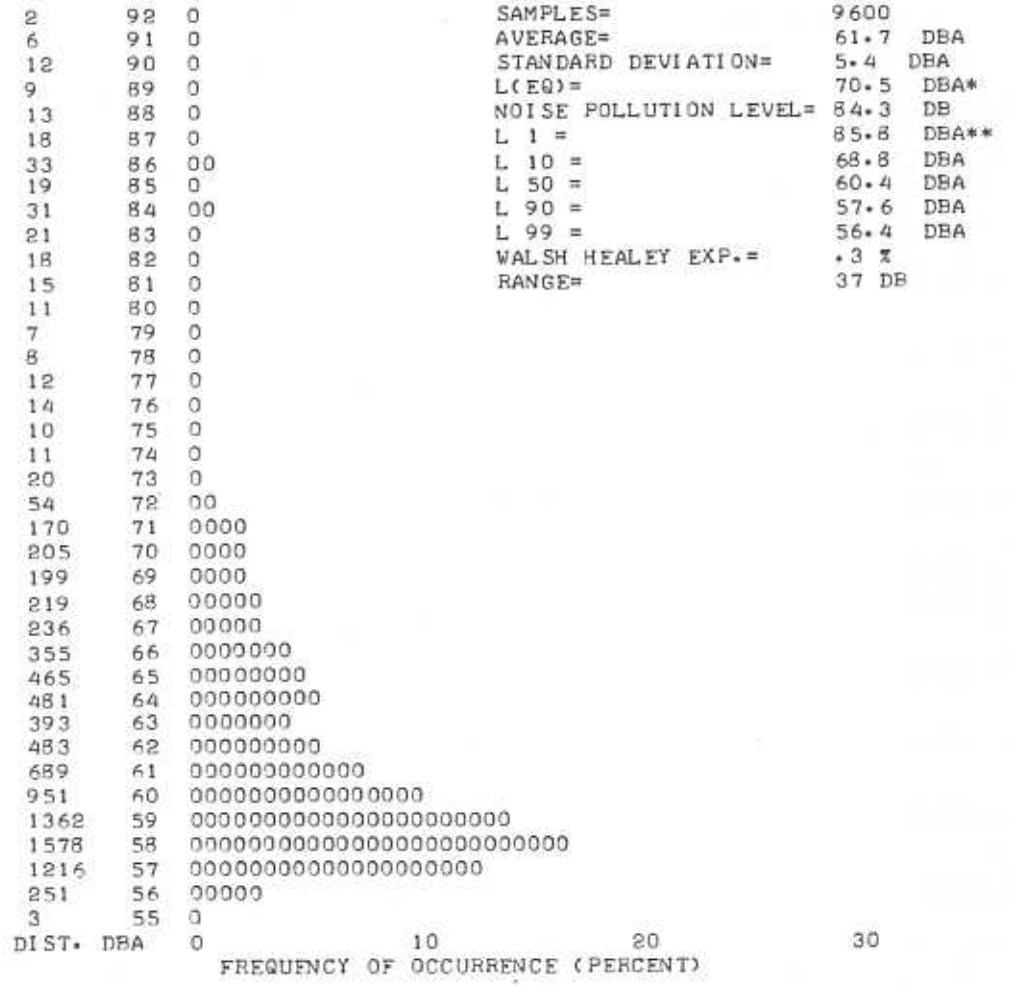


Figure A-42. Statistical Noise Data, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0725 to 0745 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-42a. Histogram, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0725 to 0745 Hours

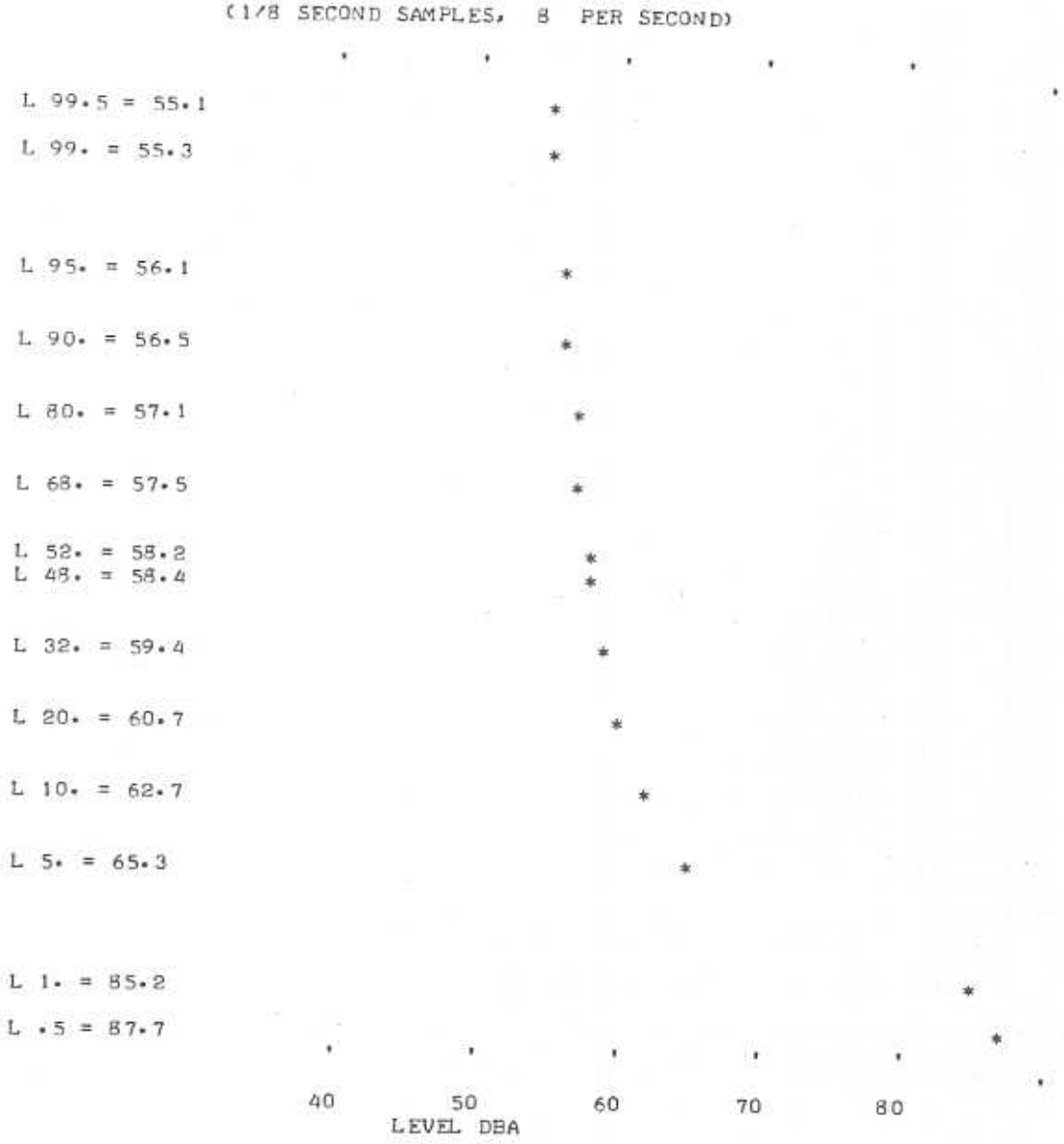
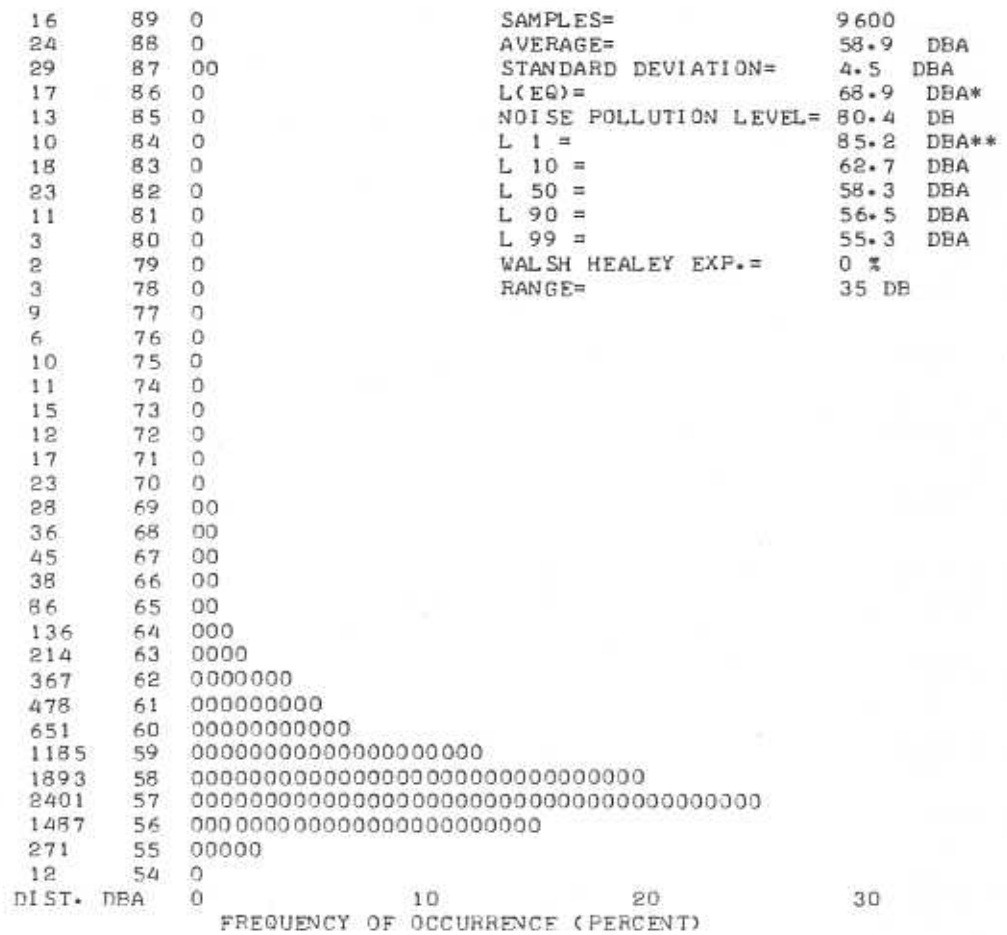


Figure A-43. Statistical Noise Data, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0745 to 0805 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-43a. Histogram, Location 1A, Argentine Freight Yard, Santa Fe RR, 4/25/73, 0745 to 0805 Hours

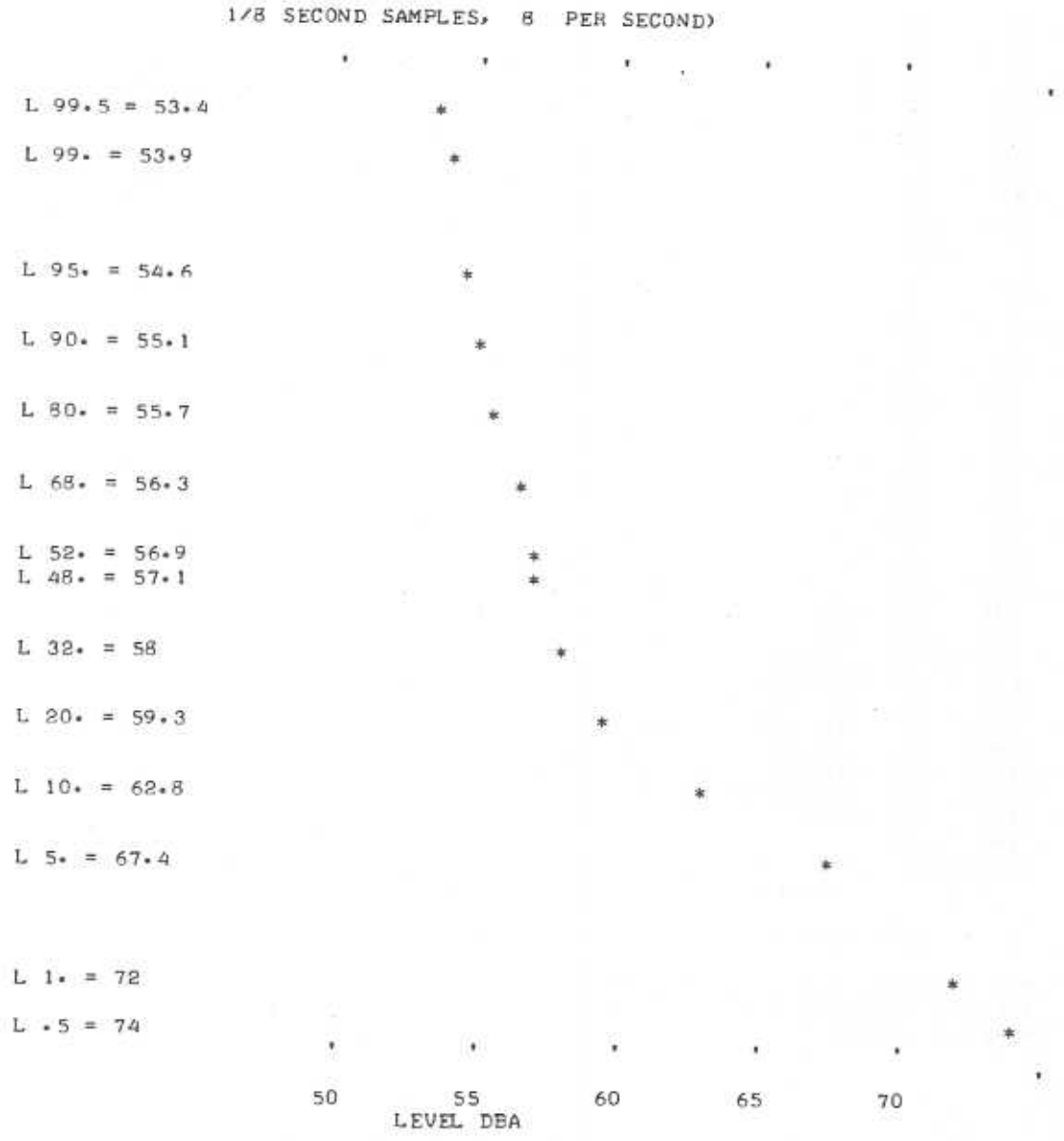
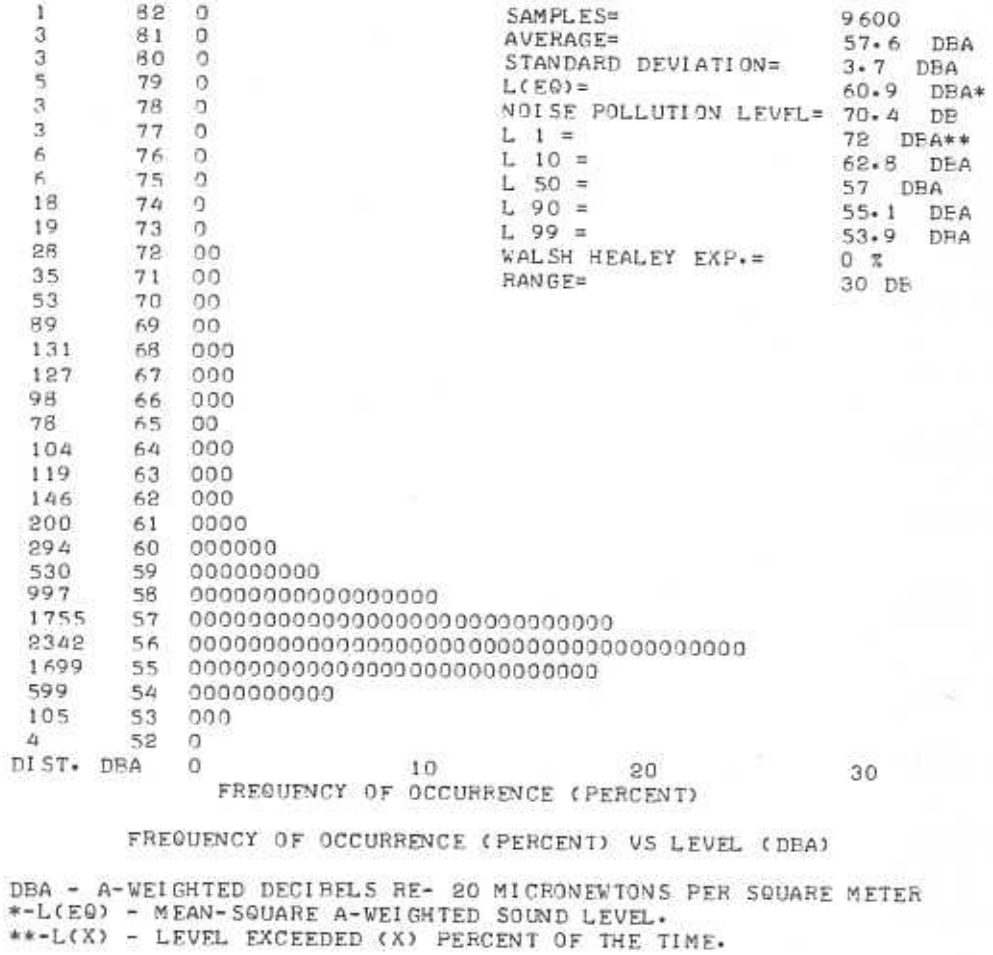


Figure A-44. Statistical Noise Data, Location 3, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1527 to 1547 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-44a. Histogram, Location 3, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1527 to 1547 Hours

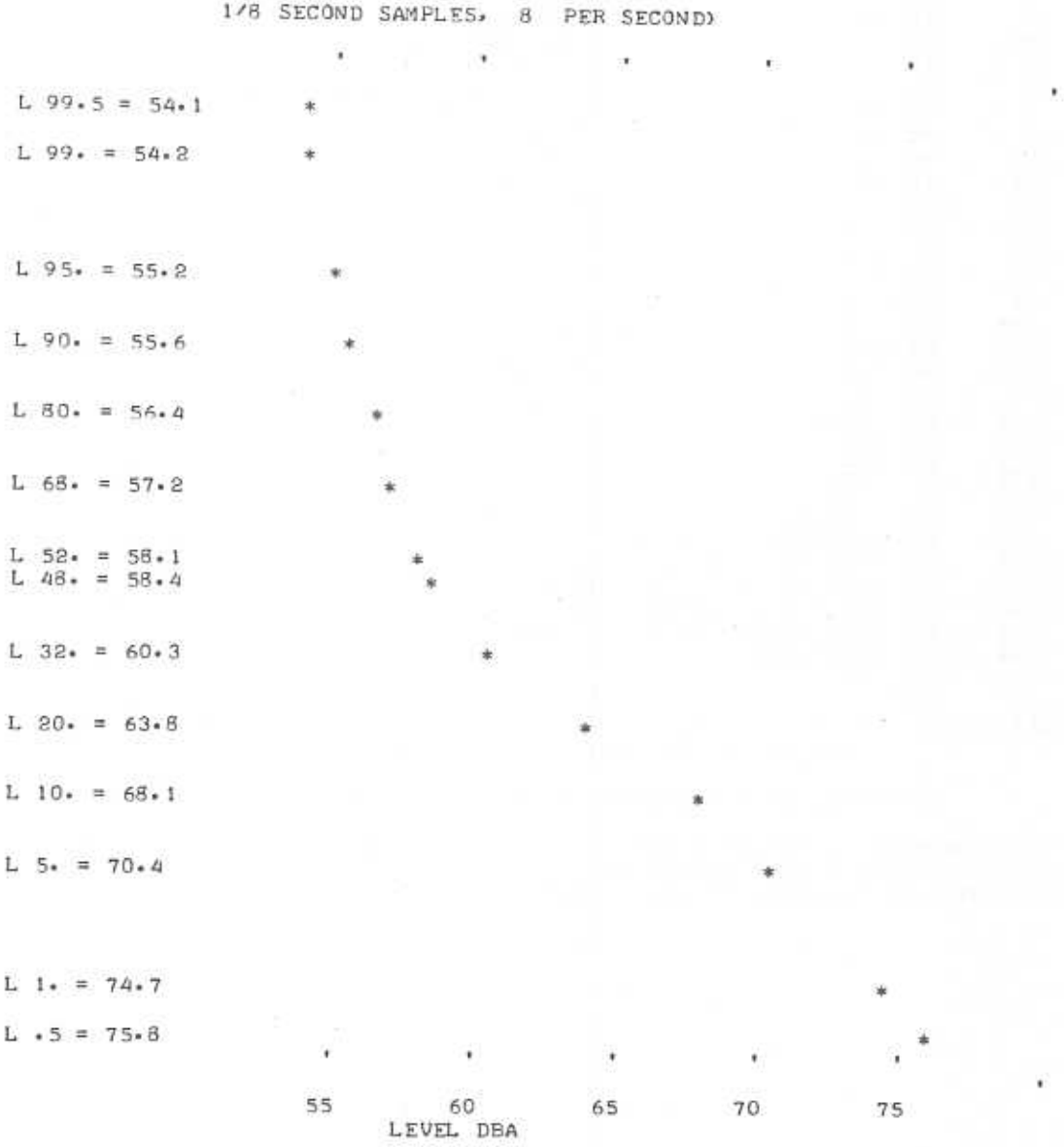


Figure A-45. Statistical Noise Data, Location 3 (Special) Argentine Freight Yard, Santa Fe RR, 4/24/73, 1528 to 1531 Hours (Three Minute Period of Humping Activity on West Hump, See Figure A-7)

```
 2       79  0                    SAMPLES=                  1440
 3       78  0                    AVERAGE=                  59.6  DBA
 0       77  0                    STANDARD DEVIATION=       4.8   DBA
 1       76  0                    L(EQ)=                    63.6  DBA*
 6       75  00                   NOISE POLLUTION LEVEL=    75.9  DB
 9       74  00                   L 1 =                     74.7  DBA**
 7       73  00                   L 10 =                    68.1  DBA
16       72  000                  L 50 =                    58.3  DBA
18       71  000                  L 90 =                    55.6  DBA
16       70  000                  L 99 =                    54.2  DBA
23       69  000                  WALSH HEALEY EXP.=        0 %
49       68  000000               RANGE=                    26 DB
28       67  0000
28       66  0000
34       65  00000
40       64  00000
36       63  00000
51       62  000000
53       61  0000000
56       60  0000000
118      59  0000000000000
172      58  00000000000000000000
258      57  000000000000000000000000000000
218      56  000000000000000000000000
149      55  0000000000000000
46       54  000000
3        53  0
DIST. DBA    0              10              20              30
                FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-45a. Histogram, Location 3 (Special), Argentine Freight Yard, Santa Fe RR, 4/24/73, 1528 to 1531 Hours
(Three Minute Period of Humping Activity on West Hump, See Figure A-7)

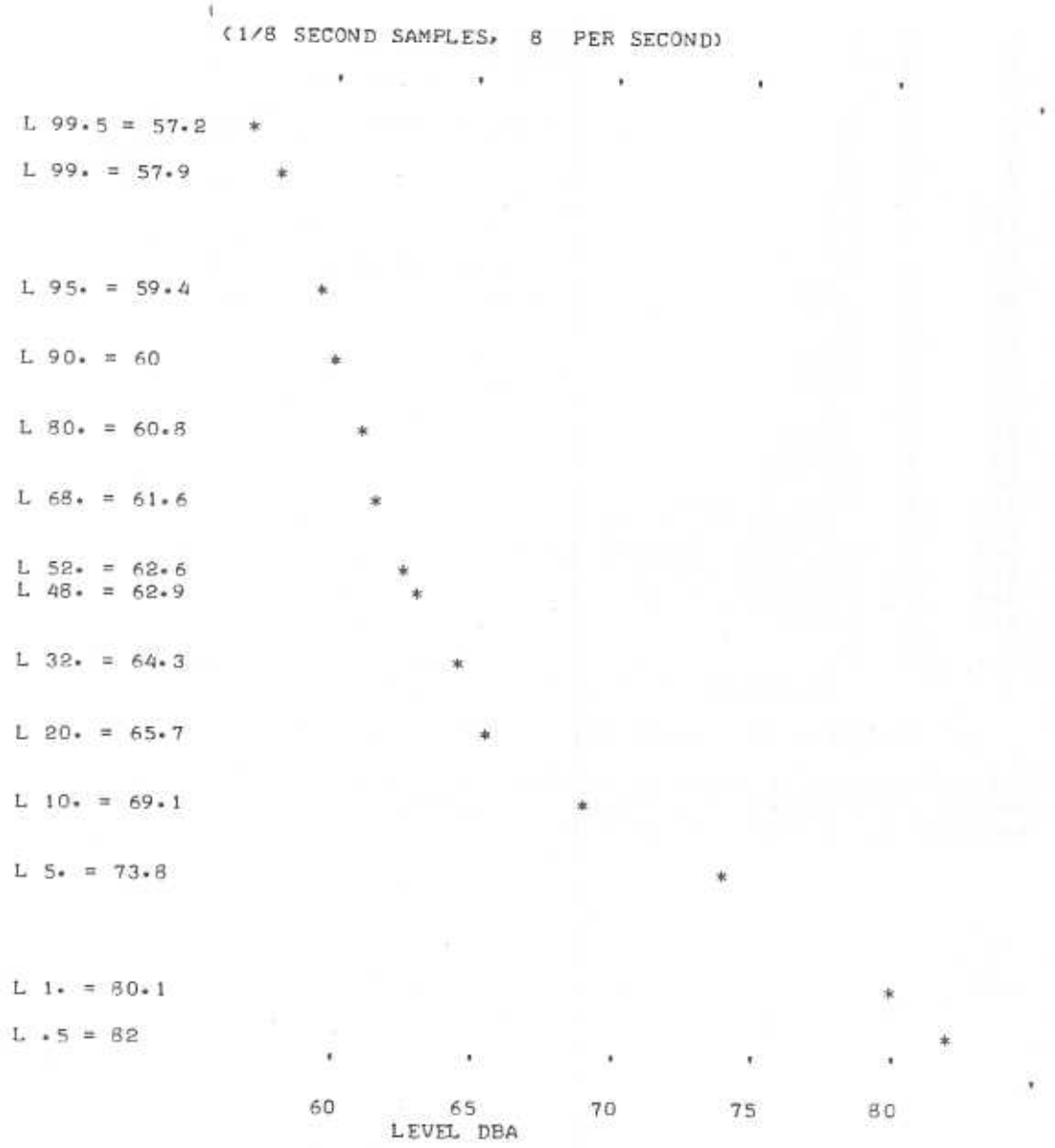


Figure A-46. Statistical Noise Data, Location 4, Argentine Freight Yard, Santa Fe RR, 4/25/73, 0936 to 0956 Hours

```
 1       92  0                    SAMPLES=                 9600
 1       91  0                    AVERAGE=                 63.4  DBA
 1       90  0                    STANDARD DEVIATION=      4.4  DBA
 2       89  0                    L(EQ)=                   68.2  DBA*
 4       88  0                    NOISE POLLUTION LEVEL=   79.5  DB
 2       87  0                    L 1 =                    80.1  DBA**
 2       86  0                    L 10 =                   69.1  DBA
 5       85  0                    L 50 =                   62.8  DBA
 9       84  0                    L 90 =                   60  DBA
 13      83  0                    L 99 =                   57.9  DBA
 8       82  0                    WALSH HEALEY EXP.=       0 %
 24      81  0                    RANGE=                   38 DB
 27      80  00
 52      79  00
 61      78  00
 61      77  00
 62      76  00
 61      75  00
 69      74  00
 80      73  00
 102     72  000
 90      71  000
 94      70  000
 138     69  000
 155     68  0000
 221     67  00000
 327     66  000000
 713     65  000000000000
 937     64  0000000000000000
 1125    63  00000000000000000000
 1529    62  0000000000000000000000000000
 1411    61  00000000000000000000000
 1299    60  0000000000000000000000
 693     59  000000000000
 121     58  000
 65      57  00
 28      56  00
 5       55  0
 2       54  0
DIST. DBA    0              10              20              30
                FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-46a. Histogram, Location 4, Argentine Freight Yard, Santa Fe RR, 4/25/73, 0936 to 0956 Hours

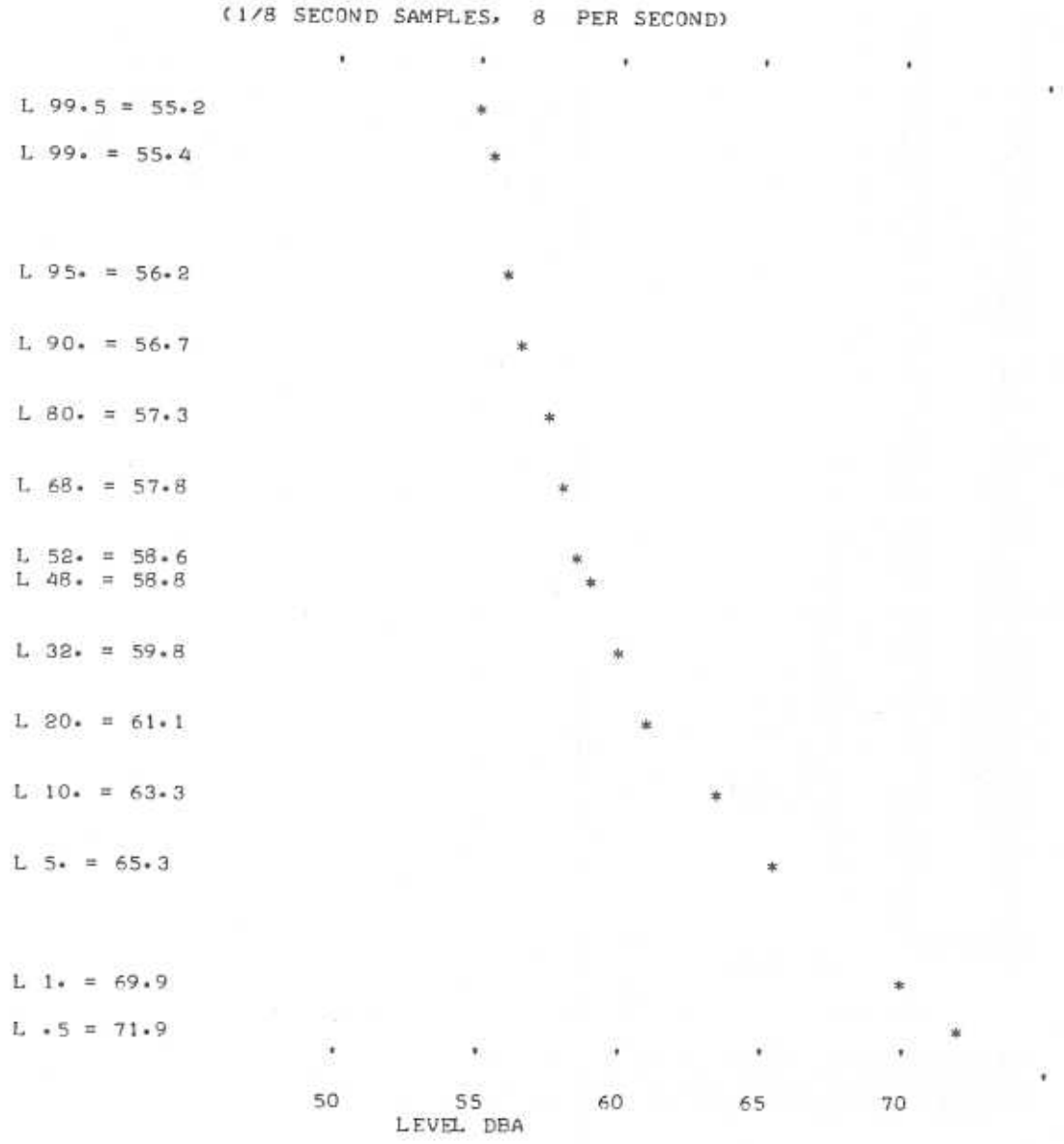


Figure A-47. Statistical Noise Data, Location 5, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1138 to 1158 Hours

```
 1       84  0                      SAMPLES=                  9600
 1       83  0                      AVERAGE=                  59   DBA
 0       82  0                      STANDARD DEVIATION=       2.9  DBA
 1       81  0                      L(EQ)=                    60.8  DBA*
 1       80  0                      NOISE POLLUTION LEVEL=    68.2  DB
 0       79  0                      L 1 =                     69.9  DBA**
 2       78  0                      L 10 =                    63.3  DBA
 0       77  0                      L 50 =                    58.7  DBA
 5       76  0                      L 90 =                    56.7  DBA
 8       75  0                      L 99 =                    55.4  DBA
 7       74  0                      WALSH HEALEY EXP.=        0 %
 10      73  0                      RANGE=                    31 DB
 11      72  0
 18      71  0
 27      70  00
 37      69  00
 65      68  00
 99      67  000
 111     66  000
 110     65  000
 209     64  0000
 329     63  000000
 388     62  0000000
 515     61  00000000
 906     60  000000000000000
 1395    59  000000000000000000000000
 1891    58  00000000000000000000000000000000
 2153    57  0000000000000000000000000000000000000
 1084    56  0000000000000000
 205     55  0000
 10      54  0
 1       53  0
DIST. DBA    0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-47a. Histogram, Location 5, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1138 to 1158 Hours

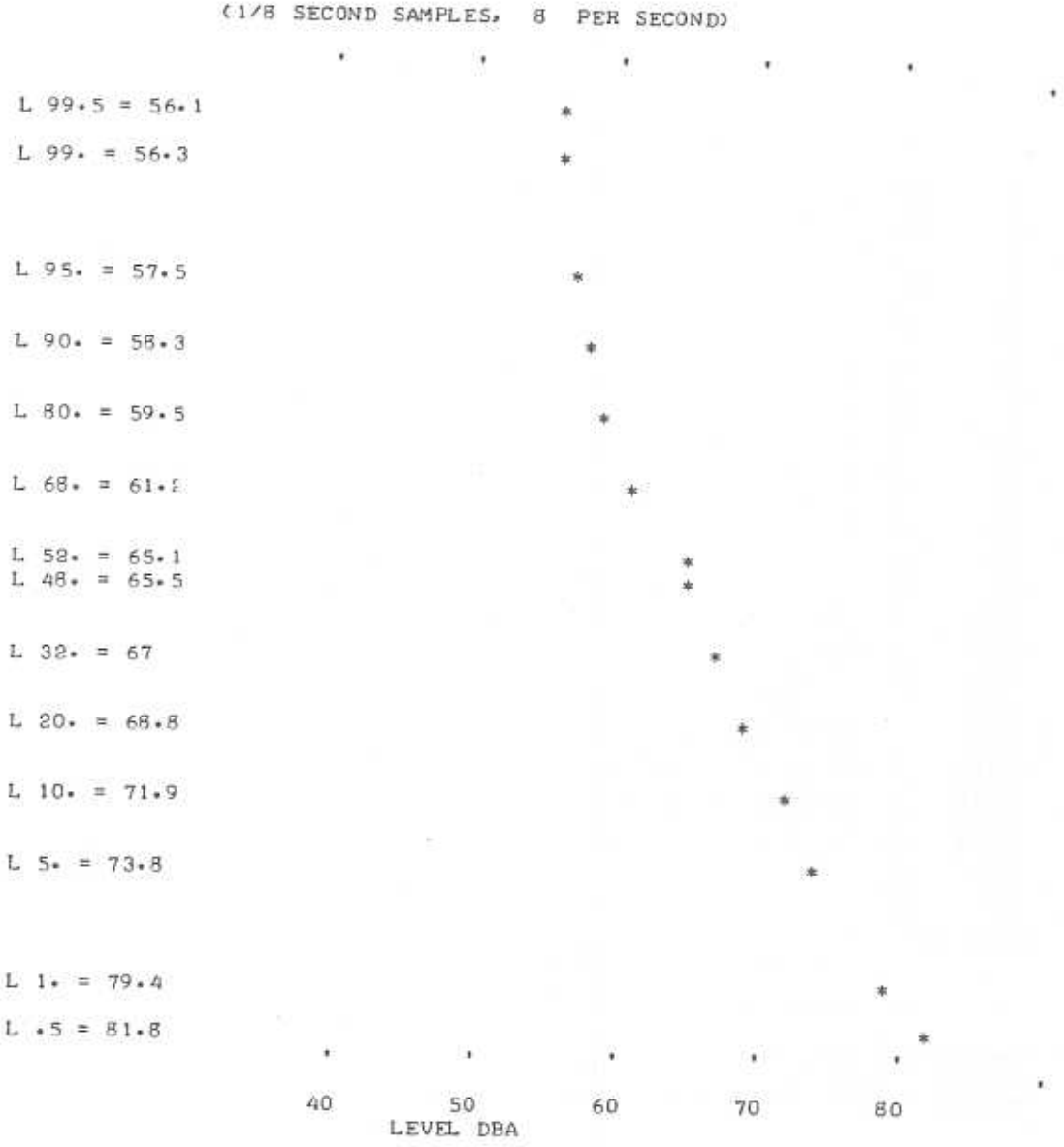
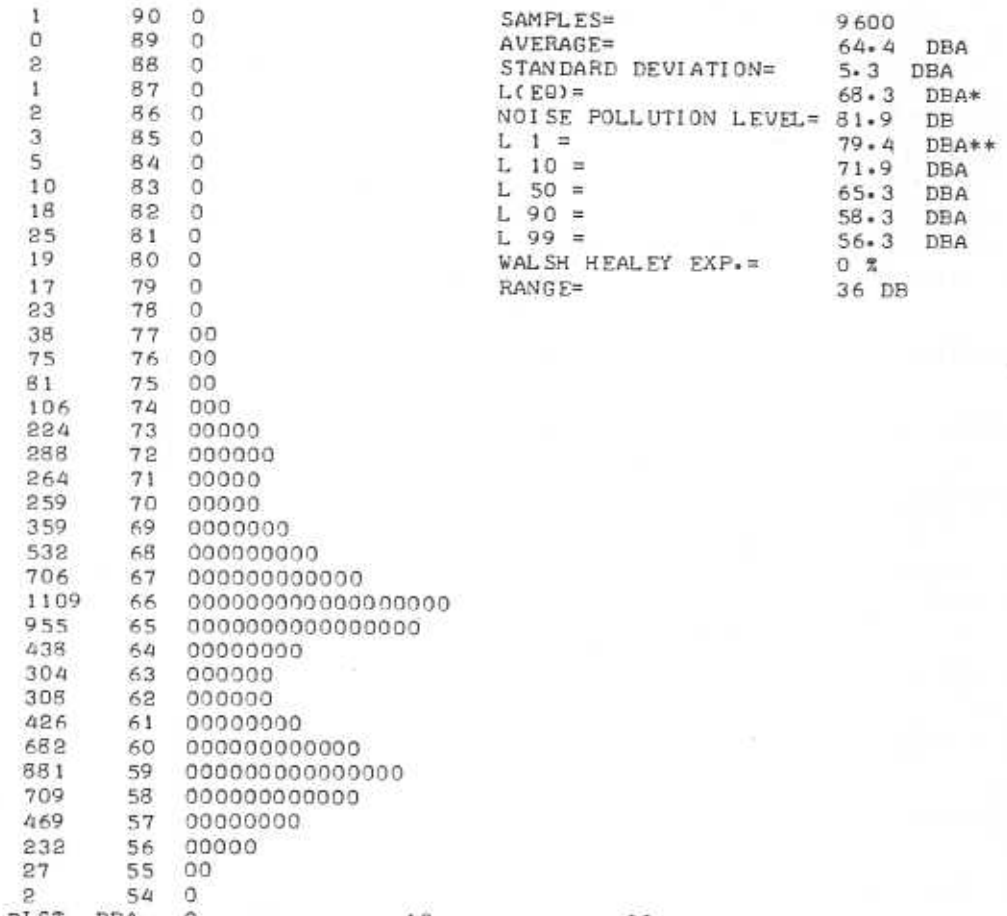


Figure A-48. Statistical Noise Data, Location 5, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1216 to 1236 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-48a. Histogram, Location 5, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1216 to 1236 Hours

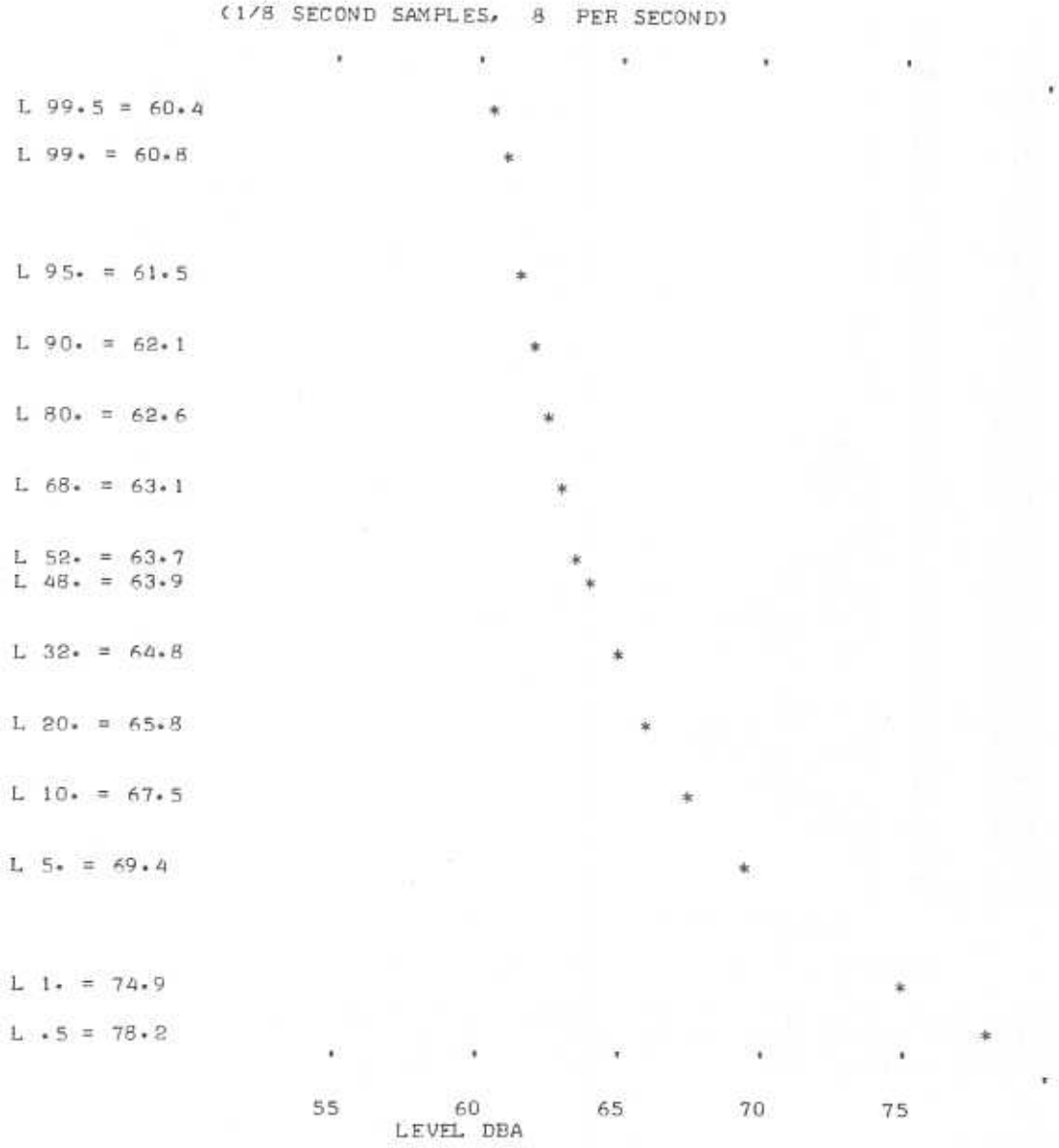


Figure A-49. Statistical Noise Data, Location 6, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1500 to 1520 Hours

```
1       86  0                       SAMPLES=                  9600
1       85  0                       AVERAGE=                  64   DBA
5       84  0                       STANDARD DEVIATION=       2.7  DBA
3       83  0                       L(EQ)=                    65.7  DBA*
4       82  0                       NOISE POLLUTION LEVEL=    72.6  DB
10      81  0                       L 1 =                     74.9  DBA**
10      80  0                       L 10 =                    67.5  DBA
3       79  0                       L 50 =                    63.8  DBA
14      78  0                       L 90 =                    62.1  DBA
9       77  0                       L 99 =                    60.8  DBA
12      76  0                       WALSH HEALEY EXP.=        0 %
22      75  0                       RANGE=                    27 DB
29      74  00
43      73  00
75      72  00
99      71  000
65      70  00
130     69  000
229     68  00000
380     67  0000000
587     66  0000000000
1051    65  000000000000000000
1621    64  00000000000000000000000000
2355    63  0000000000000000000000000000000000000000
2063    62  00000000000000000000000000000000
661     61  00000000000
108     60  000
10      59  0
DIST. DBA   0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-49a. Histogram, Location 6, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1500 to 1520 Hours

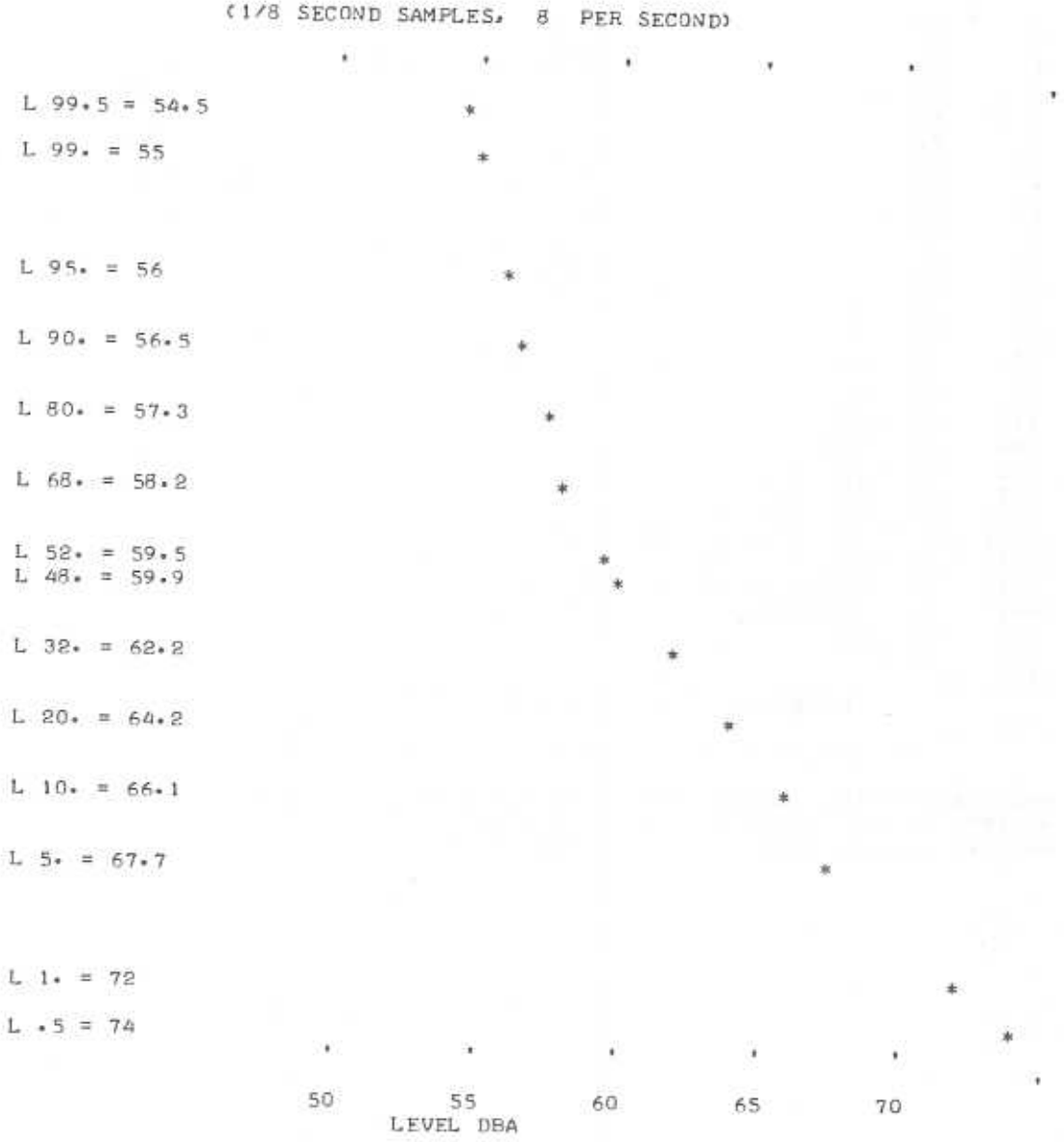


Figure A-50. Statistical Noise Data, Location 7, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1547 to 1607 Hours

```
1       82  0                   SAMPLES=                9600
0       81  0                   AVERAGE=                60.2  DBA
0       80  0                   STANDARD DEVIATION=     3.9   DBA
0       79  0                   L(EQ)=                  62.5  DBA*
2       78  0                   NOISE POLLUTION LEVEL=  72.5  DB
3       77  0                   L 1 =                   72    DBA**
7       76  0                   L 10 =                  66.1  DBA
20      75  0                   L 50 =                  59.7  DBA
15      74  0                   L 90 =                  56.5  DBA
23      73  0                   L 99 =                  55    DBA
25      72  0                   WALSH HEALEY EXP.=      0 %
35      71  00                  RANGE=                  29 DB
40      70  00
87      69  00
154     68  0000
227     67  00000
351     66  0000000
542     65  0000000000
504     64  000000000
533     63  000000000
663     62  00000000000
612     61  00000000000
676     60  000000000000
984     59  0000000000000000
1280    58  00000000000000000000
1364    57  00000000000000000000
997     56  00000000000000000
371     55  0000000
79      54  00
5       53  0
DIST. DBA   0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

TNI = 64.9          PNL(A) = 70.9457    PNL - PNL(A) = 1.55429
```

Figure A-50a. Histogram, Location 7, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1547 to 1607 Hours

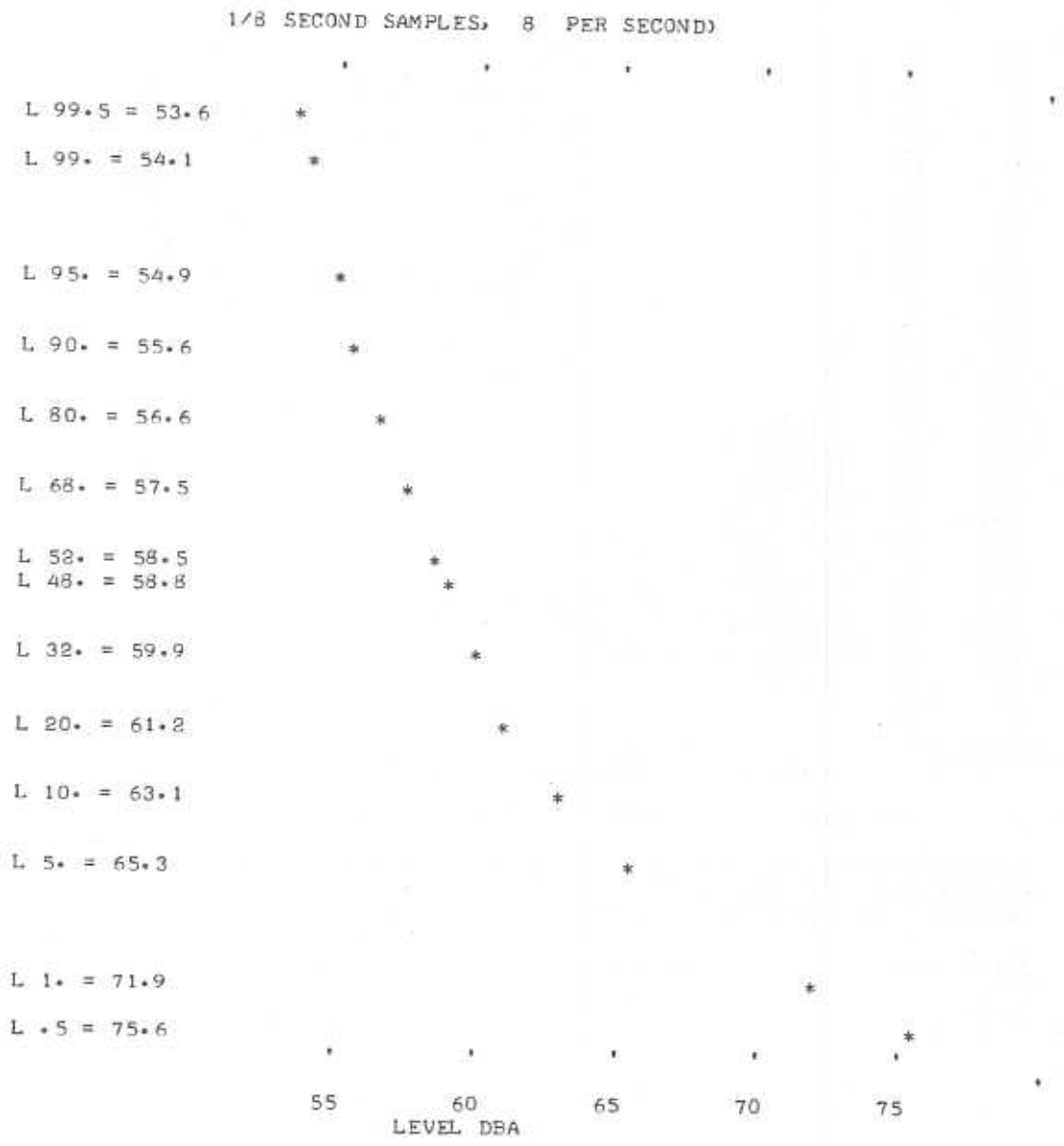


Figure A-51. Statistical Noise Data, Location 8, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1648 to 1708 Hours

```
 3       88   0                    SAMPLES=                 9600
 2       87   0                    AVERAGE=                 58.7   DBA
 1       86   0                    STANDARD DEVIATION=      3.5   DBA
 4       85   0                    L(EQ)=                   62.6   DBA*
 1       84   0                    NOISE POLLUTION LEVEL=   71.6   DB
 1       83   0                    L 1 =                    71.9   DBA**
 2       82   0                    L 10 =                   63.1   DBA
 4       81   0                    L 50 =                   58.6   DBA
 2       80   0                    L 90 =                   55.6   DBA
 4       79   0                    L 99 =                   54.1   DBA
 3       78   0                    WALSH HEALEY EXP.=       0 %
 7       77   0                    RANGE=                   35 DB
 11      76   0
 8       75   0
 14      74   0
 13      73   0
 14      72   0
 18      71   0
 23      70   0
 30      69   00
 56      68   00
 73      67   00
 99      66   000
 118     65   000
 179     64   0000
 285     63   000000
 460     62   00000000
 602     61   00000000000
 911     60   000000000000000
 1323    59   00000000000000000000
 1478    58   00000000000000000000000
 1472    57   00000000000000000000000
 1080    56   0000000000000000
 796     55   00000000000000
 429     54   00000000
 74      53   00
DIST. DBA    0              10              20              30
                FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-51a. Histogram, Location 8, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1648 to 1708 Hours

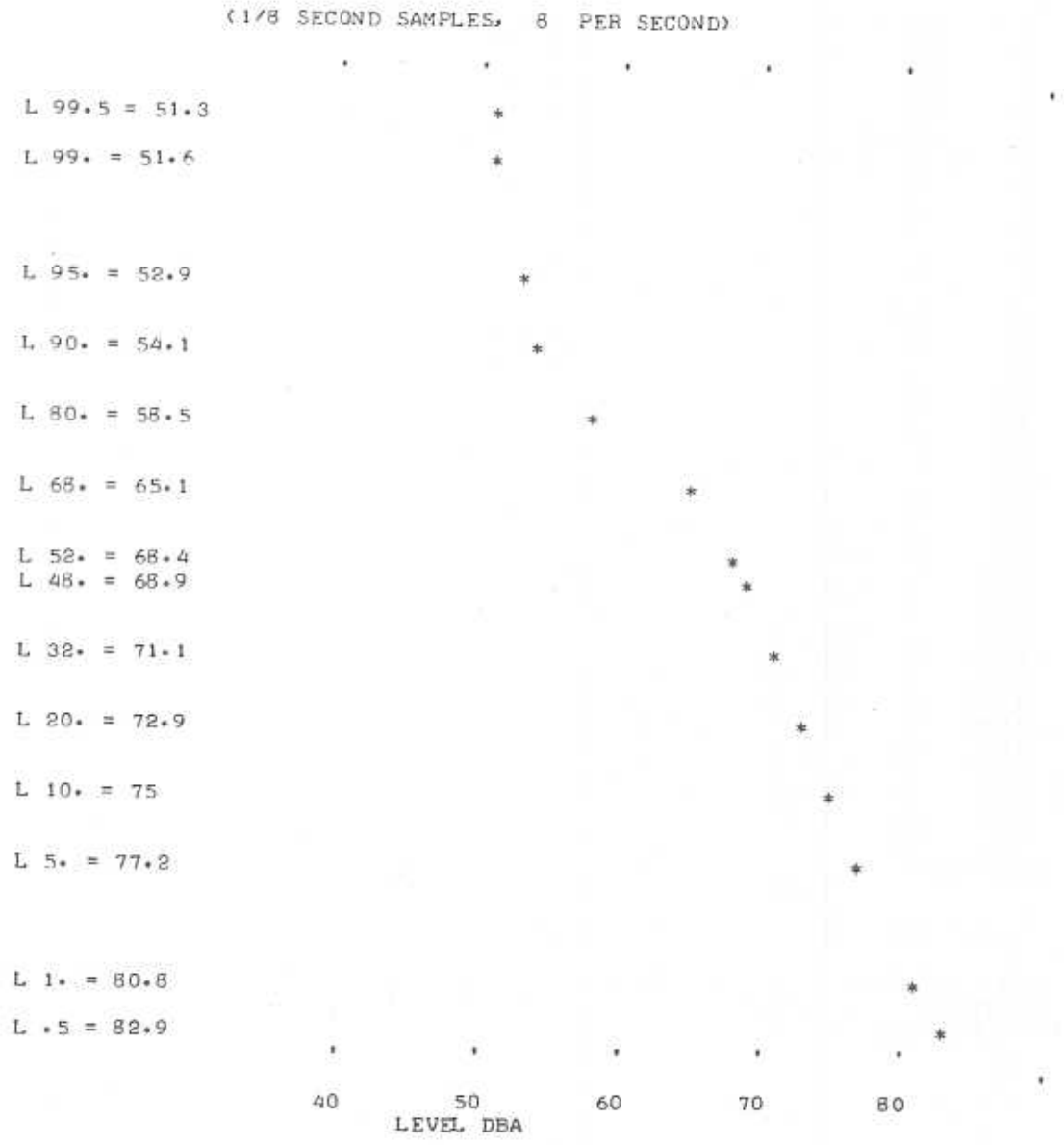


Figure A-52. Statistical Noise Data, Location 9, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2251 to 2311 Hours

```
 4      95  0                    SAMPLES=                9600
 0      94  0                    AVERAGE=                66.4  DBA
 0      93  0                    STANDARD DEVIATION=     7.6  DBA
 5      92  0                    L(EQ)=                  71.8  DBA*
 0      91  0                    NOISE POLLUTION LEVEL=  91.3  DB
 0      90  0                    L 1 =                   80.8  DBA**
 3      89  0                    L 10 =                  75  DBA
 2      88  0                    L 50 =                  68.7  DBA
 3      87  0                    L 90 =                  54.1  DBA
 7      86  0                    L 99 =                  51.6  DBA
 6      85  0                    WALSH HEALEY EXP.=      .2 %
 9      84  0                    RANGE=                  45 DB
 8      83  0
 11     82  0
 24     81  0
 71     80  00
 99     79  000
 120    78  000
 130    77  000
 170    76  0000
 280    75  00000
 373    74  0000000
 545    73  0000000000
 602    72  00000000000
 699    71  000000000000
 663    70  00000000000
 734    69  0000000000000
 709    68  000000000000
 513    67  000000000
 447    66  00000000
 341    65  000000
 276    64  00000
 172    63  0000
 139    62  000
 103    61  000
 139    60  000
 164    59  0000
 225    58  00000
 238    57  00000
 207    56  0000
 192    55  0000
 239    54  00000
 428    53  00000000
 358    52  0000000
 129    51  000
 13     50  0
DIST. DBA   0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-52a. Histogram, Location 9, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2251 to 2311 Hours

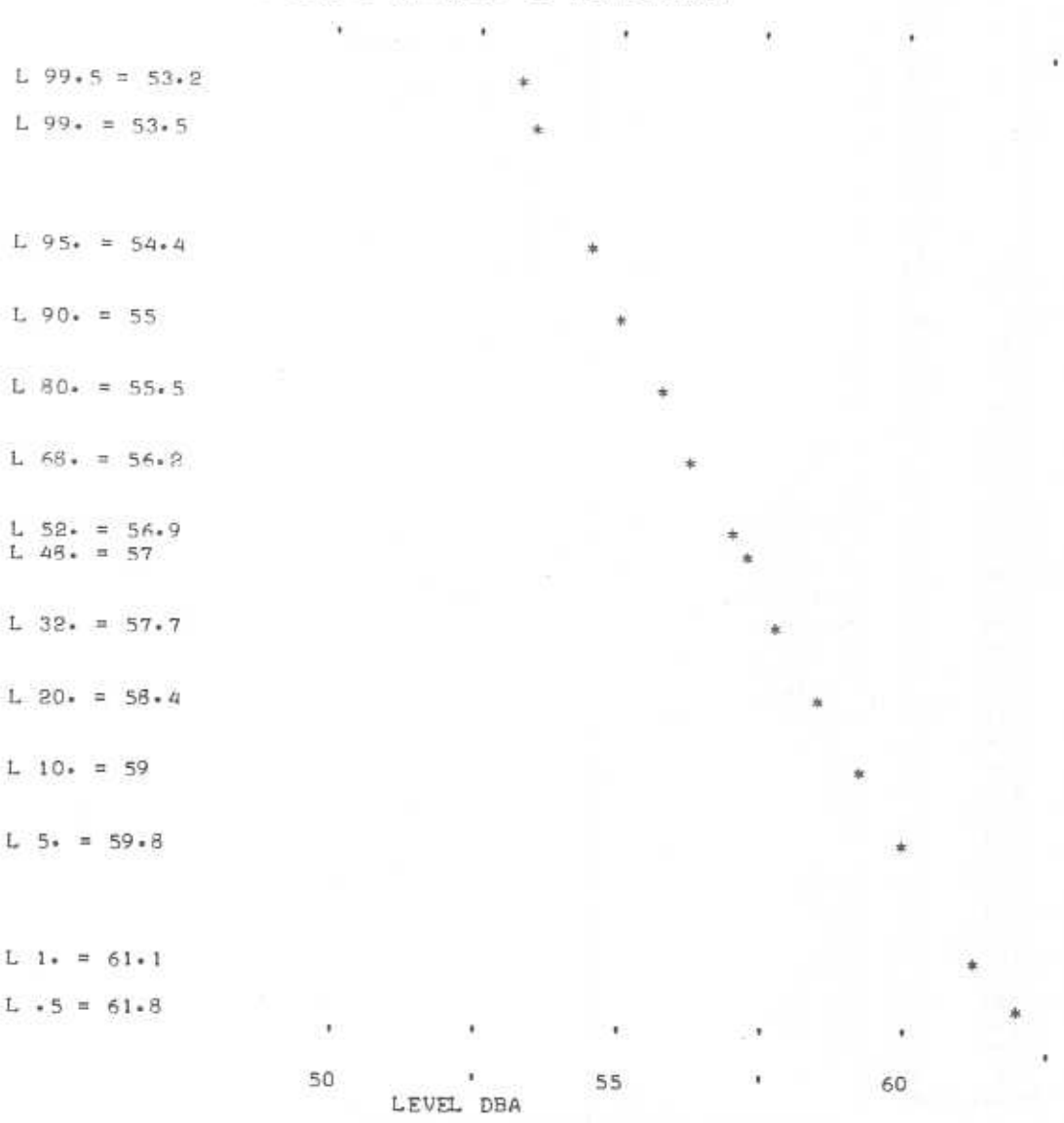
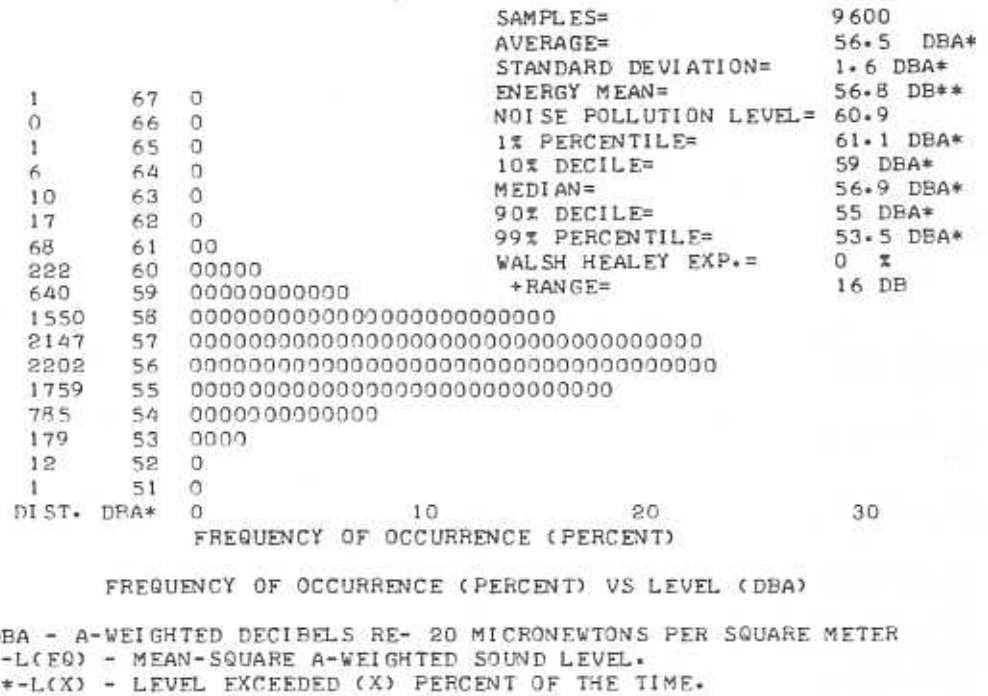


Figure A-53. Statistical Noise Data, Location 11, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2232 to 2252 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-53a. Histogram, Location 11, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2232 to 2252 Hours

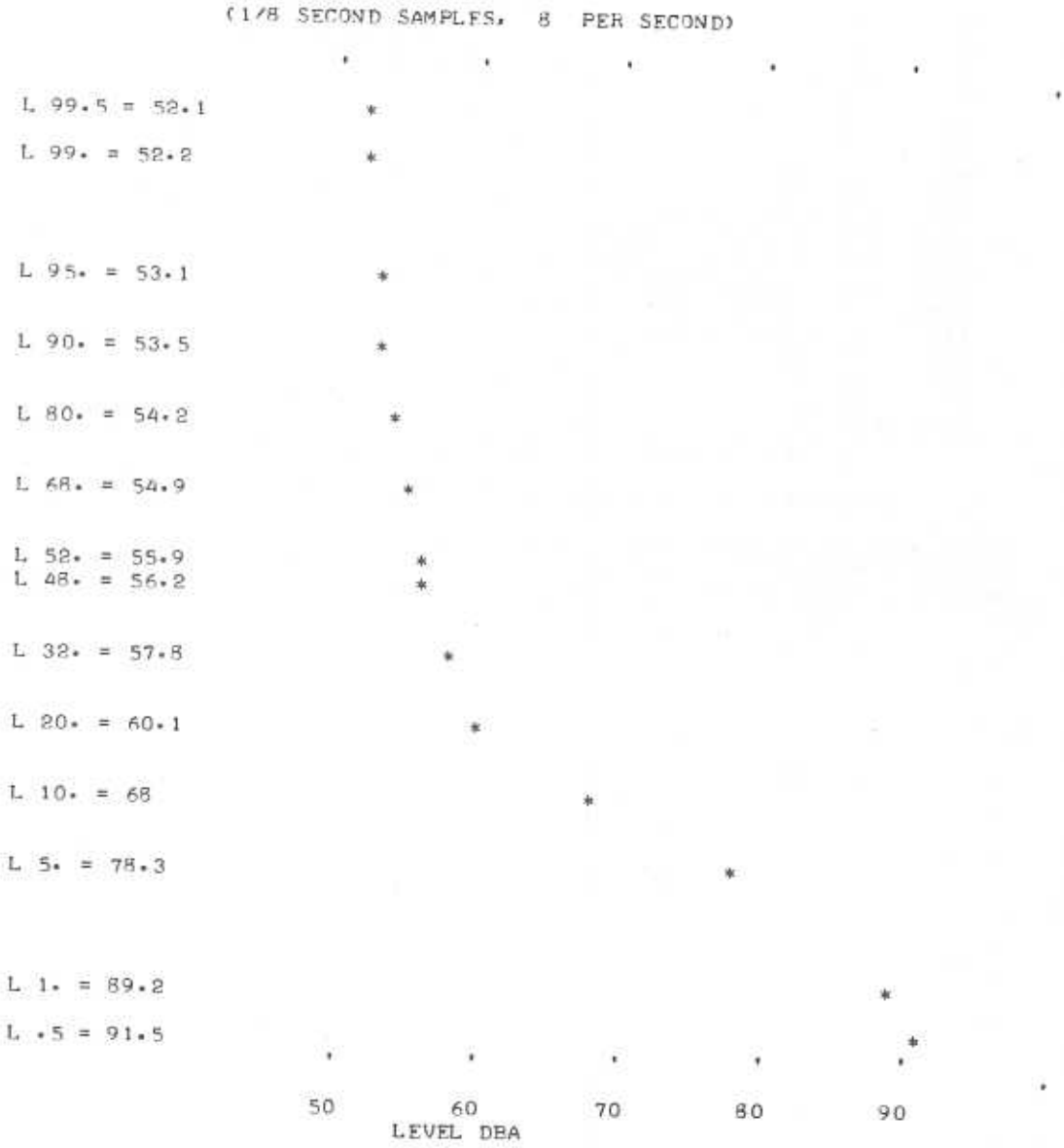


Figure A-54. Statistical Noise Data, Location 11, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2302 to 2322 Hours

```
2       100 0                       SAMPLES=                9600
2       99  0                       AVERAGE=                58.2  DBA
0       98  0                       STANDARD DEVIATION=     7.7  DBA
1       97  0                       L(EQ)=                  74.6  DBA*
1       96  0                       NOISE POLLUTION LEVEL=  94.3  DB
5       95  0                       L 1 =                   89.2  DBA**
7       94  0                       L 10 =                  68  DBA
7       93  0                       L 50 =                  56.1  DBA
11      92  0                       L 90 =                  53.5  DBA
22      91  0                       L 99 =                  52.2  DBA
21      90  0                       WALSH HEALEY EXP.=      1.5 %
22      89  0                       RANGE=                  49 DB
19      88  0
32      87  00
33      86  00
29      85  00
35      84  00
40      83  00
37      82  00
46      81  00
40      80  00
40      79  00
39      78  00
51      77  00
56      76  00
46      75  00
45      74  00
35      73  00
46      72  00
48      71  00
45      70  00
44      69  00
55      68  00
54      67  00
54      66  00
64      65  00
83      64  00
130     63  000
159     62  0000
198     61  0000
249     60  00000
407     59  0000000
557     58  0000000000
837     57  00000000000000
1136    56  0000000000000000000
1420    55  000000000000000000000000
1723    54  00000000000000000000000000000
1243    53  0000000000000000000
297     52  000000
27      51  00
DIST. DBA   0          10          20          30
          FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-54a. Histogram, Location 11, Argentine Freight Yard, Santa Fe RR, 4/25/73, 2302 to 2322 Hours

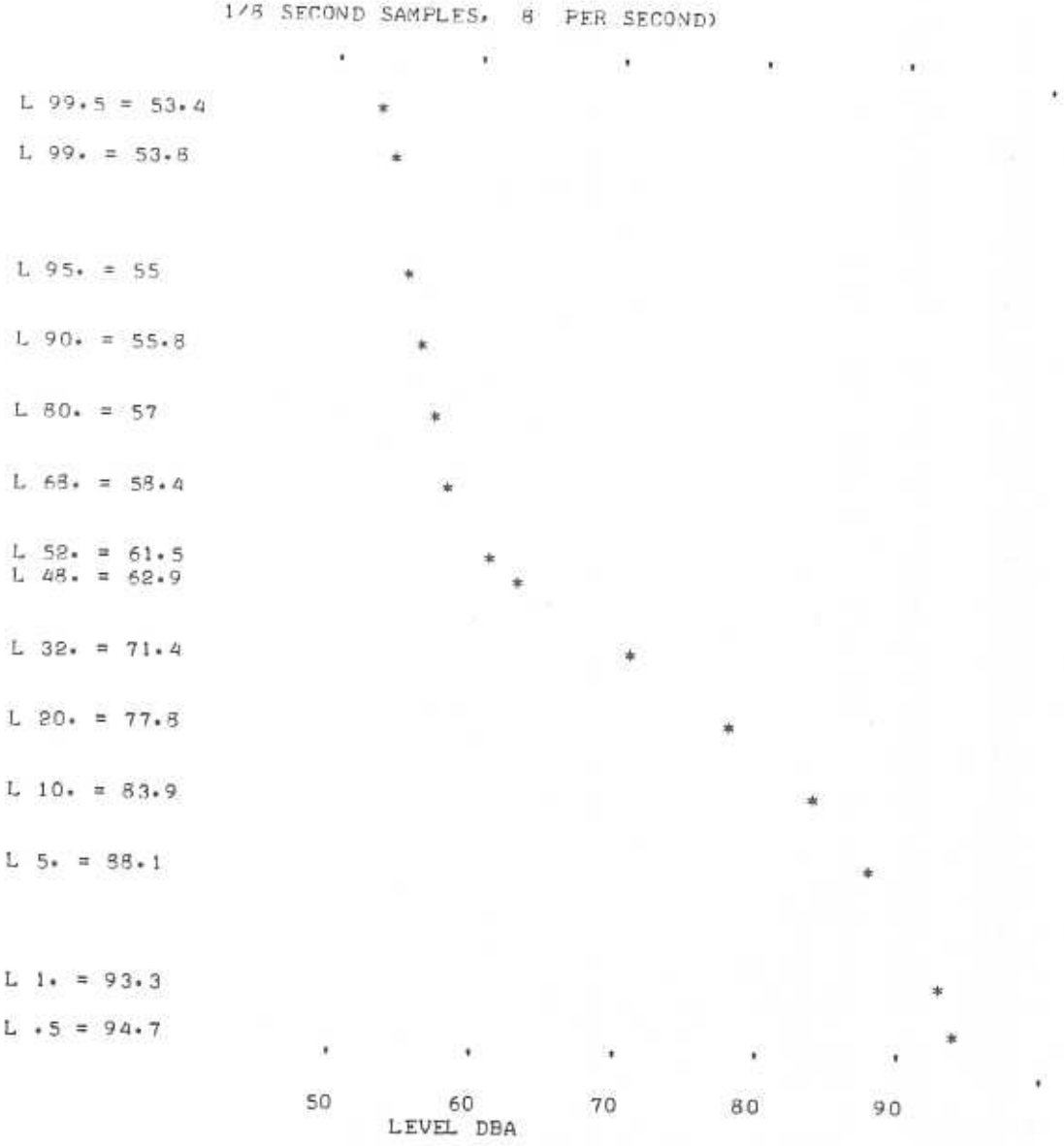


Figure A-55. Statistical Noise Data, Location 11 (Special), Argentine Freight Yard, Santa Fe RR, 4/25/73, 2306 to 2311 Hours
(Five Minute Period of Humping Activity on East Hump, See Figure A-18b)

```
2       100 0                       SAMPLES=                2400
1       99  0                       AVERAGE=                66.2  DBA
1       98  0                       STANDARD DEVIATION=     11   DBA
1       97  0                       L(EQ)=                  80.4  DBA*
1       96  0                       NOISE POLLUTION LEVEL=  108.6
DB
4       95  0                       L 1 =                   93.3  DBA**
6       94  0                       L 10 =                  83.9  DBA
12      93  00                      L 50 =                  62.1  DBA
6       92  0                       L 90 =                  55.8  DBA
20      91  00                      L 99 =                  53.8  DBA
22      90  00                      WALSH HEALEY EXP.=      5.8 %
24      89  000                     RANGE=                  47 DB
22      88  00
24      87  000
28      86  000
26      85  000
38      84  000
38      83  000
39      82  0000
42      81  0000
32      80  000
41      79  0000
42      78  0000
41      77  0000
45      76  0000
56      75  00000
42      74  0000
41      73  0000
43      72  0000
44      71  0000
38      70  000
44      69  0000
52      68  0000
40      67  0000
34      66  000
40      65  0000
54      64  0000
58      63  00000
65      62  00000
71      61  000000
105     60  00000000
130     59  000000000
188     58  0000000000000
216     57  00000000000000000
219     56  000000000000000
141     55  0000000000
91      54  0000000
30      53  000
DIST. DBA   0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-55a. Histogram, Location 11 (Special), Argentine Freight Yard, Santa Fe RR, 4/25/73, 2306 to 2311 Hours
(Five Minute Period of Humping Activity on East Hump, See Figure A-18b)

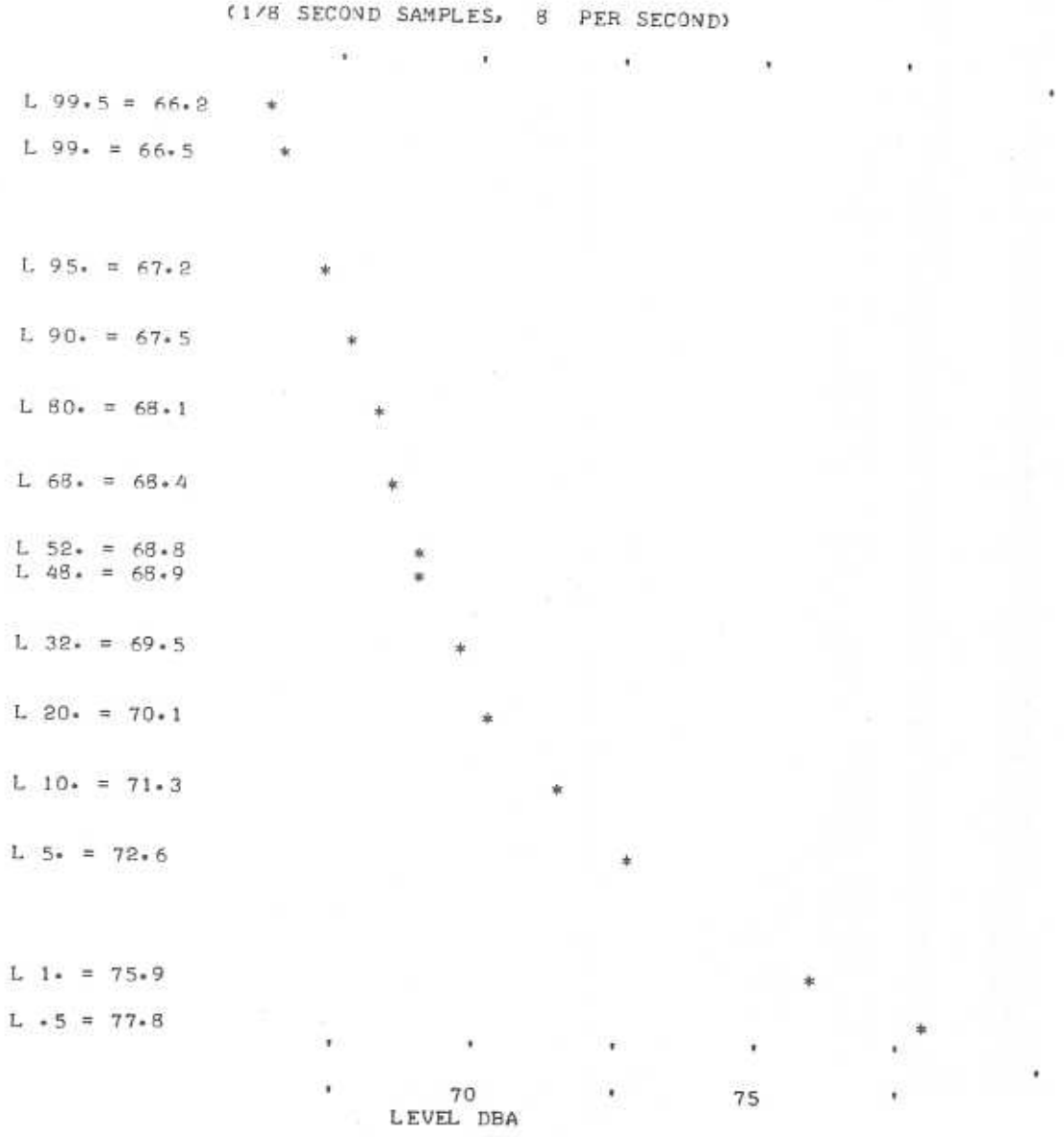


Figure A-56. Statistical Noise Data, Location 12, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1054 to 1114 Hours

```
 2       90  0                    SAMPLES=                  9600
 1       89  0                    AVERAGE=                  68.8  DBA
 0       88  0                    STANDARD DEVIATION=       1.8   DBA
 0       87  0                    L(EQ)=                    69.5  DBA*
 0       86  0                    NOISE POLLUTION LEVEL=    74.1  DB
 2       85  0                    L 1 =                     75.9  DBA**
 0       84  0                    L 10 =                    71.3  DBA
 6       83  0                    L 50 =                    68.9  DBA
 4       82  0                    L 90 =                    67.5  DBA
 5       81  0                    L 99 =                    66.5  DBA
 6       80  0                    WALSH HEALEY EXP.=        0 %
 9       79  0                    RANGE=                    25 DB
 10      78  0
 16      77  0
 29      76  00
 75      75  00
 92      74  000
 143     73  000
 284     72  00000
 471     71  00000000
 895     70  000000000000000
 2379    69  000000000000000000000000000000000000000
 3626    68  000000000000000000000000000000000000000000000000000
 1411    67  0000000000000000000000
 188     66  0000
 6       65  0
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-56a. Histogram, Location 12, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1054 to 1114 Hours

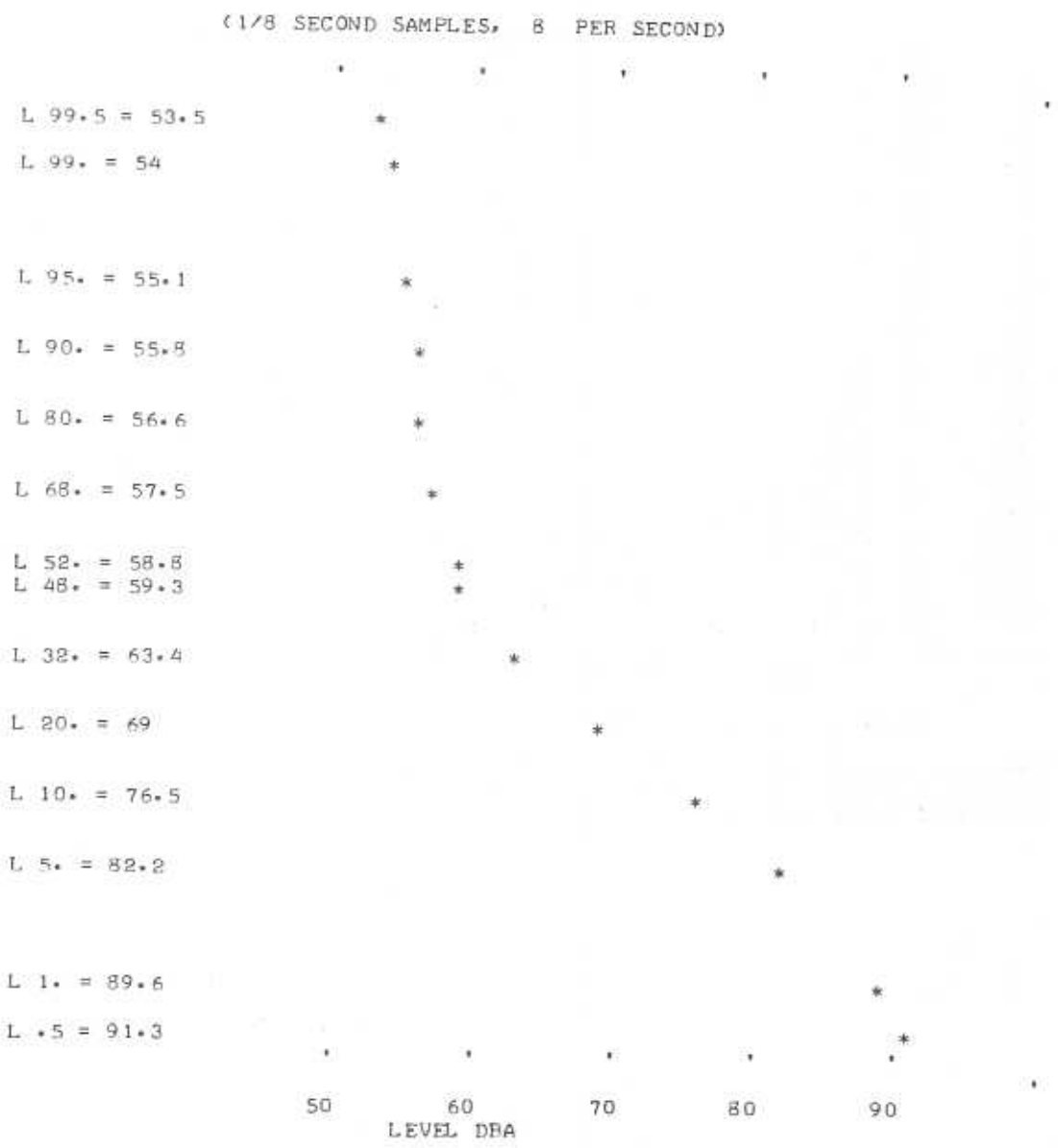


Figure A-57. Statistical Noise Data, Location 13, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0952 to 1012 Hours

```
1       101 0                   SAMPLES=                9600
1       100 0                   AVERAGE=                62.3  DBA
0       99  0                   STANDARD DEVIATION=     8.6   DBA
0       98  0                   L(EQ)=                  75.6  DBA*
2       97  0                   NOISE POLLUTION LEVEL=  97.6  DB
0       96  0                   L 1 =                   89.6  DBA**
3       95  0                   L 10 =                  76.5  DBA
3       94  0                   L 50 =                  59    DBA
11      93  0                   L 90 =                  55.8  DBA
16      92  0                   L 99 =                  54    DBA
16      91  0                   WALSH HEALEY EXP.=      1.6 %
33      90  00                  RANGE=                  49 DB
23      89  0
30      88  00
42      87  00
54      86  00
65      85  00
64      84  00
54      83  00
82      82  00
74      81  00
75      80  00
86      79  00
90      78  000
84      77  00
98      76  000
95      75  000
104     74  000
126     73  000
147     72  000
142     71  000
127     70  000
167     69  0000
199     68  0000
168     67  0000
213     66  0000
243     65  00000
207     64  0000
204     63  0000
273     62  00000
288     61  000000
398     60  0000000
718     59  000000000000
1012    58  00000000000000000
1282    57  0000000000000000000
1372    56  00000000000000000000000
696     55  000000000000
321     54  000000
88      53  00
3       52  0
DIST. DBA   0              10              20              30
              FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-57a. Histogram, Location 13, Argentine Freight Yard, Santa Fe RR, 4/26/73, 0952 to 1012 Hours

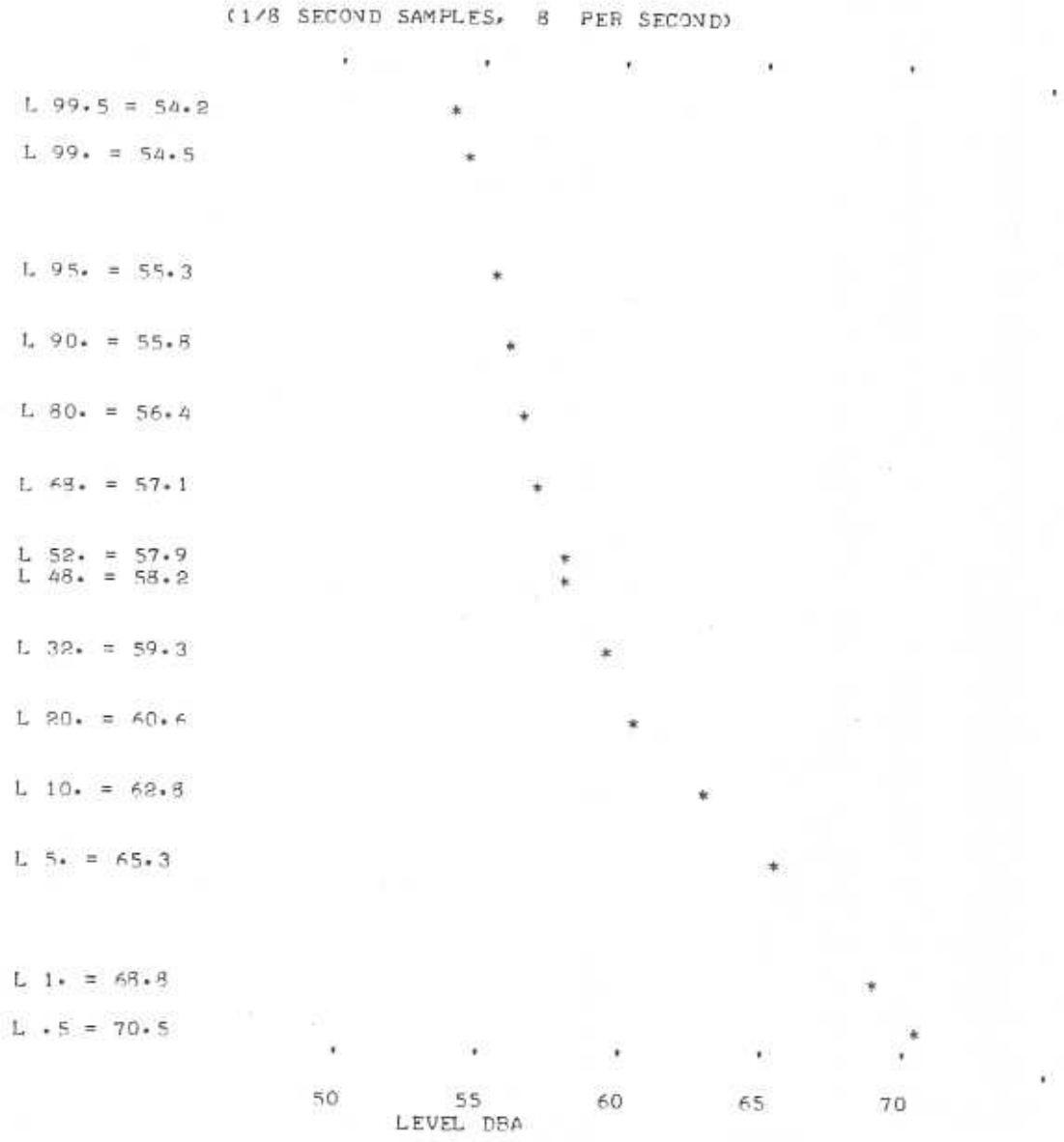


Figure A-58. Statistical Noise Data, Location 14, Argentine Freight Yard, Santa Fe RR, 4/26/73, 1036 to 1056 Hours

```
 1       84  0                      SAMPLES=                  9600
 1       83  0                      AVERAGE=                  58.3  DBA
 0       82  0                      STANDARD DEVIATION=       3.1   DBA
 2       81  0                      L(EQ)=                    60.3  DBA*
 1       80  0                      NOISE POLLUTION LEVEL=    68.2  DB
 0       79  0                      L 1 =                     68.8  DBA**
 3       78  0                      L 10 =                    62.8  DBA
 3       77  0                      L 50 =                    58.1  DBA
 2       76  0                      L 90 =                    55.8  DBA
 2       75  0                      L 99 =                    54.5  DBA
 5       74  0                      WALSH HEALEY EXP.=        0 %
 8       73  0                      RANGE=                    31 DB
 8       72  0
 6       71  0
 12      70  0
 31      69  00
 73      68  00
 107     67  000
 119     66  000
 146     65  000
 154     64  0000
 196     63  0000
 329     62  000000
 414     61  00000000
 686     60  000000000000
 1168    59  0000000000000000000
 1394    58  00000000000000000000000
 1759    57  0000000000000000000000000000
 1852    56  00000000000000000000000000000
 923     55  000000000000000
 182     54  0000
 13      53  0
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

TNI = 53.8          PNL(A) = 65.975     PNL - PNL(A) = 2.225
```

Figure A-58a. Histogram, Location 14, Argentine Freight Yard, Santa Fe RR, 4/26/73, 1036 to 1056 Hours

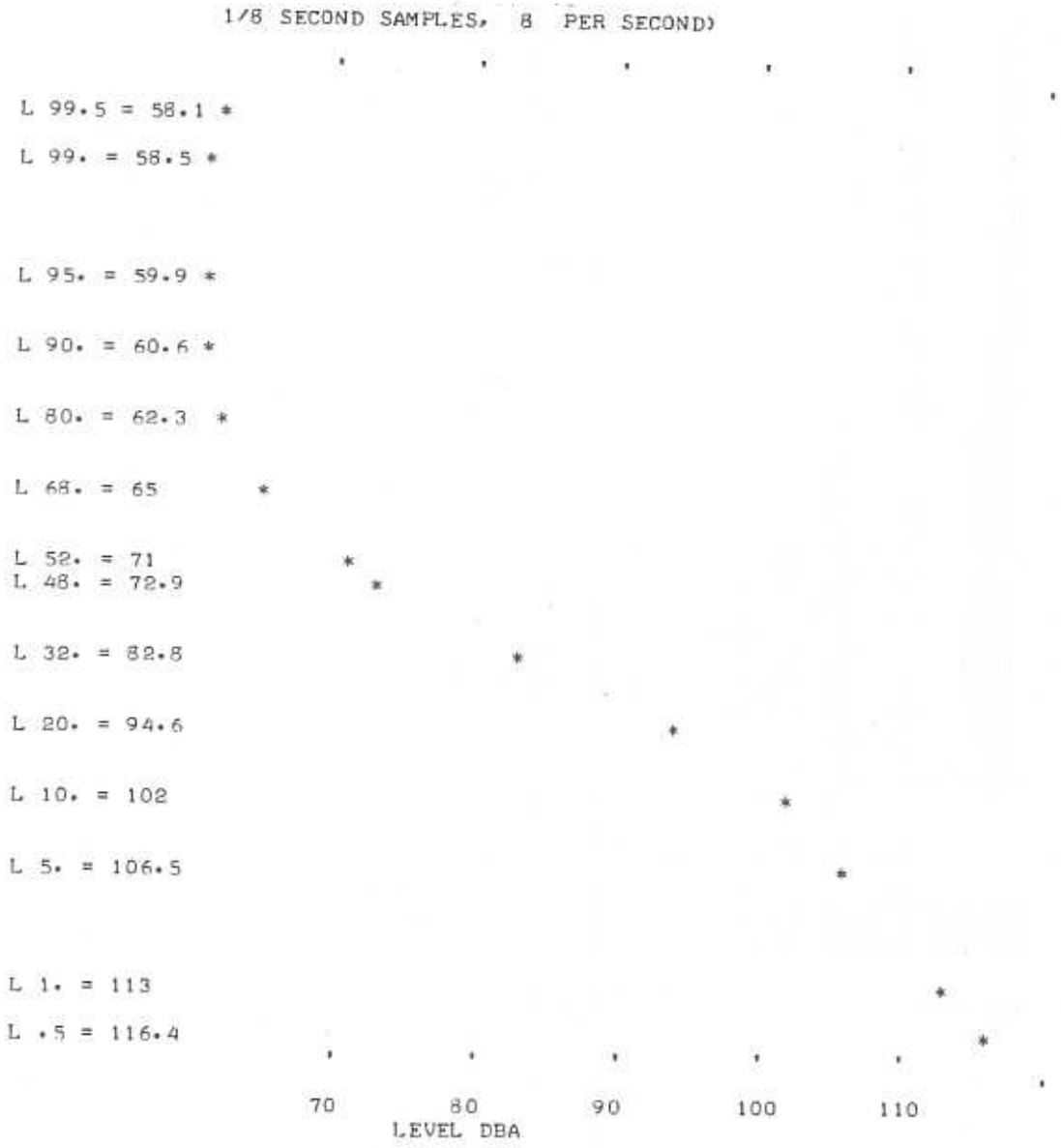


Figure A-59. Statistical Noise Data, Location 15, Argentine Freight Yard, Santa Fe RR, 4/25/73, 0926 to 0943 Hours

```
3       125 0
4       124 0
4       123 0
5       122 0
5       121 0
2       120 0
4       119 0
3       118 0
5       117 0
9       116 0
7       115 0
13      114 0
18      113 0
31      112 0
31      111 0
46      110 0
56      109 0
53      108 0
67      107 0
91      106 000
75      105 00
68      104 00
96      103 000
117     102 000
104     101 000
117     100 000
107     99  000
128     98  000
118     97  000
104     96  000
101     95  000
94      94  000
104     93  000
76      92  00
102     91  000
80      90  000
56      89  00
77      88  000
64      87  00
74      86  00
92      85  000
95      84  000
80      83  000
110     82  000
113     81  000
112     80  000
121     79  000
117     78  000
110     77  000
127     76  000
176     75  0000
166     74  0000
161     73  0000
177     72  0000
169     71  0000
164     70  0000
179     69  0000
217     68  00000
191     67  00000
288     66  000000
262     65  000000
297     64  0000000
376     63  00000000
414     62  000000000
506     61  0000000000
574     60  000000000000
311     59  0000000
108     58  000
24      57  00
1       56  0
DIST. DBA   0              10              20              30
          FREQUENCY OF OCCURRENCE (PERCENT)
```

```
SAMPLES=                  8159
AVERAGE=                  76.5  DBA
STANDARD DEVIATION=       15.8  DBA
L(EQ)=                    99.5  DBA*
NOISE POLLUTION LEVEL=    139.9 DB

L 1 =                     113   DBA**
L 10 =                    102   DBA
L 50 =                    72    DBA
L 90 =                    60.6  DBA
L 99 =                    58.5  DBA
WALSH HEALEY EXP.=        197.3 %

RANGE=                    69 DB
```

FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-59a. Histogram, Location 15, Argentine Freight Yard, Santa Fe RR, 4/25/73, 0926 to 0943 Hours

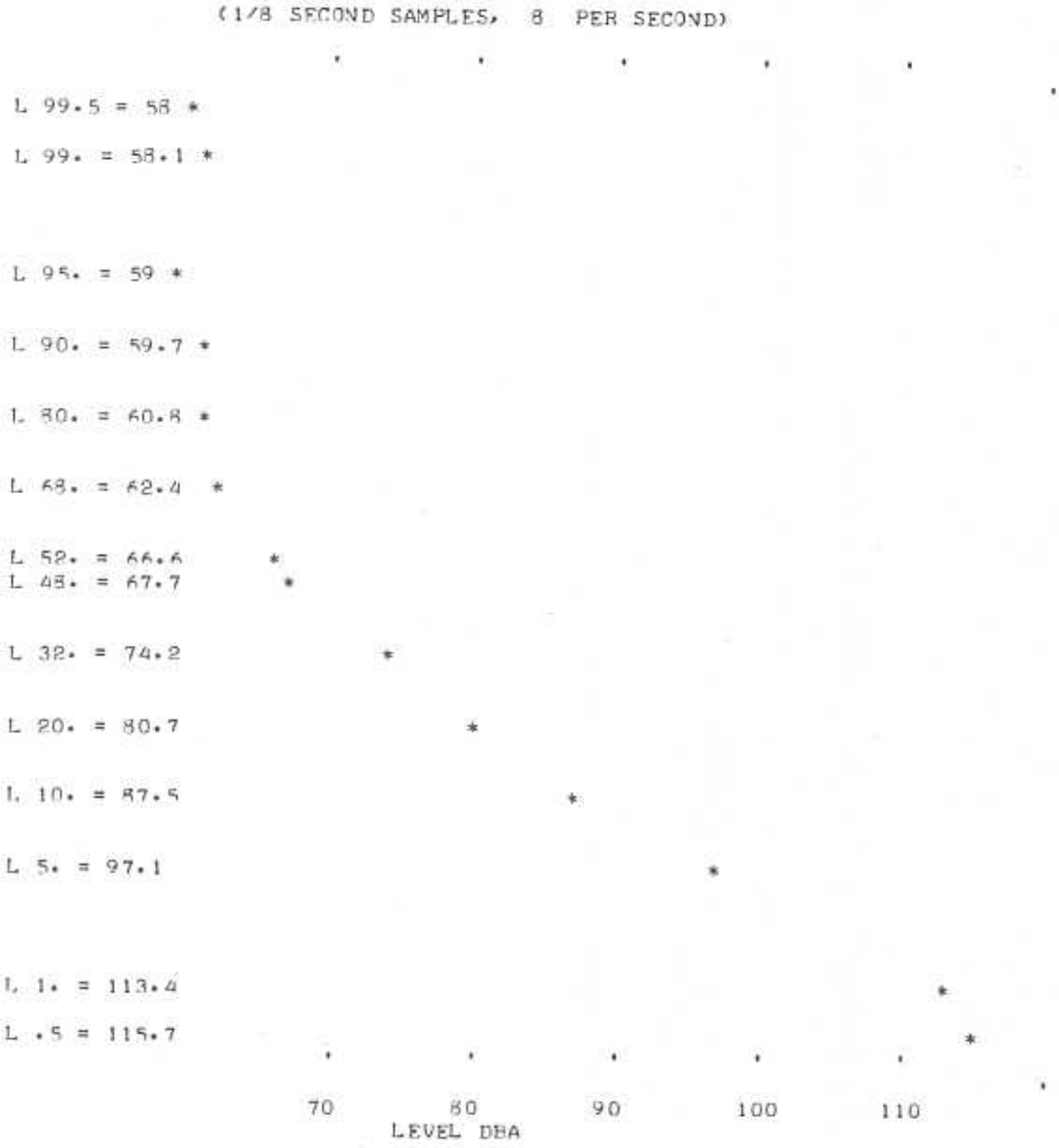
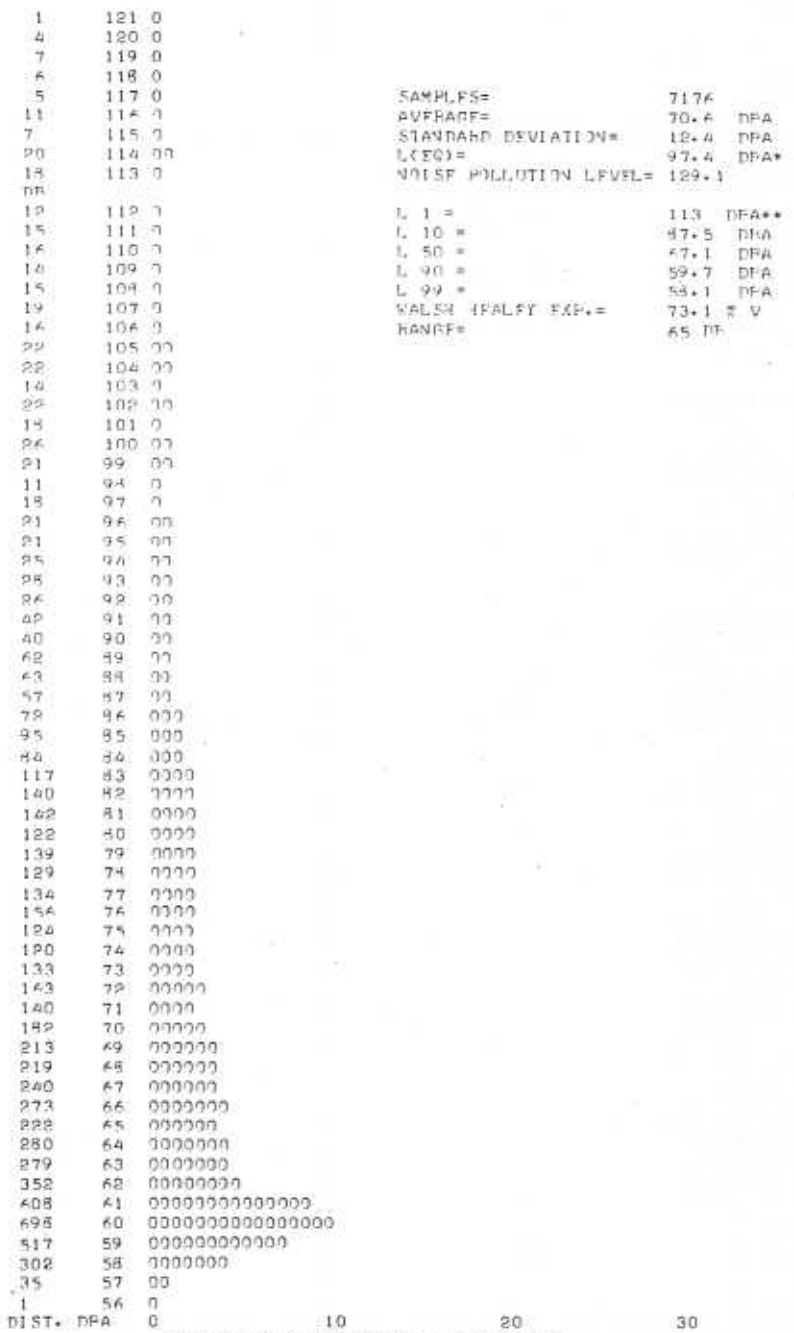


Figure A-60. Statistical Noise Data, Location 16, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1631 to 1646 Hours



FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DPA)

DPA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.

Figure A-60a. Histogram, Location 16, Argentine Freight Yard, Santa Fe RR, 4/24/73, 1631 to 1646 Hours

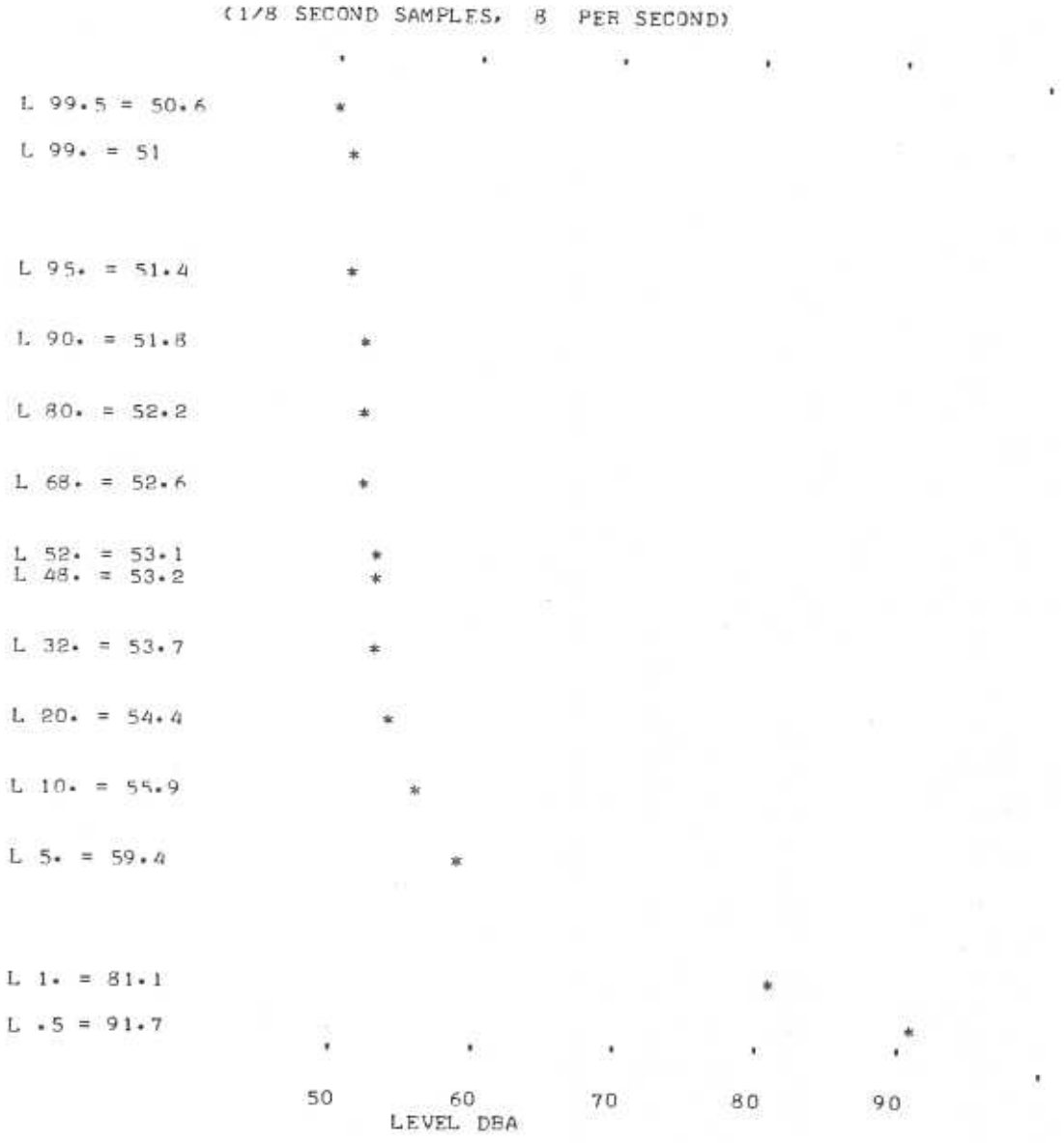


Figure A-61. Statistical Noise Data, Location 17, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1630 to 1645 Hours

```
 1       96  0                    SAMPLES=                  7200
 8       95  0                    AVERAGE=                  53.7  DBA
 13      94  0                    STANDARD DEVIATION=       5  DBA
 7       93  0                    L(EQ)=                    72.1  DBA*
 5       92  0                    NOISE POLLUTION LEVEL=    84.9  DB
 7       91  0                    L 1 =                     81.1  DBA**
 8       90  0                    L 10 =                    55.9  DBA
 5       89  0                    L 50 =                    53.1  DBA
 2       88  0                    L 90 =                    51.8  DBA
 1       87  0                    L 99 =                    51  DBA
 1       86  0                    WALSH HEALEY EXP.=        1.3 %
 0       85  0                    RANGE=                    46 DB
 1       84  0
 2       83  0
 4       82  0
 8       81  0
 15      80  0
 18      79  0
 14      78  0
 7       77  0
 10      76  0
 5       75  0
 4       74  0
 3       73  0
 3       72  0
 1       71  0
 5       70  0
 7       69  0
 5       68  0
 8       67  0
 11      66  0
 12      65  0
 10      64  0
 14      63  0
 15      62  0
 17      61  0
 56      60  00
 82      59  000
 52      58  00
 86      57  000
 155     56  0000
 274     55  0000000
 818     54  0000000000000000000
 2069    53  000000000000000000000000000000000000000000000000
 2436    52  0000000000000000000000000000000000000000000000000000
 857     51  00000000000000000000
 58      50  00
DIST. DBA    0              10              20              30
               FREQUENCY OF OCCURRENCE (PERCENT)

        FREQUENCY OF OCCURRENCE (PERCENT) VS LEVEL (DBA)

DBA - A-WEIGHTED DECIBELS RE- 20 MICRONEWTONS PER SQUARE METER
*-L(EQ) - MEAN-SQUARE A-WEIGHTED SOUND LEVEL.
**-L(X) - LEVEL EXCEEDED (X) PERCENT OF THE TIME.
```

Figure A-61a. Histogram, Location 17, Argentine Freight Yard, Santa Fe RR, 4/25/73, 1630 to 1645 Hours

APPENDIX B

NOISE LEVEL DATA MEASURED AT THREE FACILITIES OF THE BOSTON AND MAINE RR, BOSTON MA

CHART 1 - GENERAL ARRANGEMENT, DRAINS AND FILLERS

1. Engine Model 16-567B.
2. Main Gen. Model D12-D14.
3. Generator Blower.
4. Auxiliary Generator.
5. Control Cabinet.
6. Air Compressor.
7. Traction Motor Blower.
8. Control Panel & Instrument Board.
9. Control Stand.
10. Speed Recorder.
11. Air Brake Valve.
12. Cab Heater.
13. Seat.
14. Hand Brake.
15. Gauge Panel.
16. Lub. Oil Filler.
17. Lub. Oil Cooler.
18. Engine Water Tank.
19. Engine Water Filler.
20. Load Regulator.
21. 36" Fan & Motor.
22. Radiator.
23. Horn.
24. Exhaust Manifold.
25. Sand Box - 9 Cu. Ft.
26. Fuel Filler.
27. Headlight - Twin Sealed Beam.
28. Batteries.
29. Fuel Tank
30. Main Air Reservoir.
31. Air Intake & Shutters.
32. Emergency Fuel Cut-Off.
33. Air Intake For Engine Room.
34. Fuel Tank Gauge.
35. Trap Door.
36. Boiler Water Filler.
37. Boiler Water Softener.
38. Boiler Water Tanks
39. Boiler.
40. Lub. Oil Filter.
41. Dual Fuel Filter.
42. Engine Air Intake Silencer.
43. Toilet.
44. Wash Stand.
45. Clothes Locker.
46. Third Cab Seat.

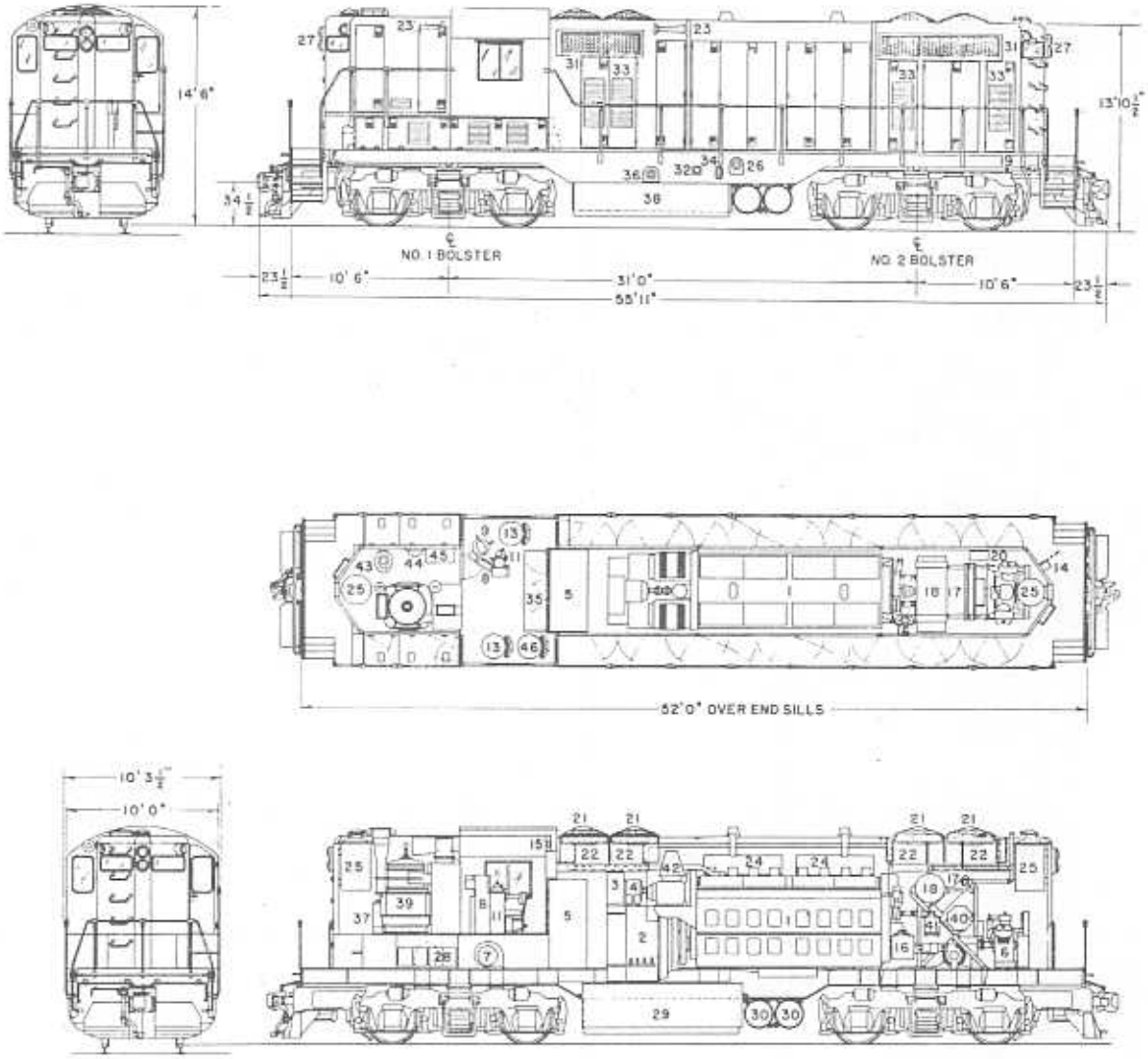


Figure B-1. Physical Dimension and General Equipment Layout, General Motors Locomotive Model GP-7

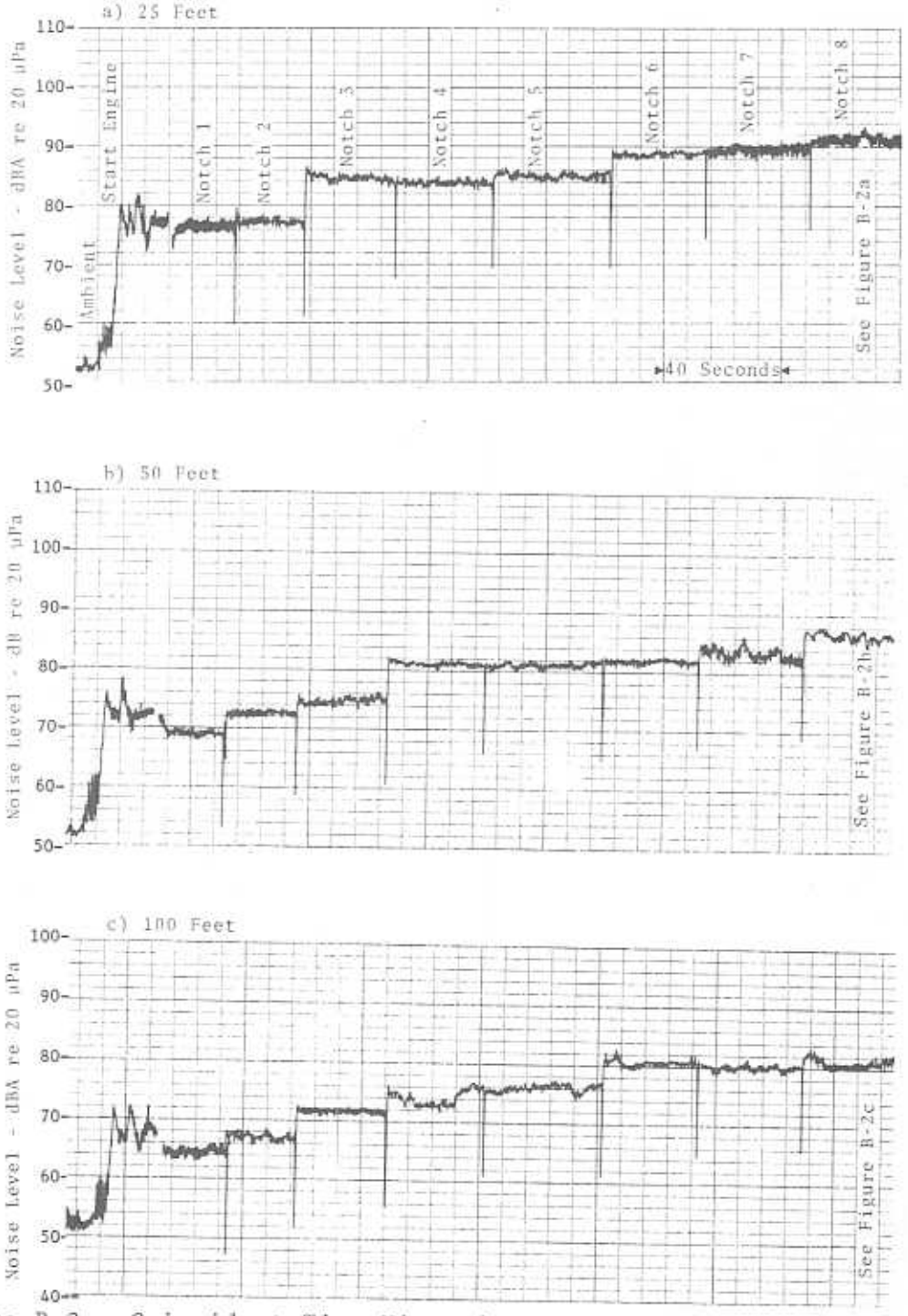


Figure B-2. Coincident Time Histories - Wayside Levels, General Motors Locomotive GP-7, 1550 Horsepower, B&M RR, Iron Horse Park, Billerica MA, 3/21/73 Locomotive Stationary and Unloaded. Microphones 5.5 Feet above Grade Level and Offset 25, 50, and 100 Feet from Track Center-line.

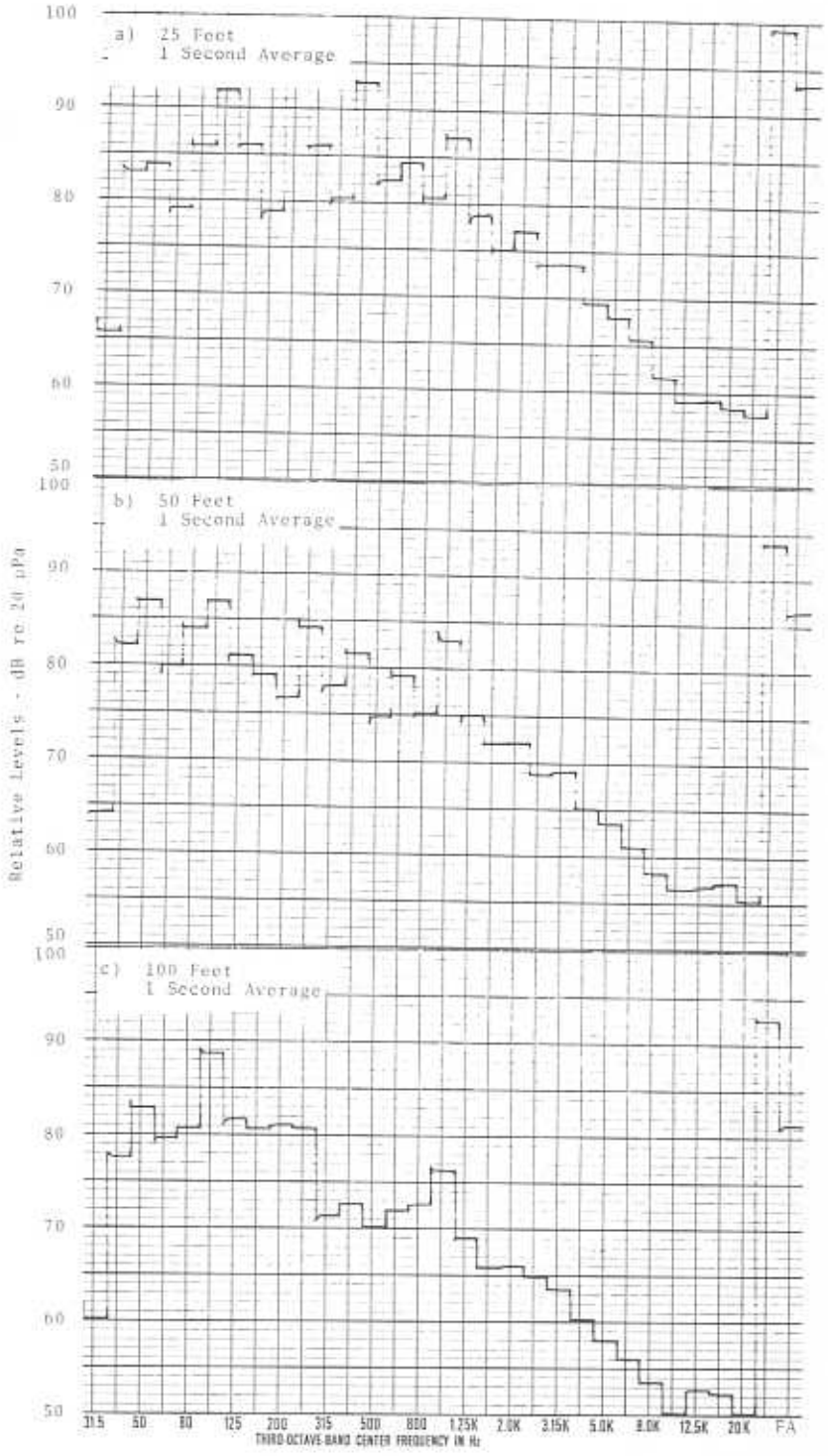


Figure B-3. Coincident Frequency Spectra - Wayside Noise Data, General Motors Locomotive GP-7, 1550 Horsepower, B&M RR, Iron Horse Park Billerica MA, 3/21/73 Locomotive Stationary, and unloaded at Eighth Notch. See figure B-2 for noise-level time history

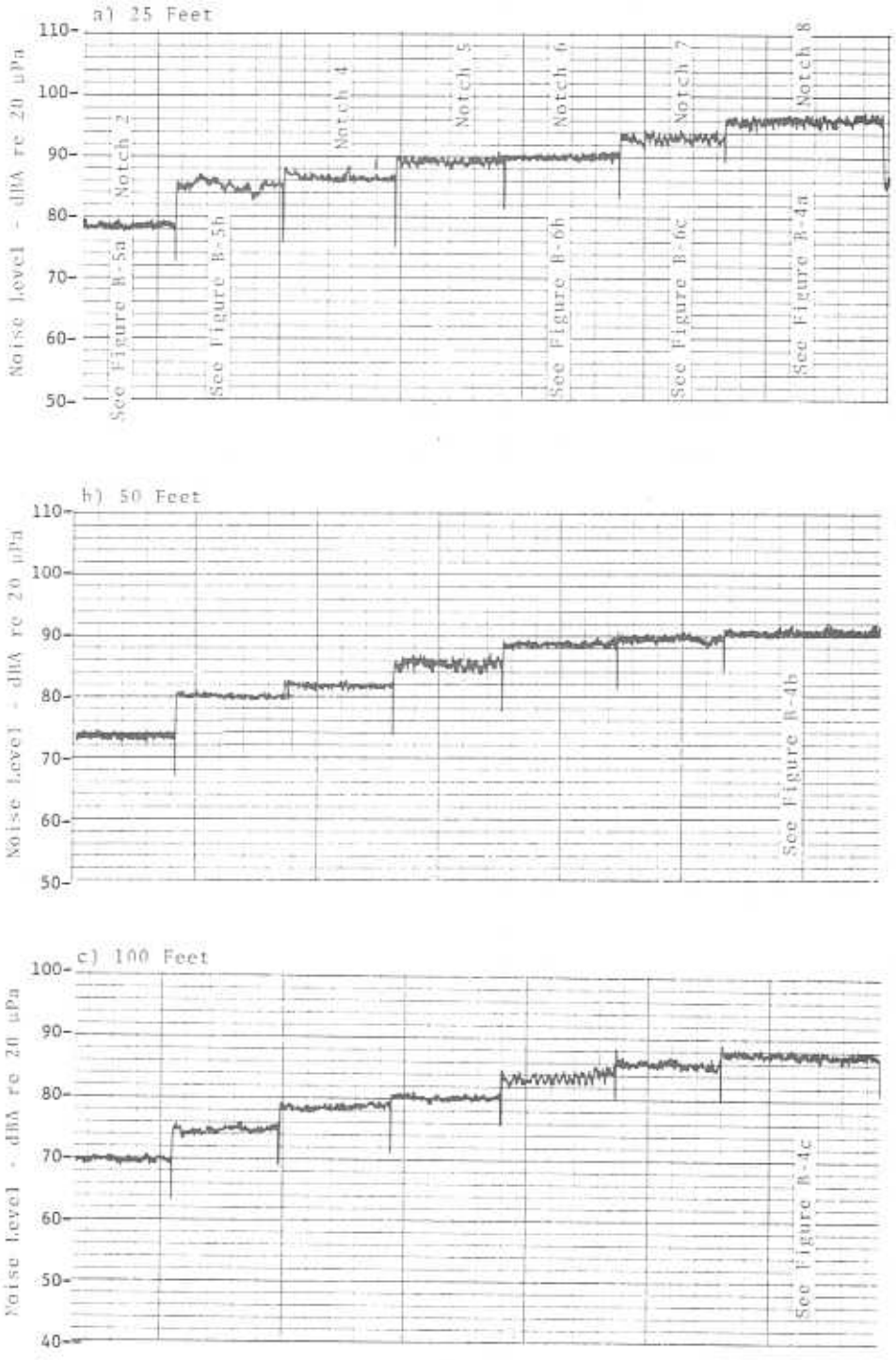


Figure B-4. Coincident Time Histories - Wayside Noise Levels, General Motors Locomotive GP-7, B&M RR, Locomotive Stationary and Loaded. Iron Horse Park, Billerica MA, 3/21/73, Microphones 5.5 Feet above Grade Level and Offset 25, 50, and 100 Feet from Track Centerline.

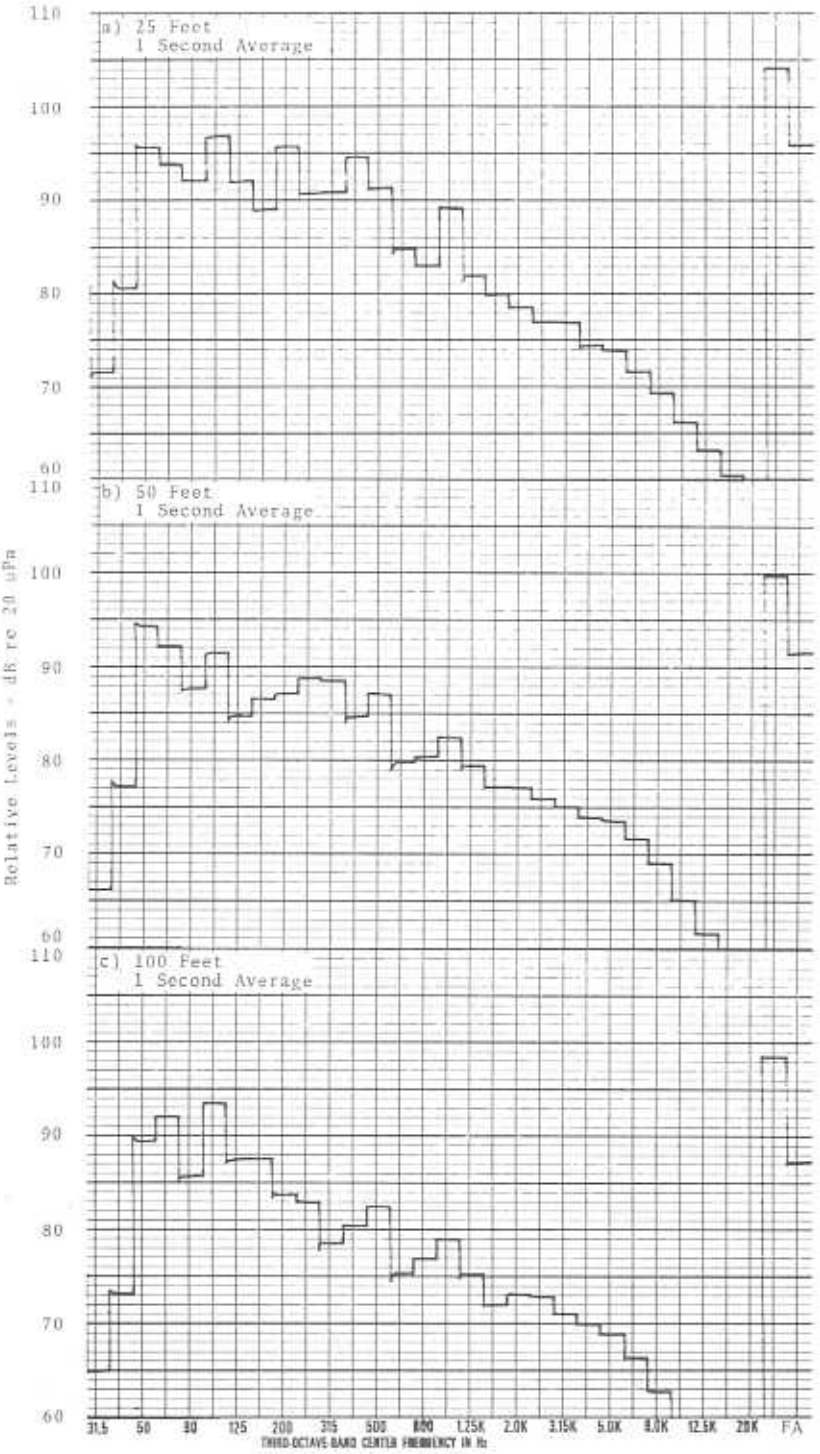


Figure B-5. Coincident Frequency Spectra - Wayside Noise Data, General Motors Locomotive GP-7, 1550 Horsepower, Ser. No. 1563. B&M RR, Iron Horse Park, Billerica MA, 3/21/73, Locomotive Stationary and Loaded at Eighth Notch. See figure B-4 for noise-level time history.

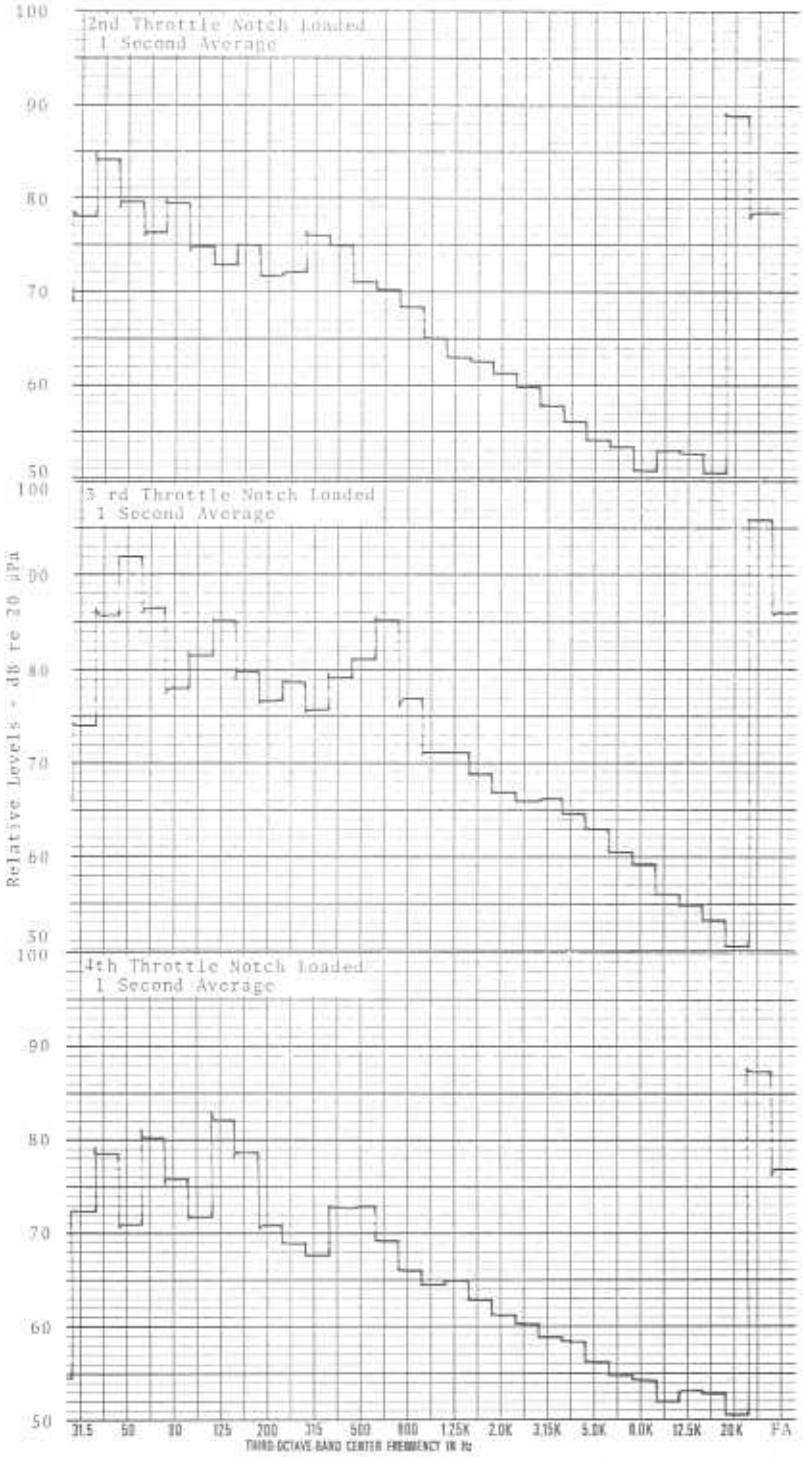


Figure B-6. Frequency Spectra - Wayside Noise Data, General Motors Locomotive GP-7, B&M RR, Iron Horse Park, Billerica MA, 3/26/73 Locomotive Stationary and Loaded at Second, Third, and Fourth Notches. Microphone 5.5 Feet High and Offset 25 Feet from Track Center-line. (See Figure B-1 for Noise Level Time Histories.)(155 HP).

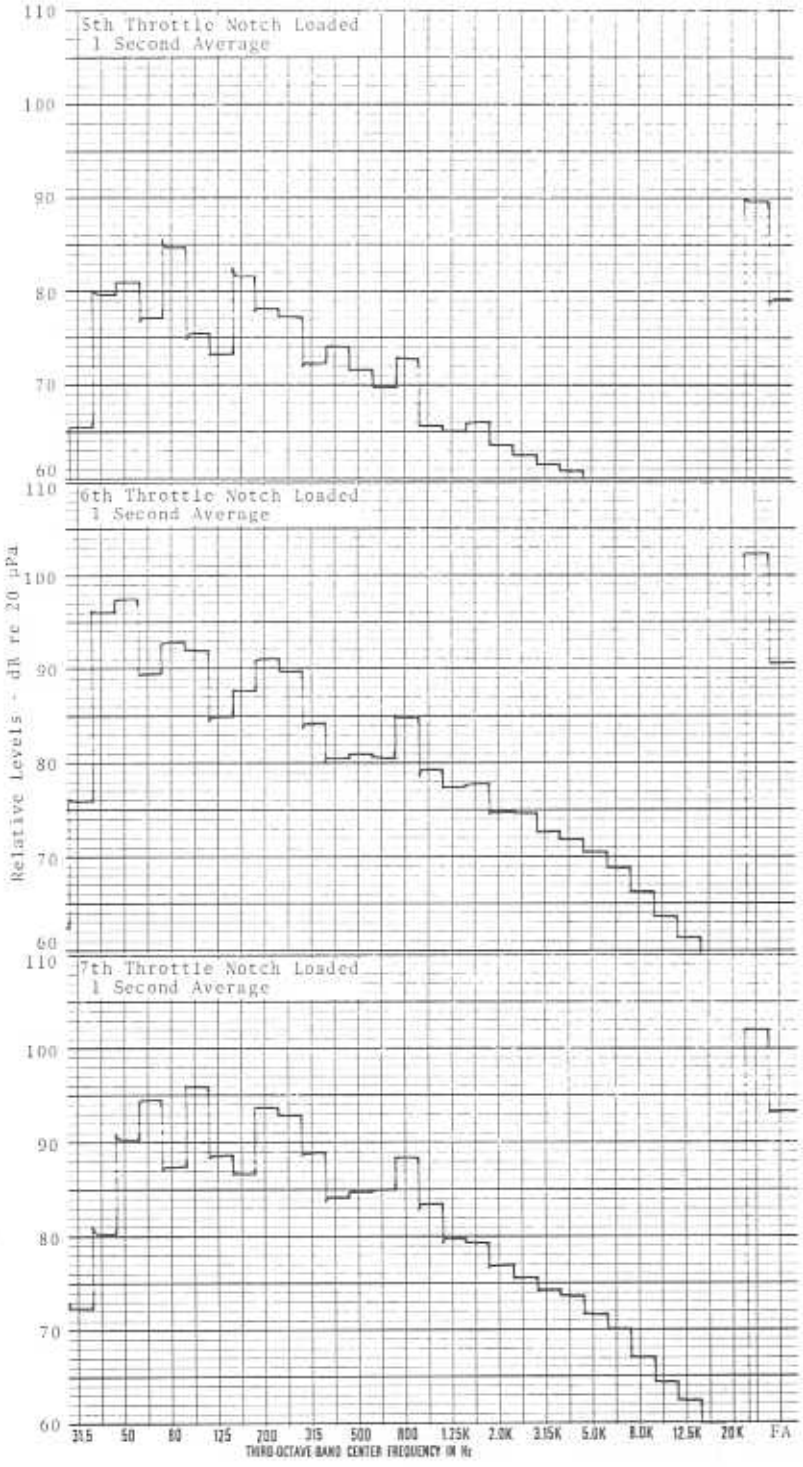


Figure B-7. Frequency Spectra - Wayside Noise Data, General Motors Locomotive GP-7, B&M RR, Iron Horse Park Billerica MA 3/21/73. Locomotive Stationary. Loaded at Fifth, Sixth, and Seventh Notches. Microphone 5.5 Feet High and Offset 25 Feet from Track Center-line. See Figure B-4 for Noise Level Time History. (1550 HP)

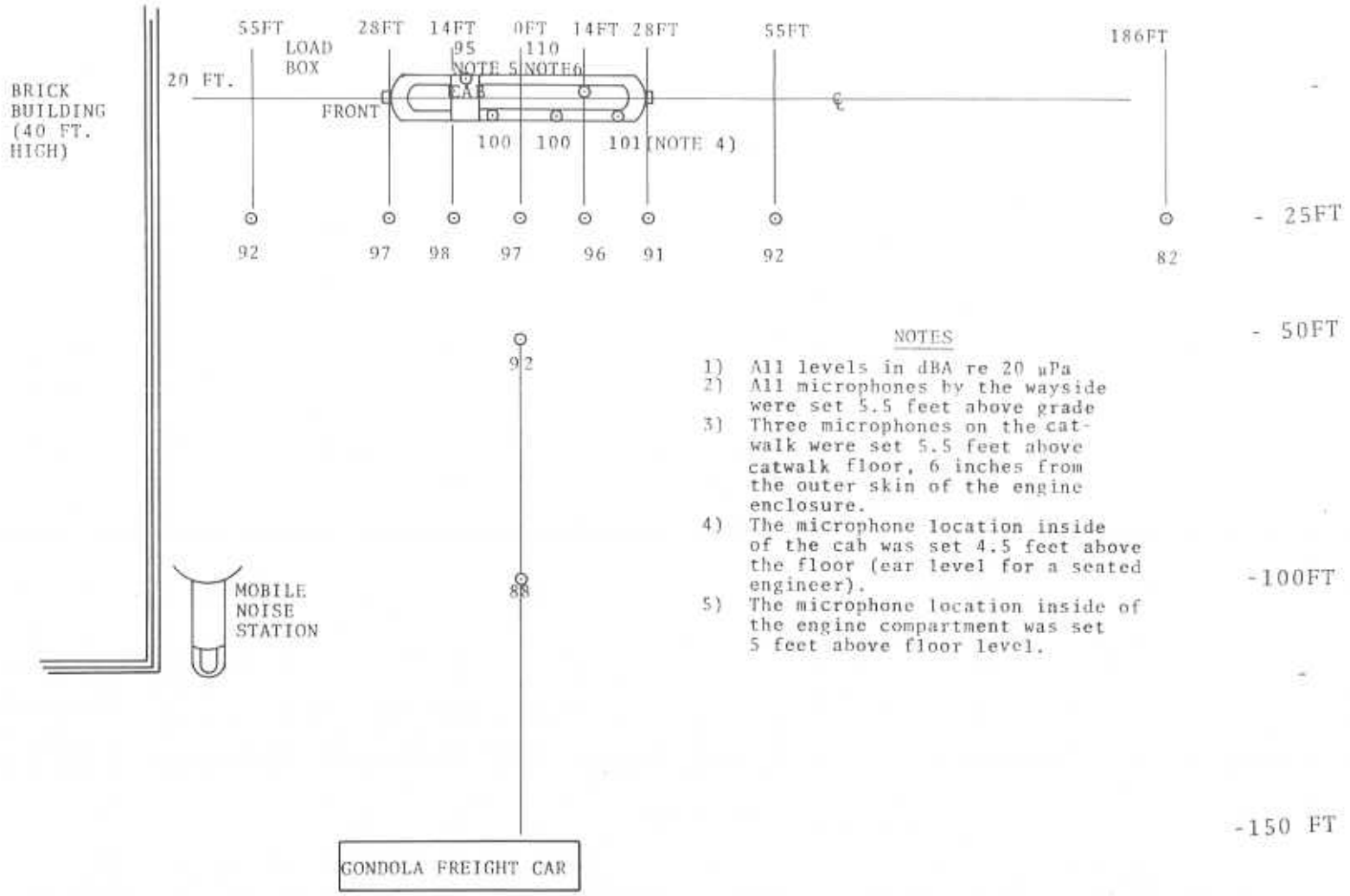


Figure B-8. Spatial Wayside Noise-Level Data, General Motors Locomotive GP-7, 1550 Horsepower, B&M RR, Iron Horse Park, Billerica, MA 3/21/73 Locomotive Stationary and Loaded at Eighth Notch.

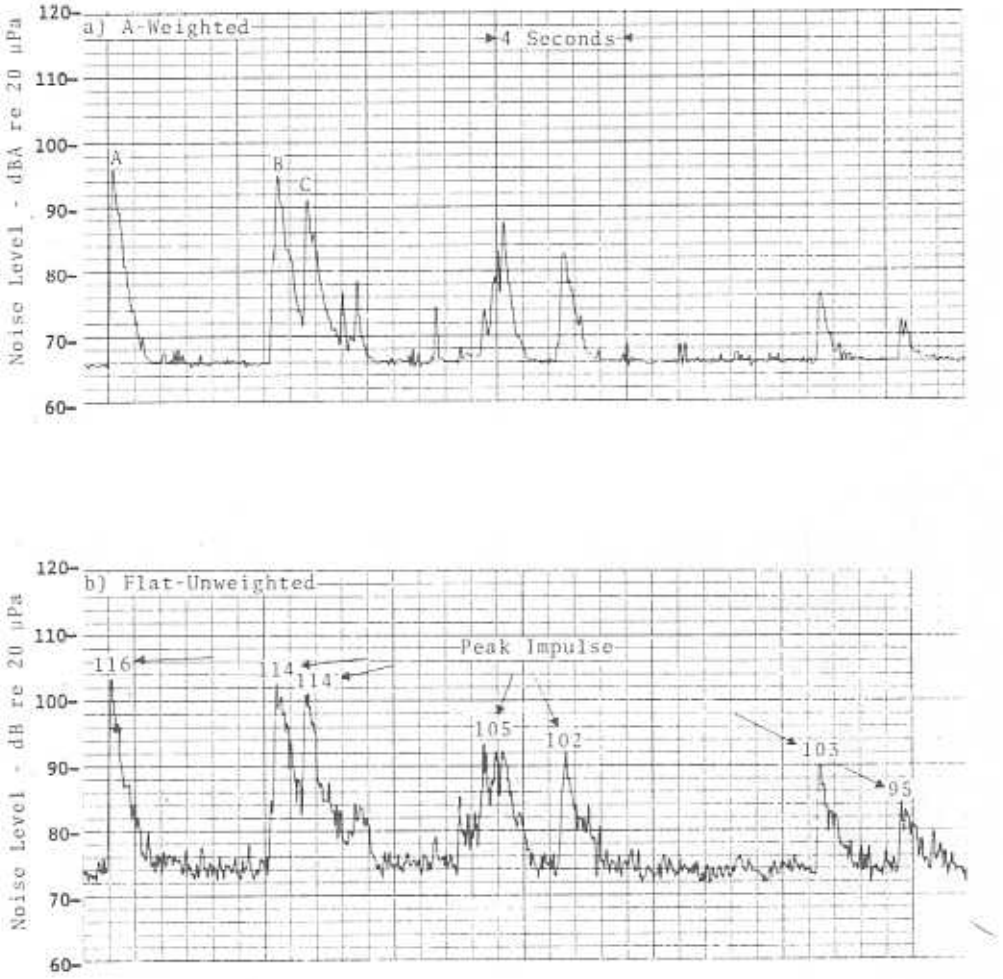
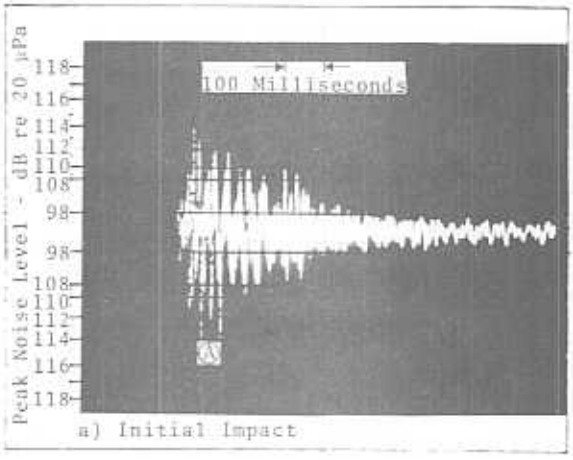


Figure B-9. Time History (A-Weighted and Flat-unweighted), Impact Noise Levels, B&M RR, Somerville Hump Yard, Somerville MA, 3/27/73.



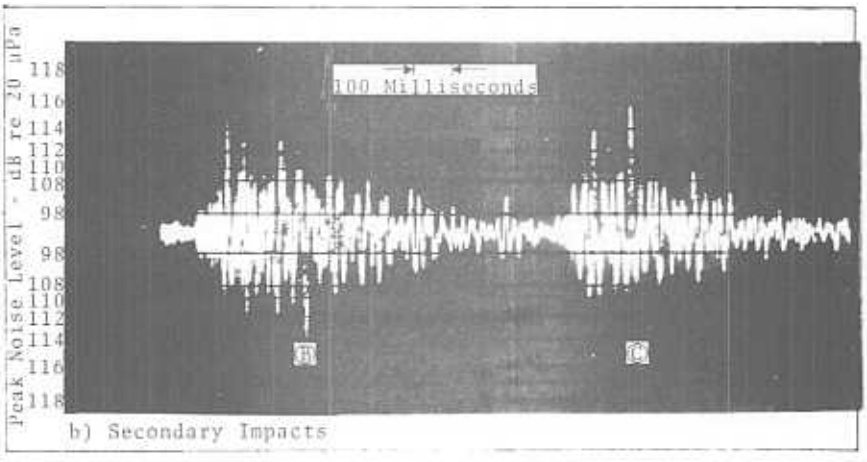


Figure B-10. Oscilloscope Display, Impact Noise (Flat-unweighted), B&M RR, Somerville Hump Yard Somerville MA. See Time History B-9b

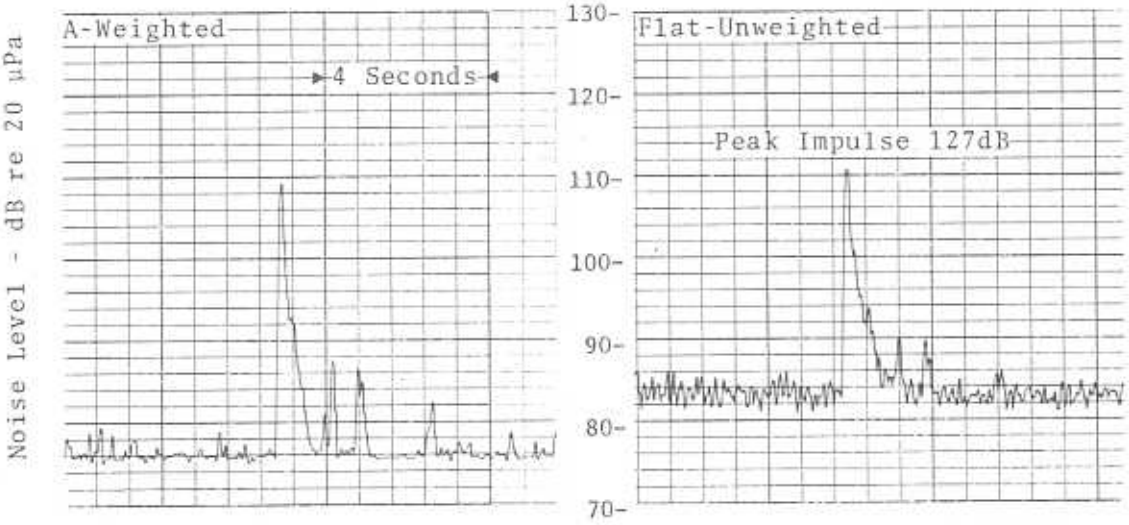


Figure B-11. Time History (A-weighted and Flat-unweighted), Impact Noise Levels, B&M RR, Somerville Hump Yard, Somerville MA, 3/27/73. Two Freight Cars at 8 mph Impacting Standing Line of Cars. Microphone 5 Feet above Level at Rails and Offset 50 Feet from Track Center-line.

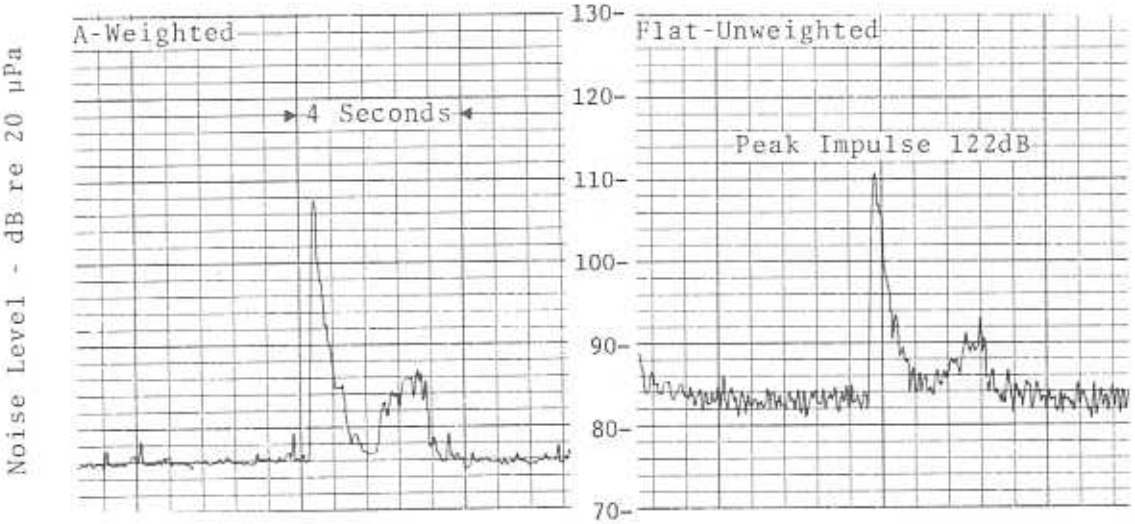


Figure B-12. Time History (A-weighted and Flat-unweighted), Impact Noise Levels, B&M RR Somerville Hump Yard, Somerville MA, 3/27/73. Three Empty Freight Cars at 8 mph Impacting Line of Standing Cars. Microphone 5 Feet above the Level of the Rails and 50 Feet Offset from Track Center-line.

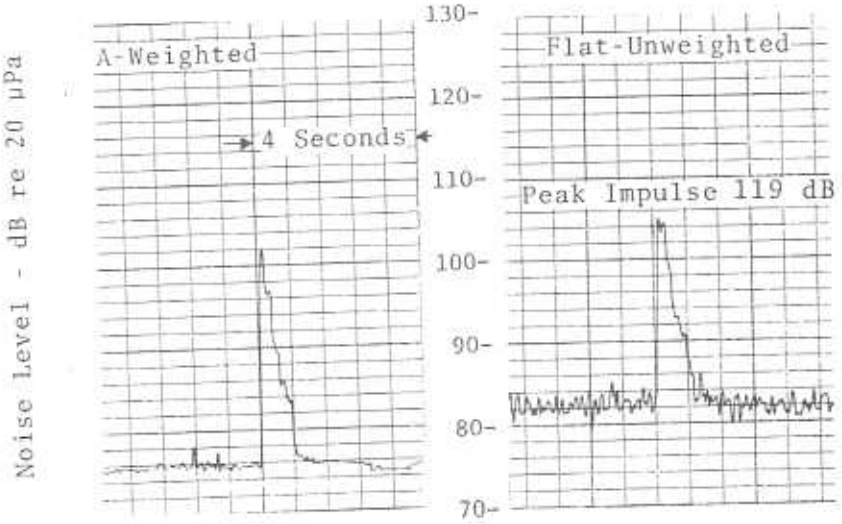


Figure B-13. Time History (A-weighted and Flat-unweighted) Impact Noise Levels, B&M RR, Somerville Hump Yard, Somerville MA, 3/27/73. Single Empty Freight Car at 8 mph Impacting Single Empty Standing Freight Car. Microphone 5 Feet above Level of Rails and Offset 50 Feet from Track Center-line.

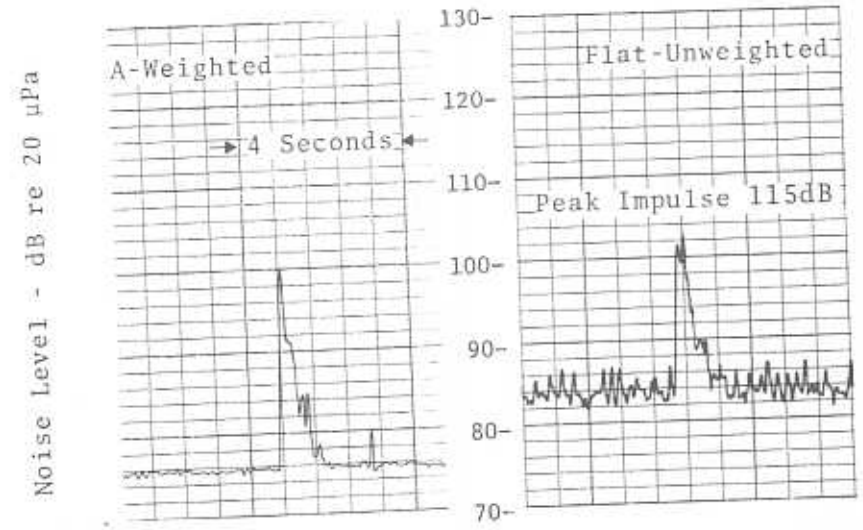
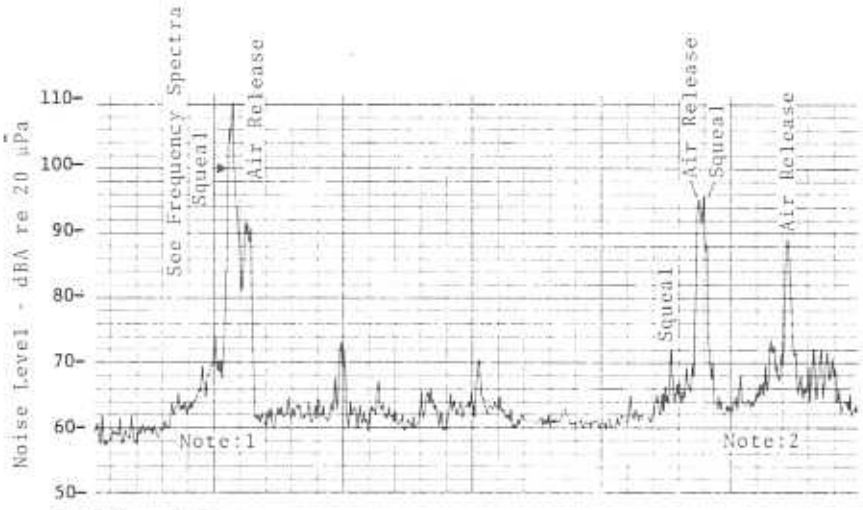


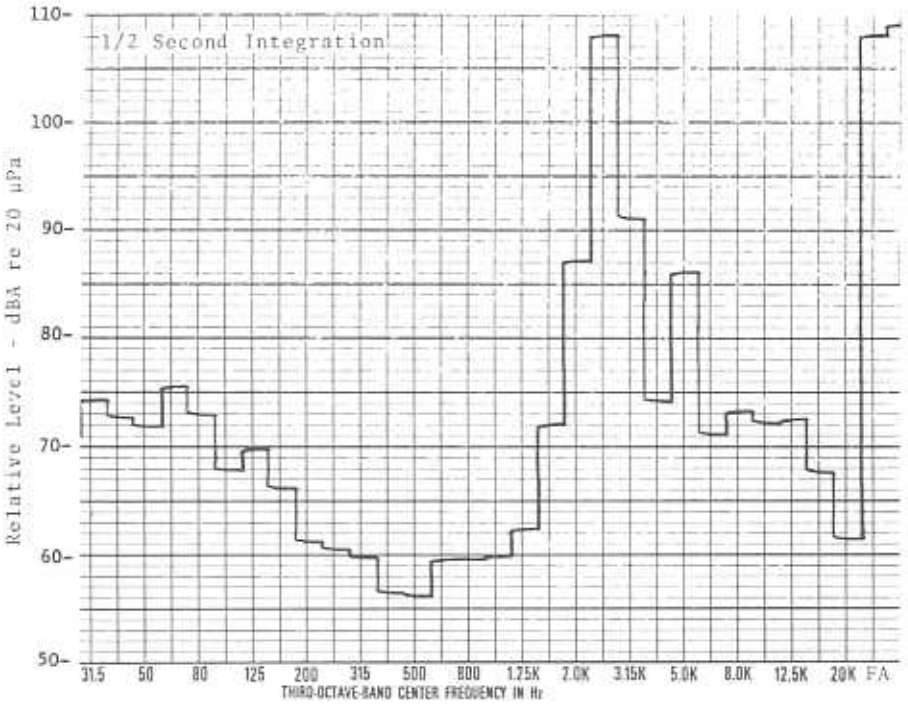
Figure B-14. Time History (A-weighted and Flat-unweighted) Impact Noise Levels, B&M RR, Somerville Hump Yard, Somerville MA, 3/27/73. Single Loaded Freight Car (150,000 pounds) at 4 mph Impacting Standing Line of 20 to 30 Freight Cars. Microphone 3 Feet above Level of Rails and Offset 50 Feet from Track Center-line.



a) Time History

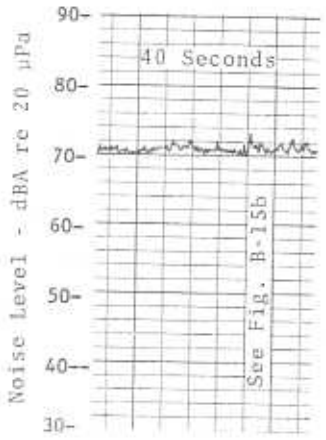
Note 1: Single Freight Car with Roller Bearings Slowed from 8 to 4 mph (Estimated)

Note 2: Two Coupled Cars: First with Roller Bearing, Second with Journal Box: Slowed from 6 to 4 mph.

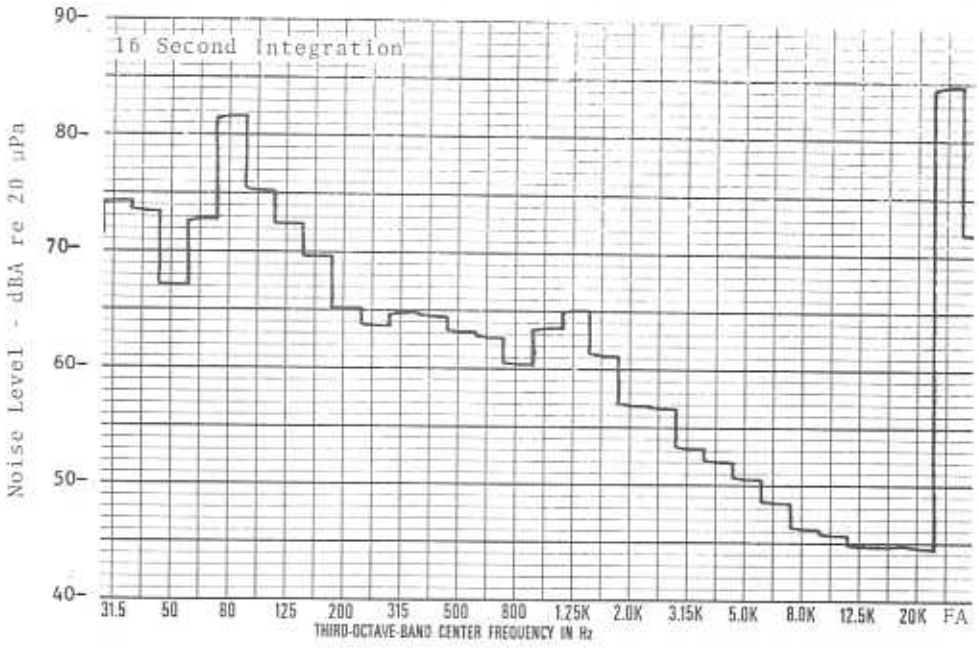


b) Frequency Spectra

Figure B-15. Noise Data, Master Retarder, B&M RR Somerville Hump Yard, Somerville MA, 3/27/73. Microphone Centered on Master Retarder at a Height of 5 Feet Above the Rails and Offset 50 Feet from Track Center-line.



a) Time History



b) Frequency Spectra

Figure B-16. Noise Data, Diesel Engine, Mechanical Refrigeration Car, B&M RR, Somerville Hump Yard, Somerville MA, 3/27/73. Microphone Offset 50 Feet from Track Center-line at a Height of 5 Feet above the Level of Rails, Directly Opposite Open Grille.

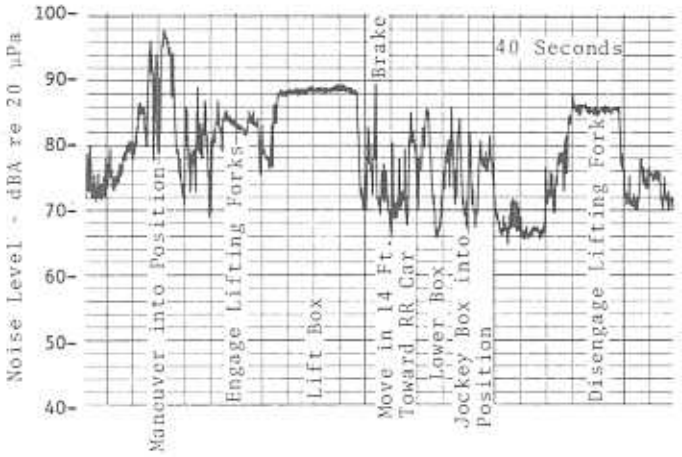


Figure B-17. Time History, Noise Level Data, Piggyback Packer, (Fork-Lift Truck) FWD Wagner Model P-70, B&M RR, Yard 7, Charlestown MA, 3/28/73

Microphone 5.5 ft. High and 50 ft. Offset to the Right Side of Packer

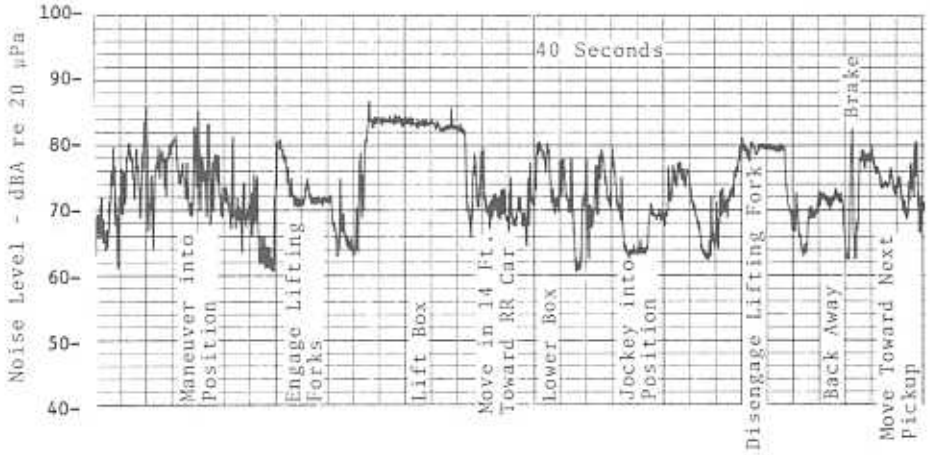


Figure B-18. Time History, Noise Level Data, Piggyback Packer, (Fork-Lift Truck) FWD Wagner Model P-70, B&M RR, Yard 7, Charlestown MA, 3/28/73

Microphone 5.5 ft. High and Offset 50 ft. to the Rear of Packer

APPENDIX C

PASSENGER AND LINE-HAUL NOISE LEVEL DATA MEASURED AT THREE WAYSIDE LOCATIONS OF THE PENN CENTRAL RR, NEW YORK-TO-WASHINGTON LINES, PLAINSBORO NJ

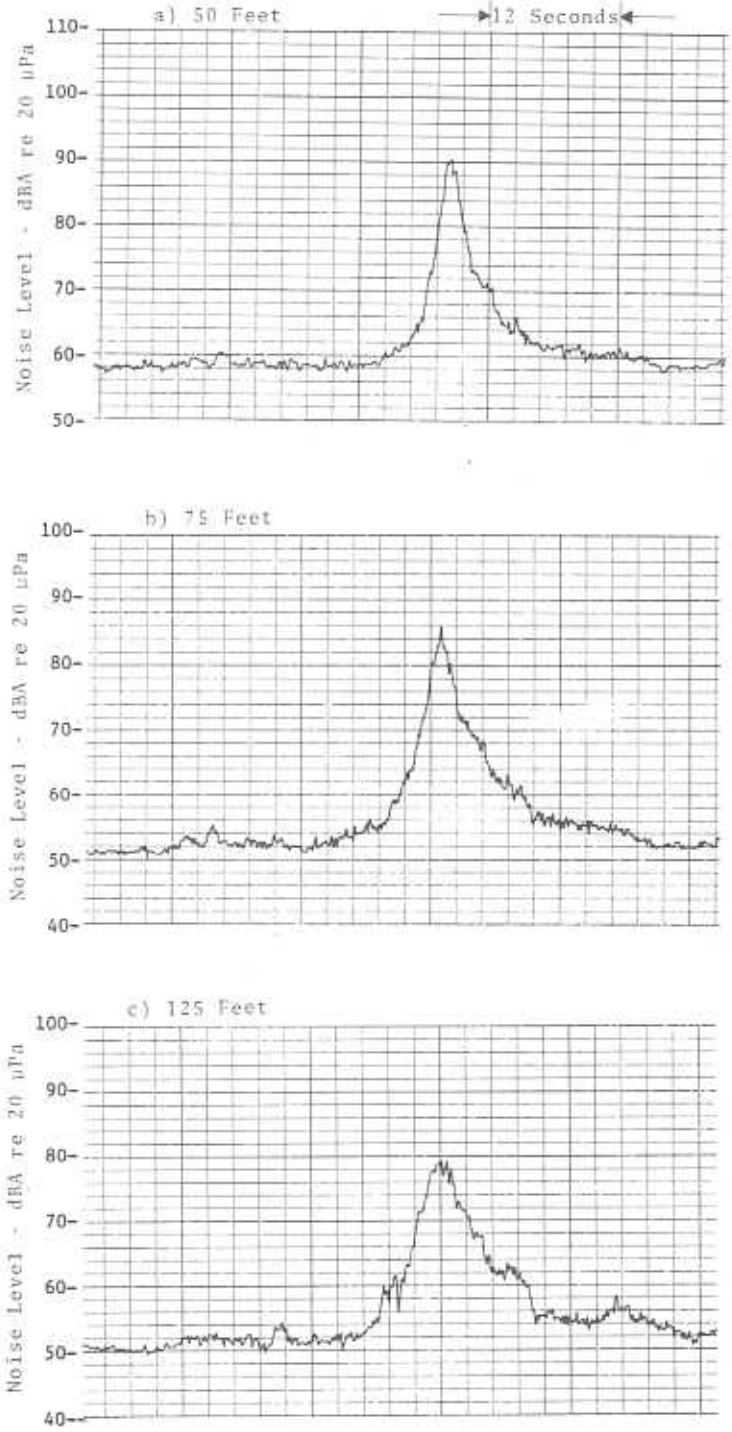


Figure C-1. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 feet from Center-line of Track 4, Penn Central RR, Plainsboro NJ, 5/23/72, Single Electric Locomotive, Northbound 49 mph.

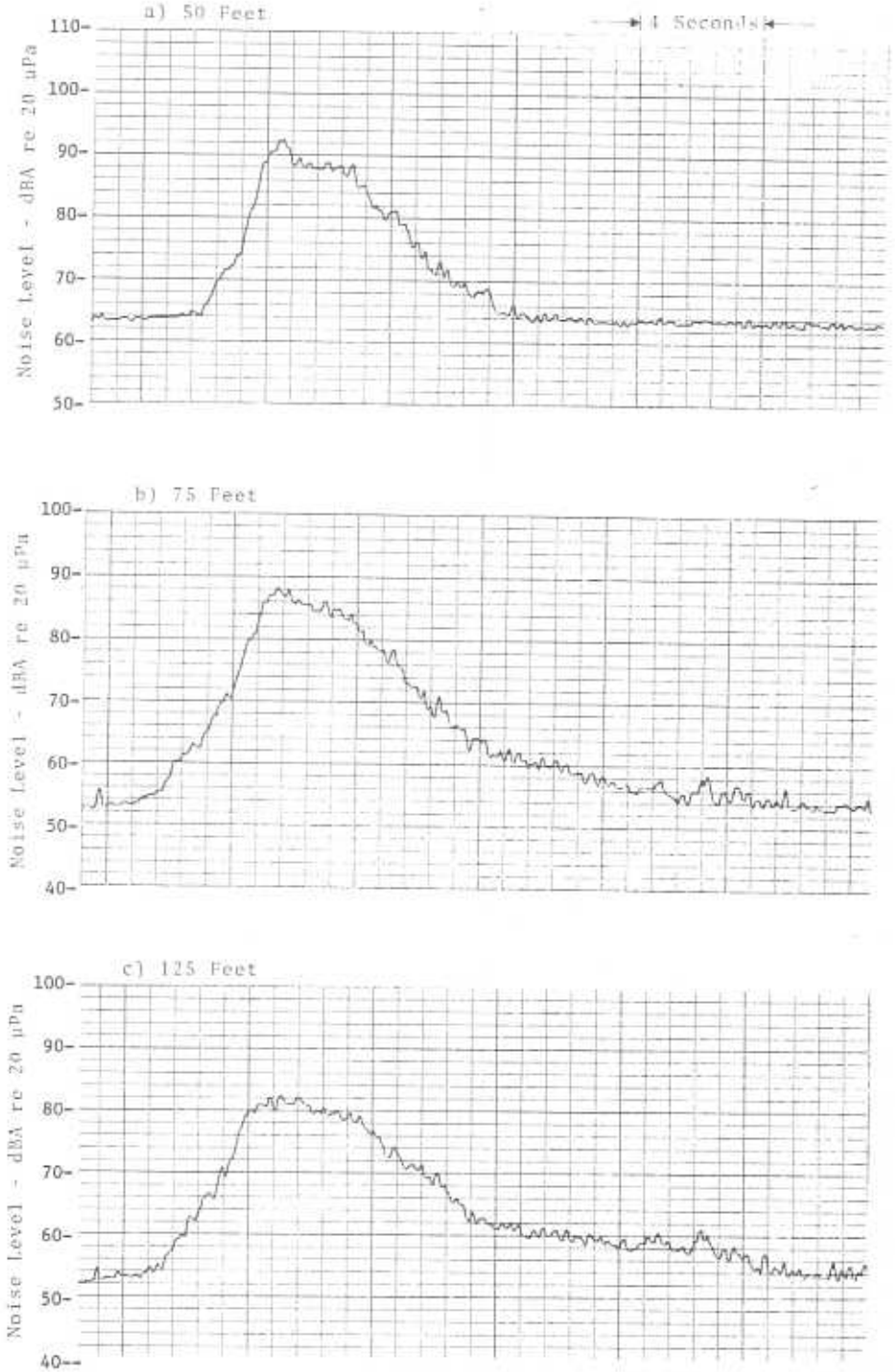


Figure C-2. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4, Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 5 Cars, 78 mph.

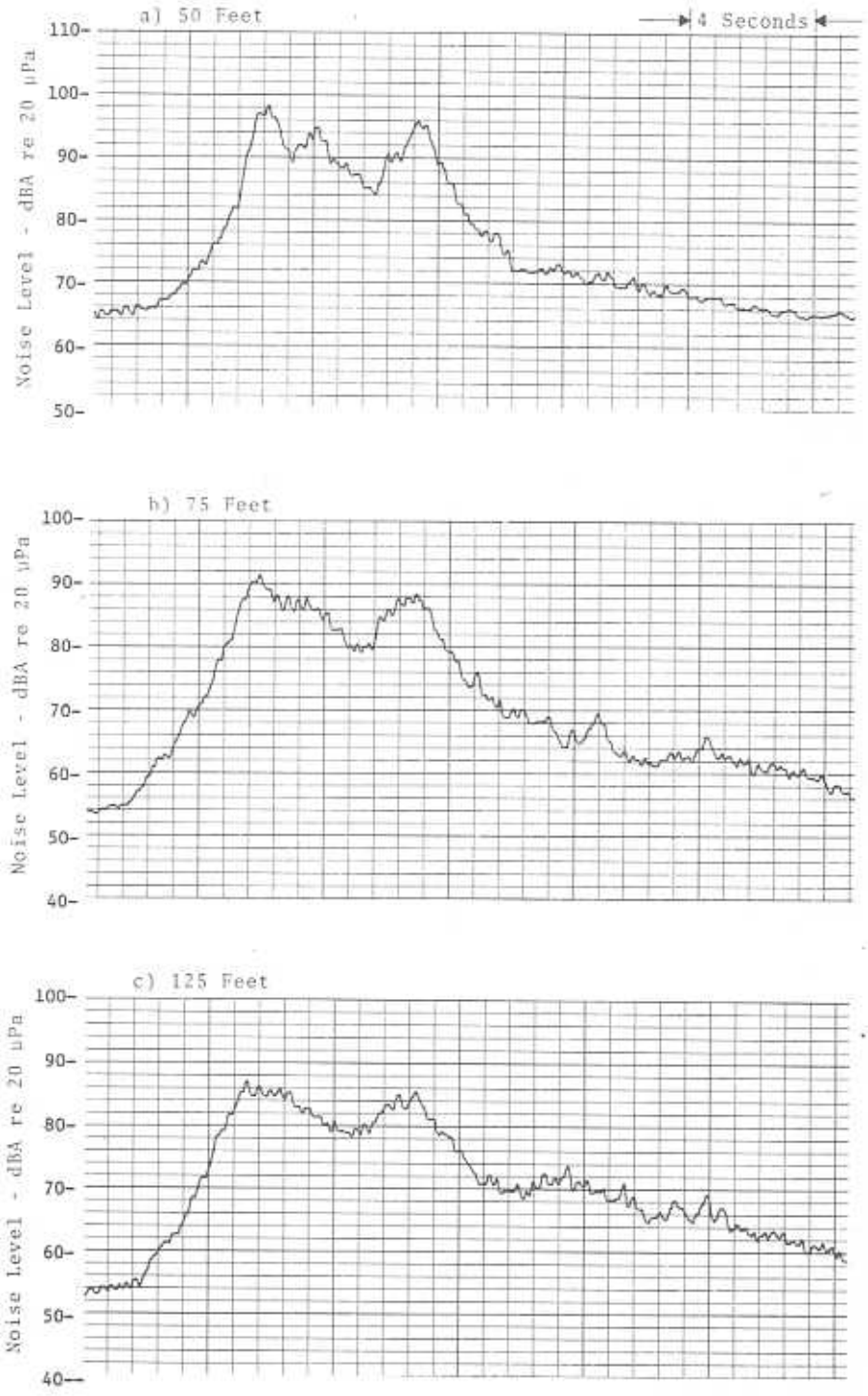


Figure C-3. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4, Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 8 Cars, 78 mph.

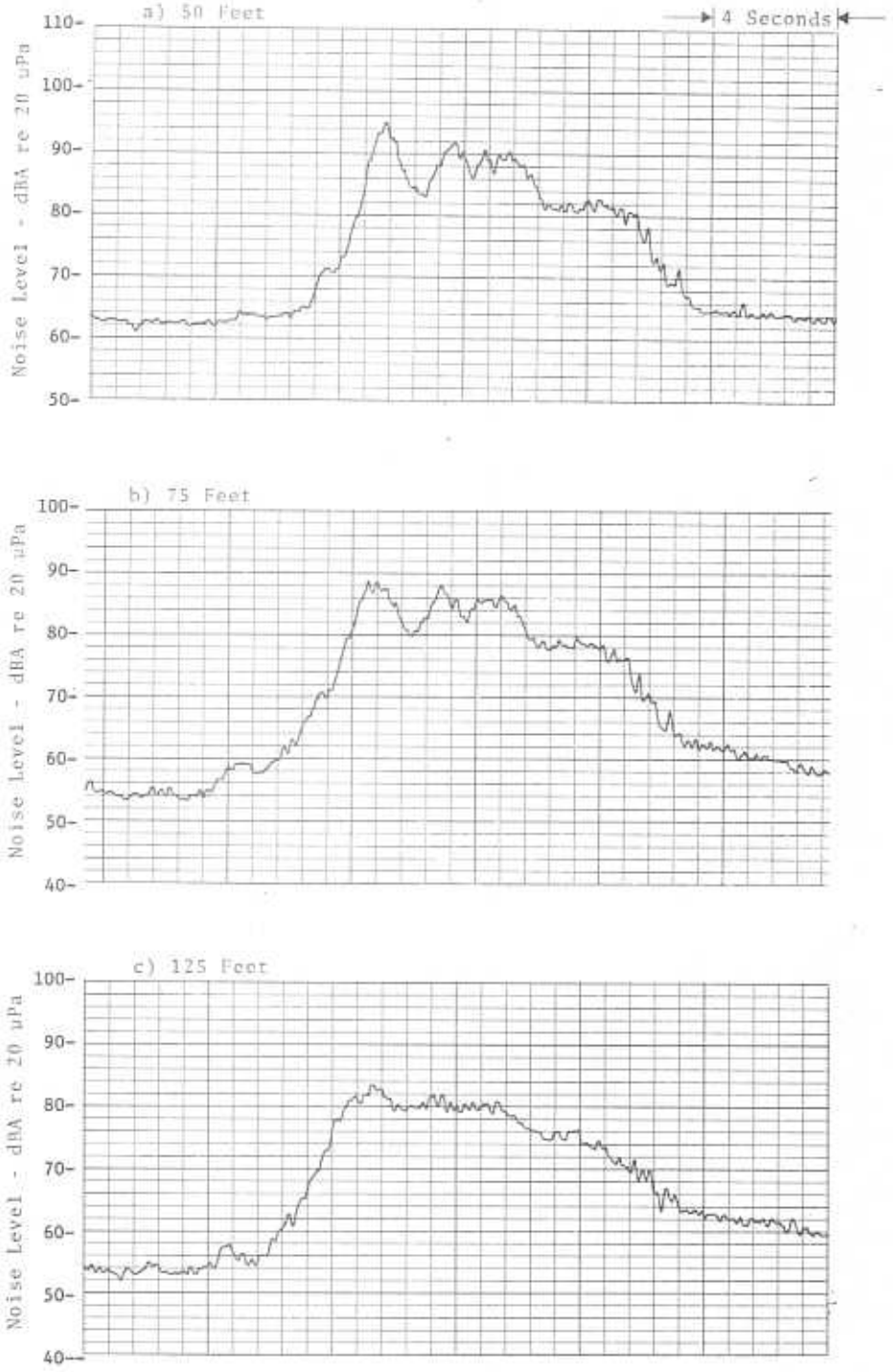


Figure C-4. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4 Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 11 Cars, 95 mph.

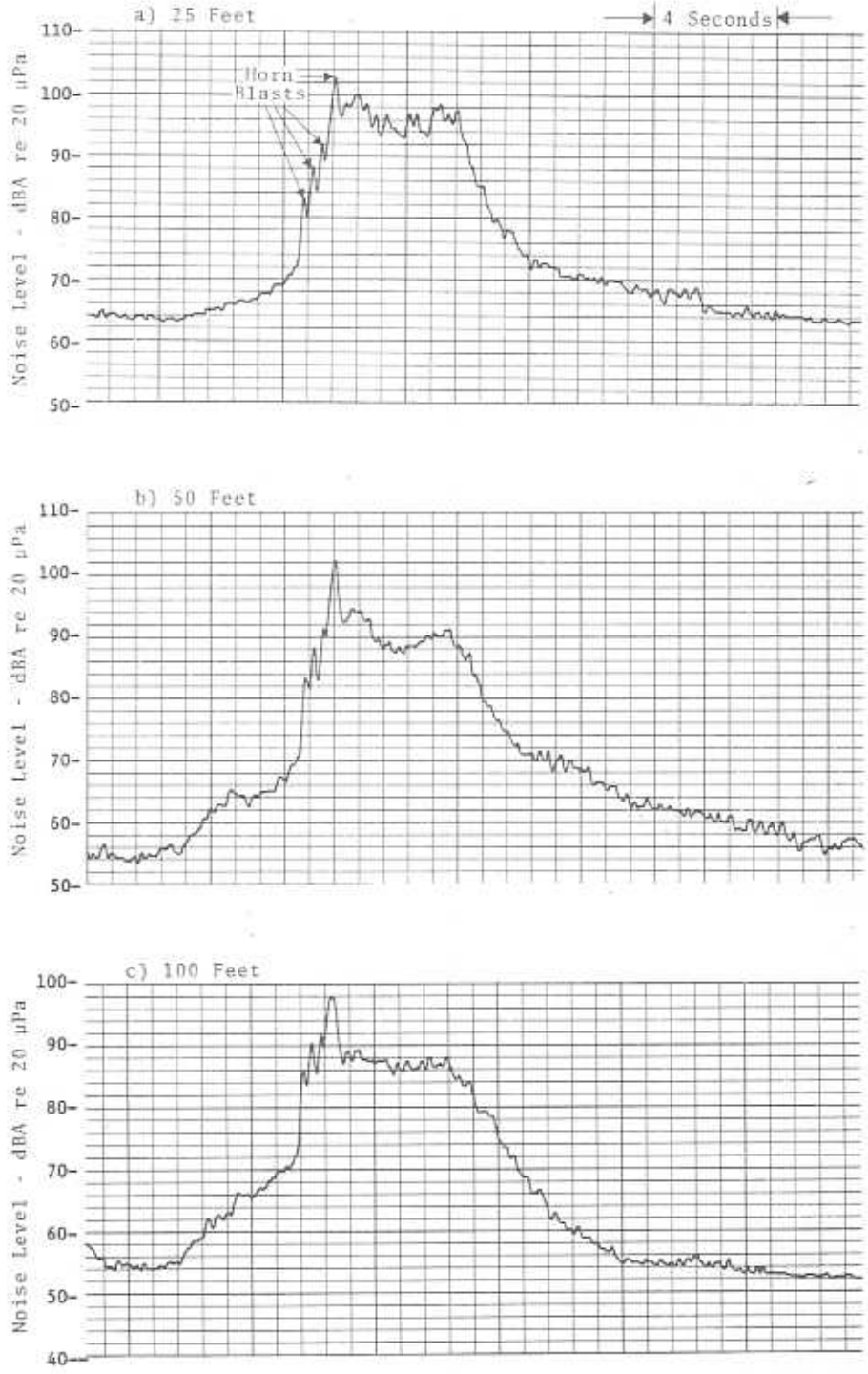


Figure C-5. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 4 Cars, 73 mph.

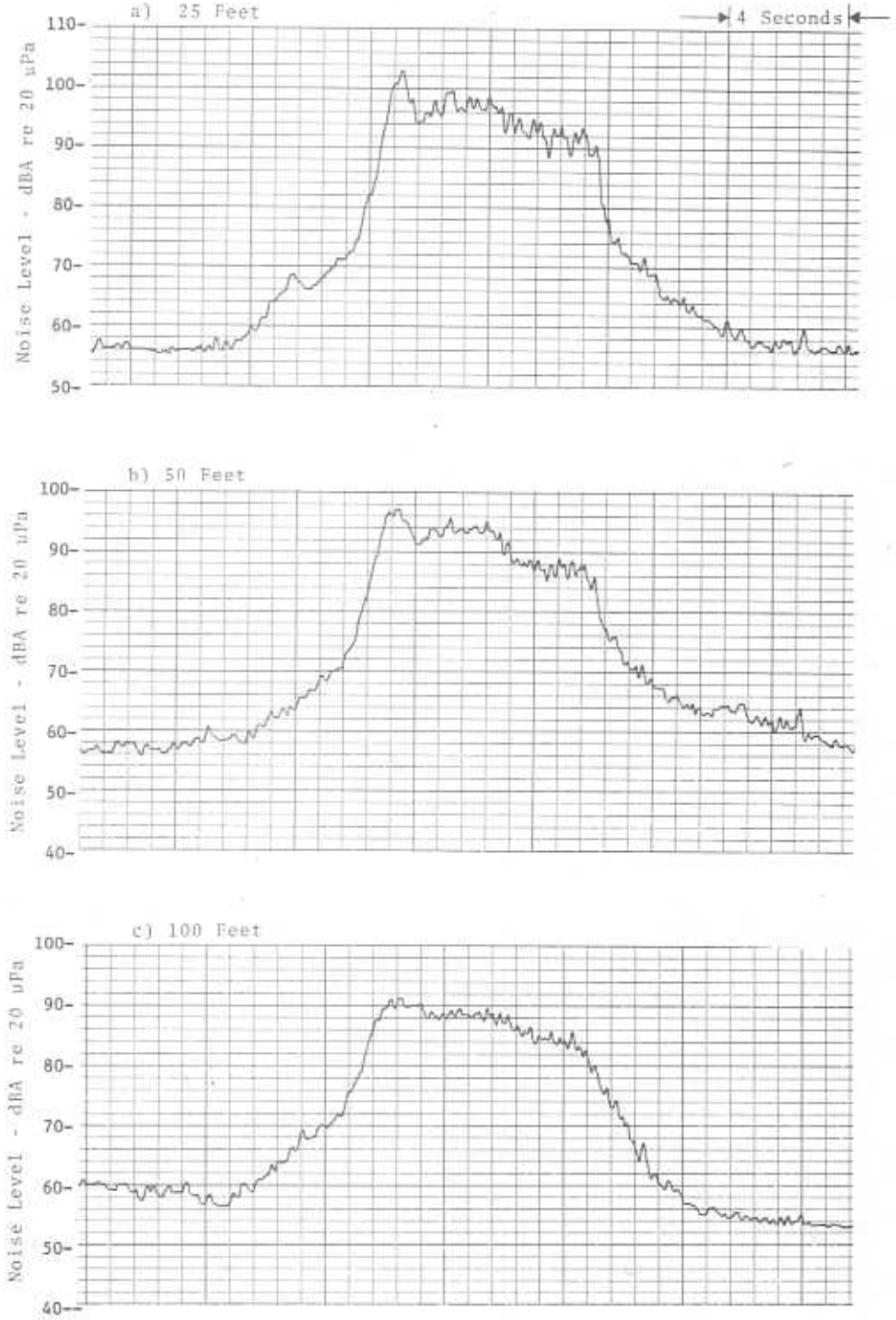


Figure C-6. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 10 Cars, 82 mph.

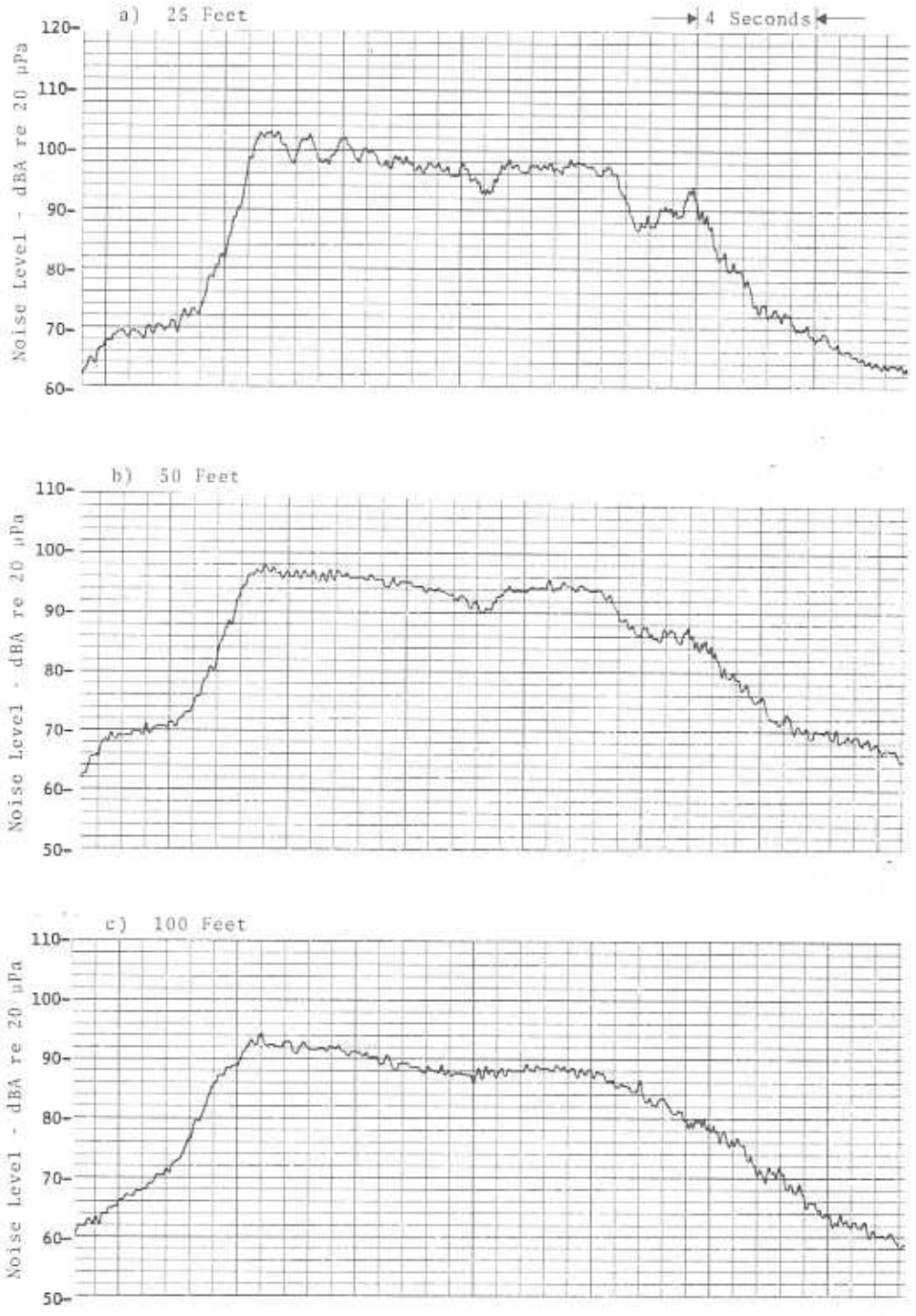


Figure C-7. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Passenger Train, Electric Locomotive Plus 12 Cars, 40 mph.

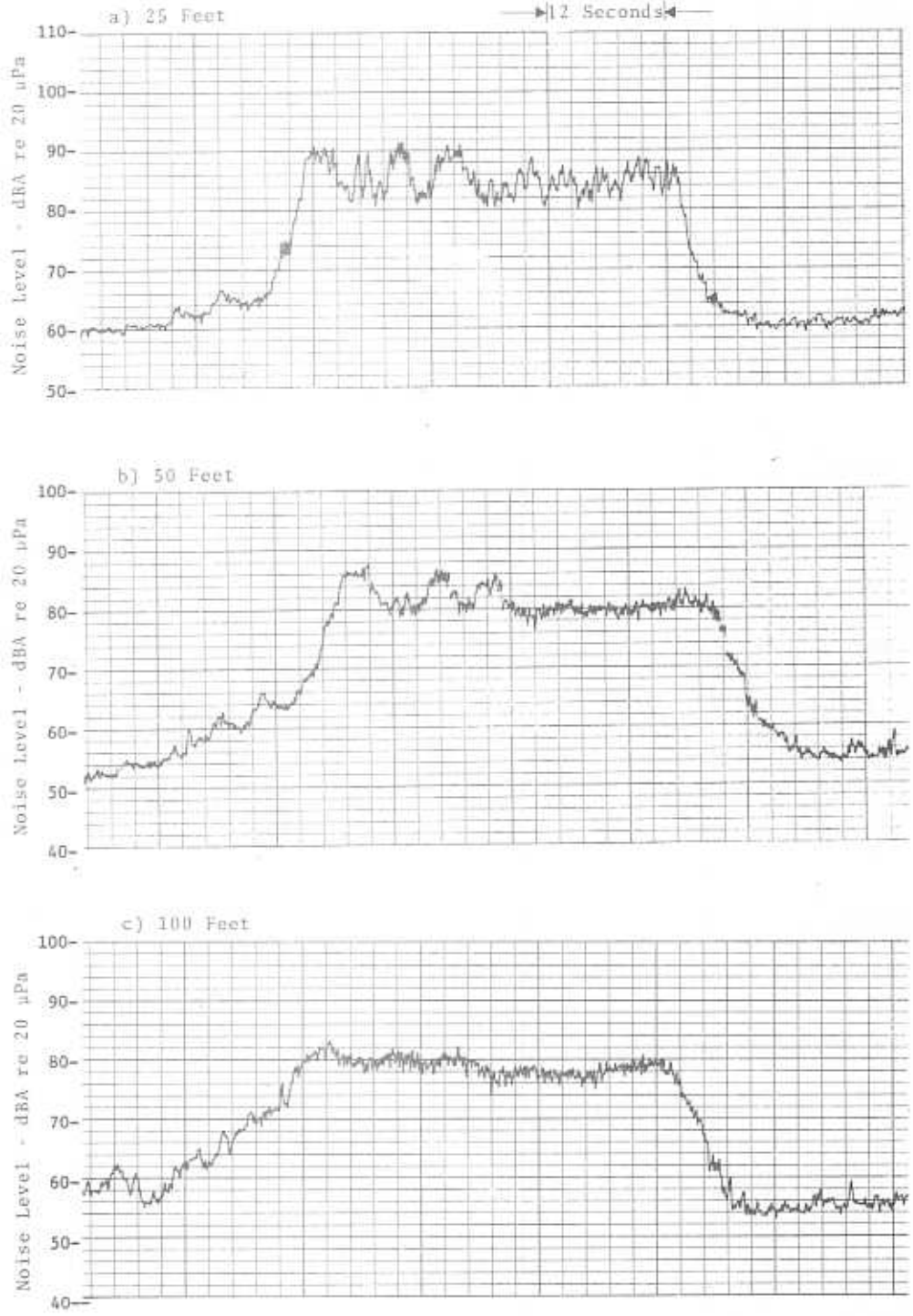


Figure C-8. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Diesel Locomotives Plus 33 Cars, 34 mph.

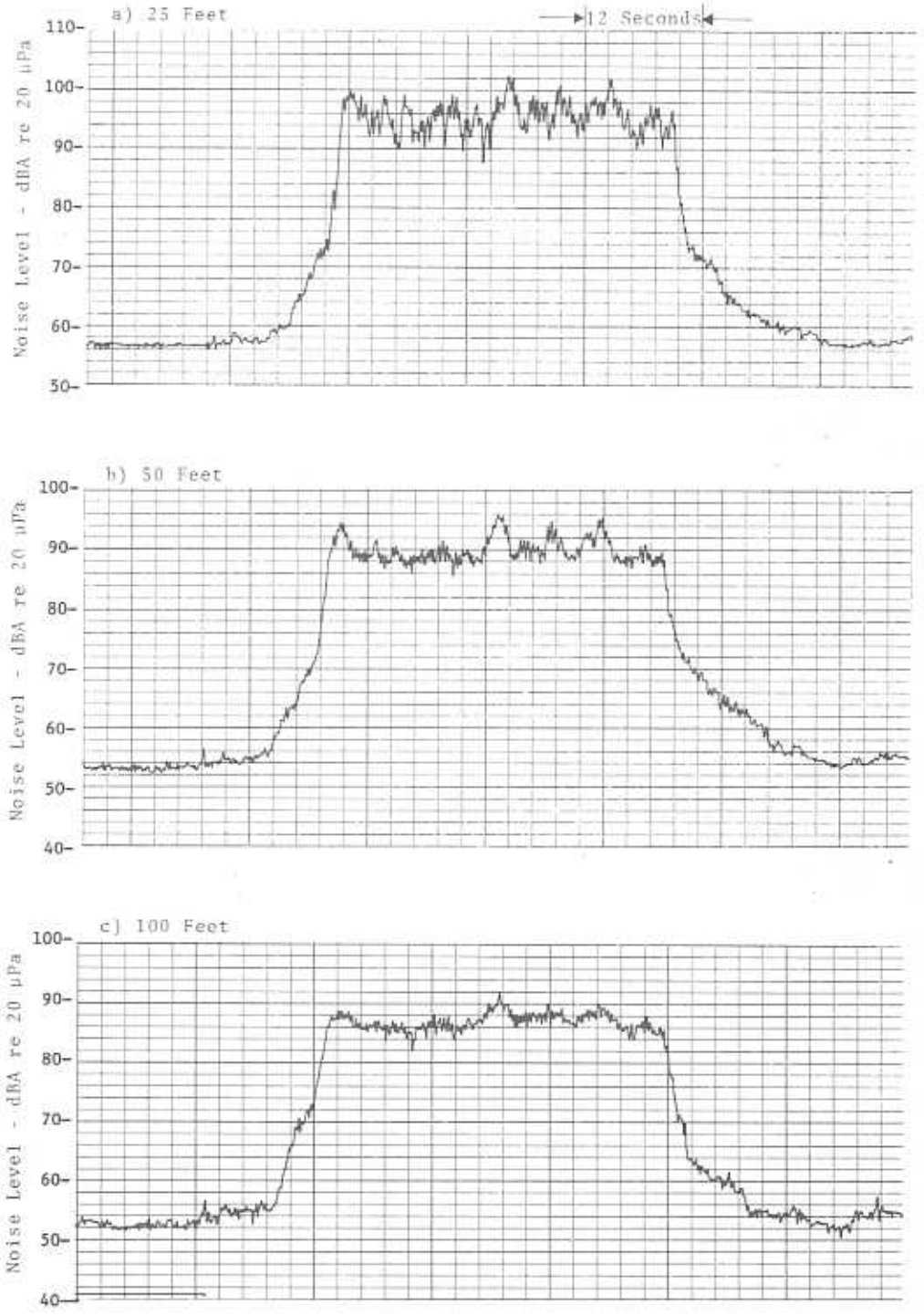


Figure C-9. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 58 Cars, 66 mph.

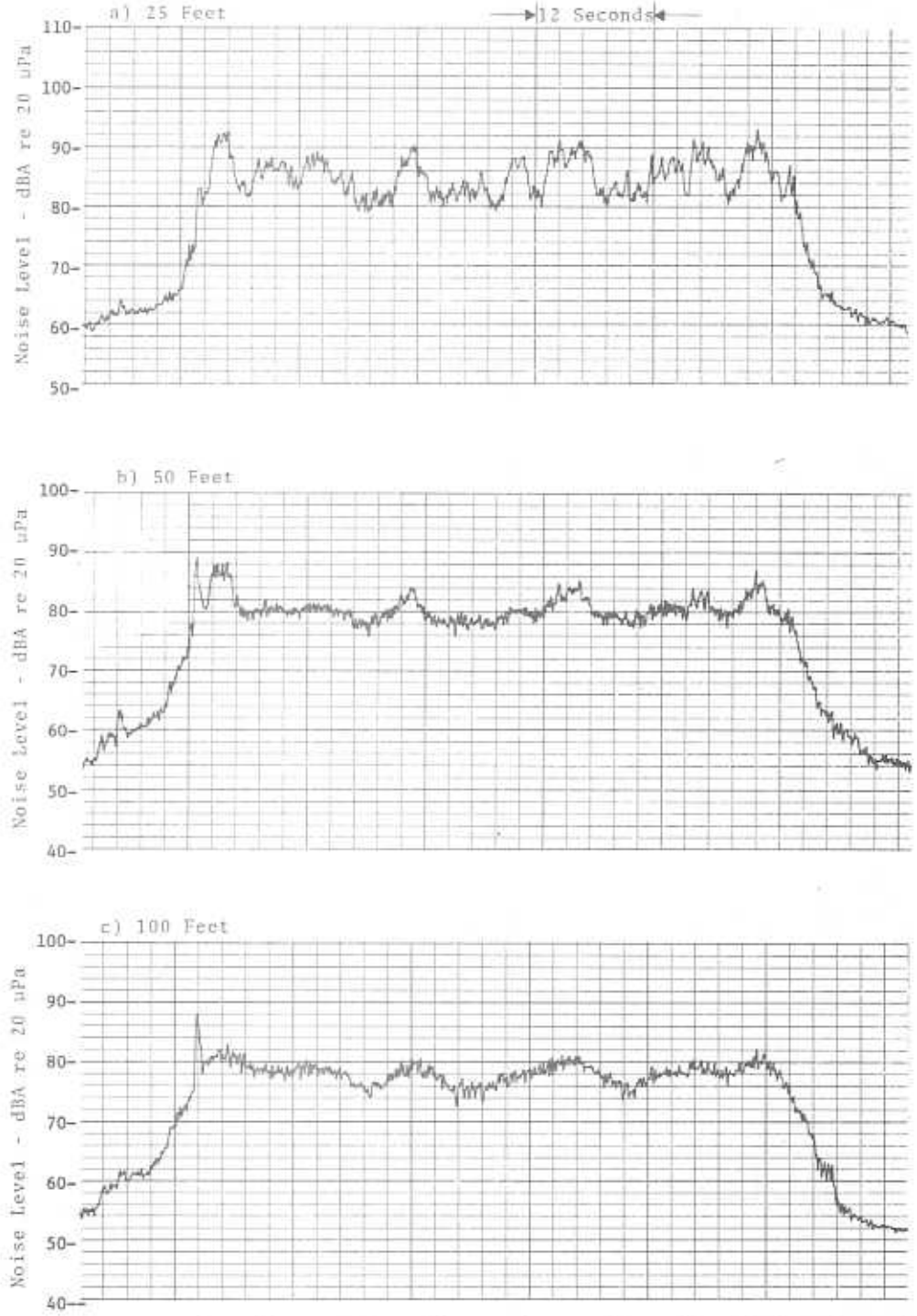


Figure C-10. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 48 Cars, 32 mph.

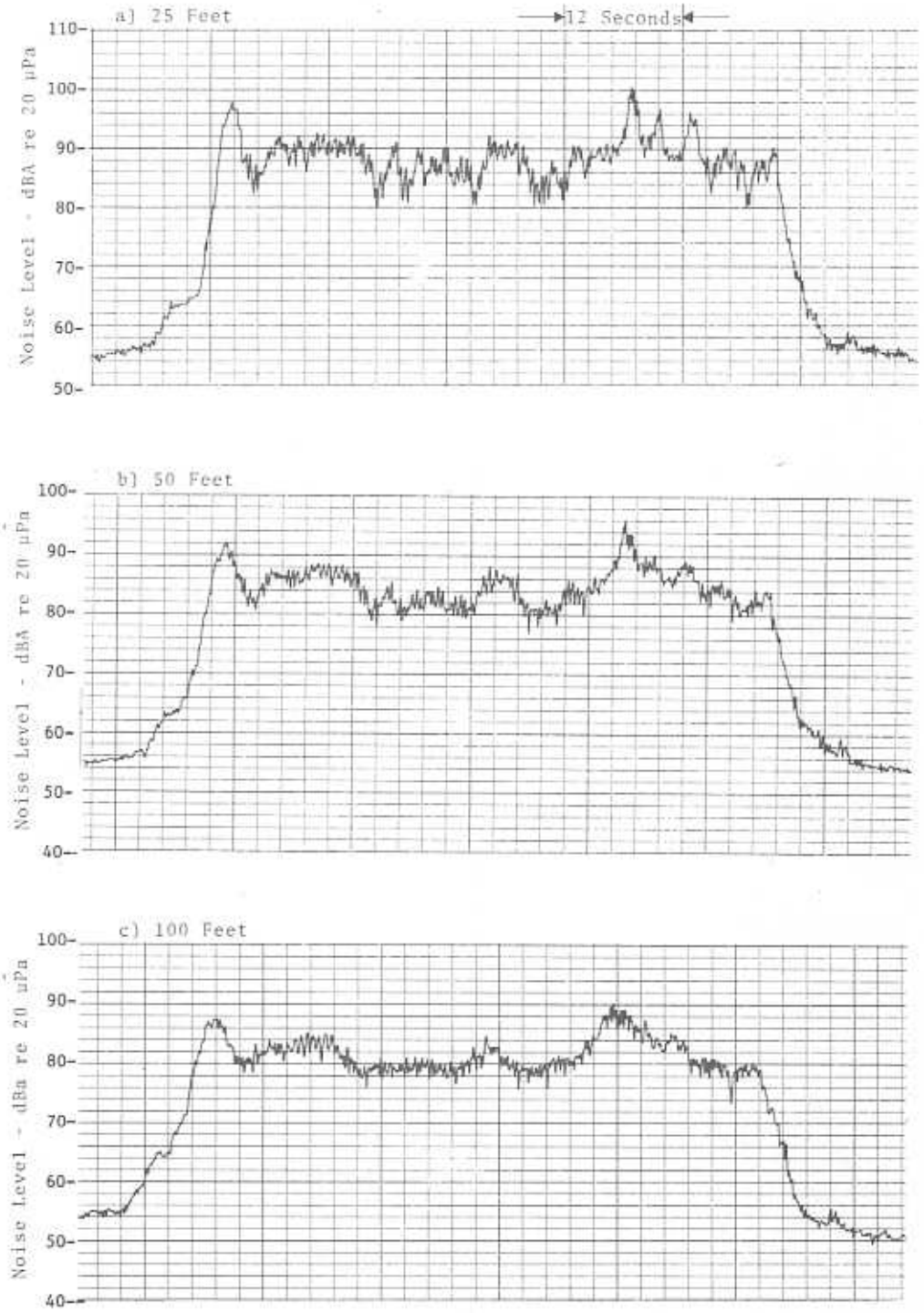


Figure C-11. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Centerline of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 63 Cars, 50 mph.

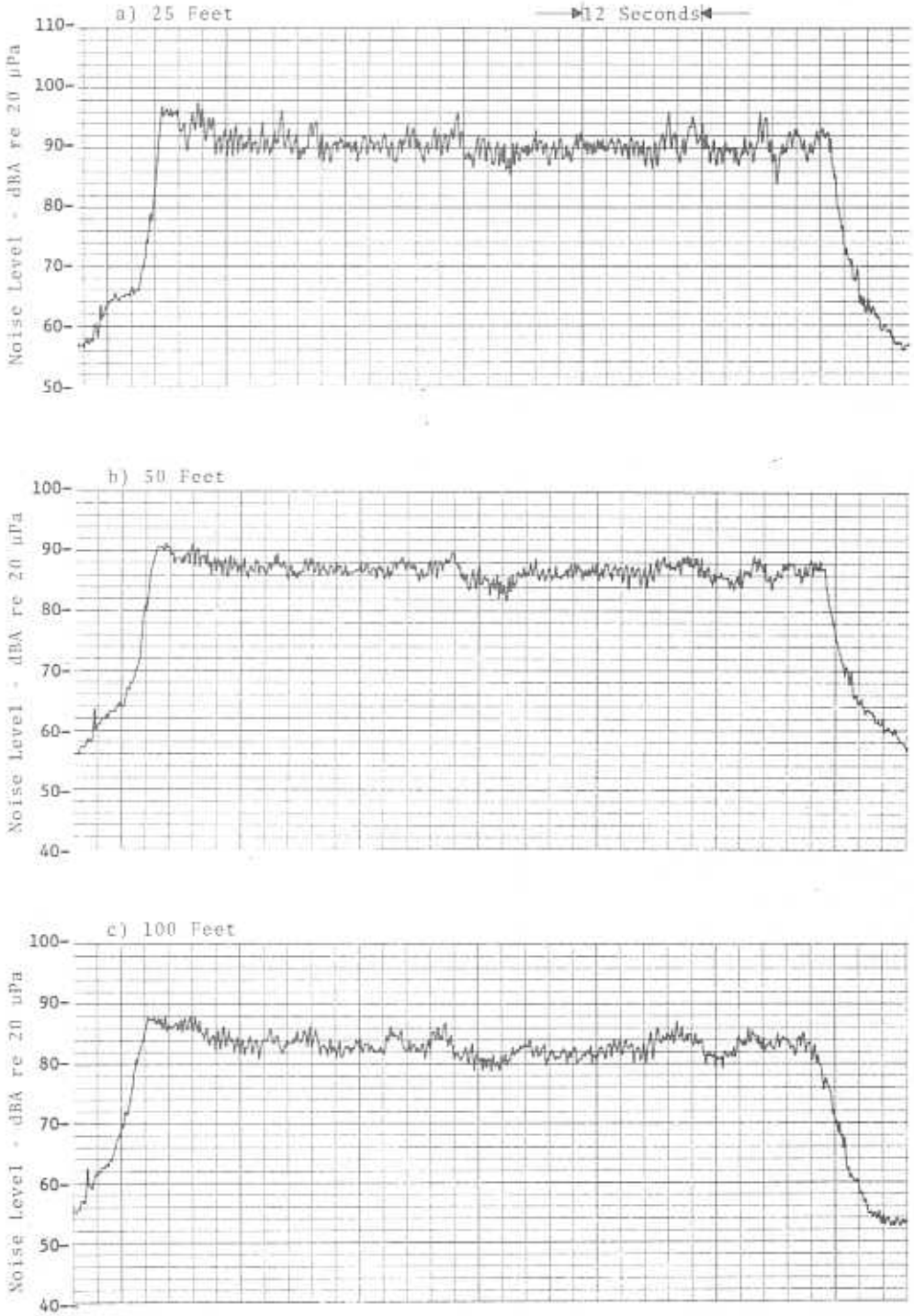


Figure C-12. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 2, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 95 Cars, 50 mph.

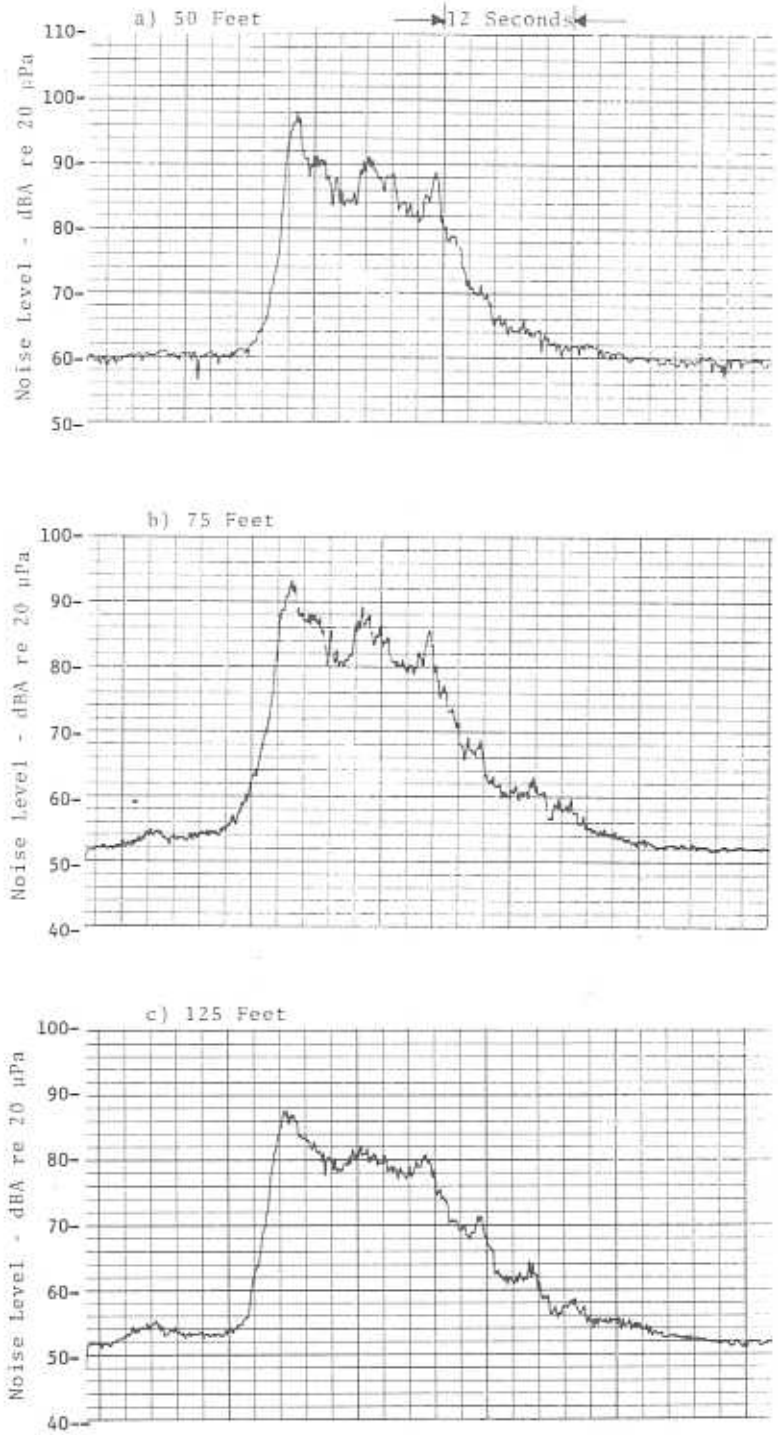


Figure C-13. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives, Plus 35 Cars, 84 mph.

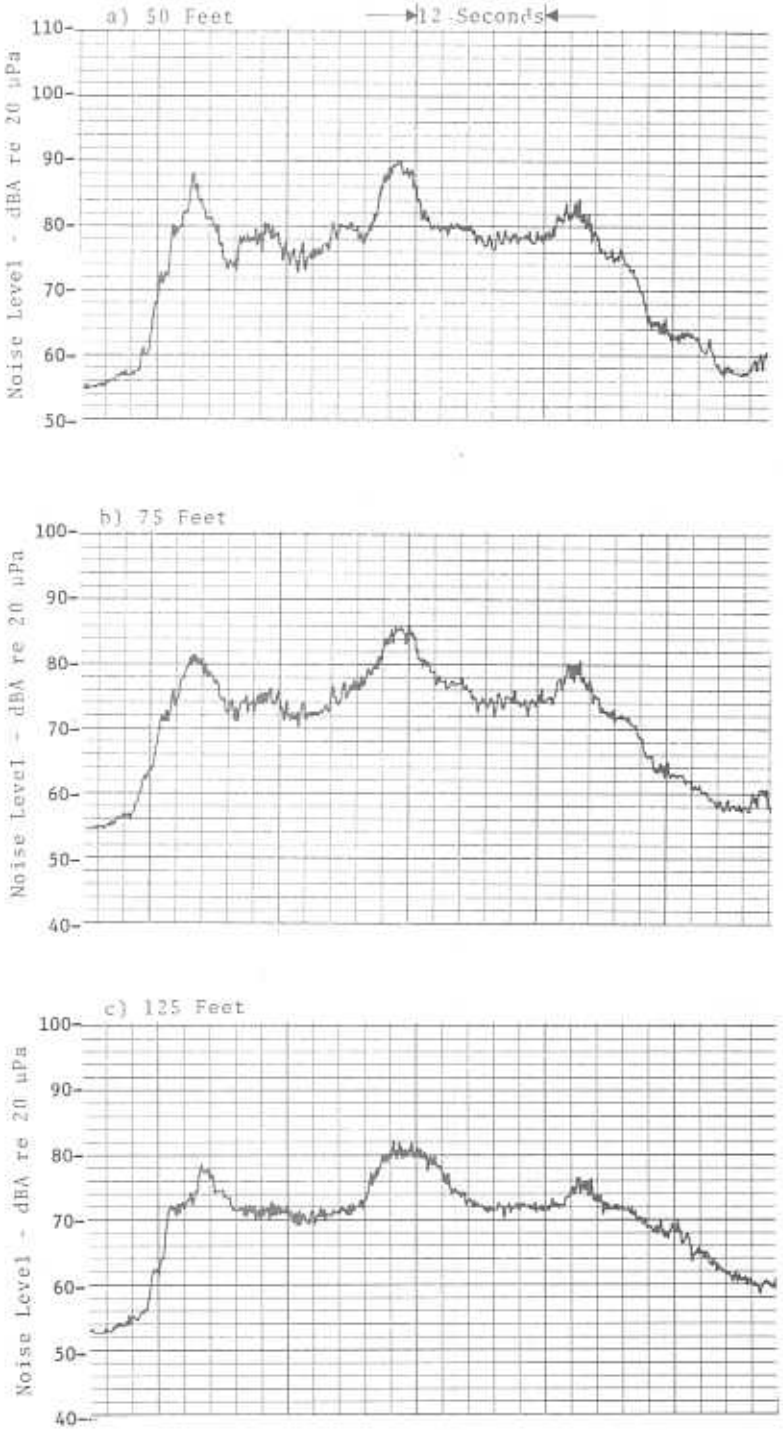


Figure C-14. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4. Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 41 Cars, 35 mph.

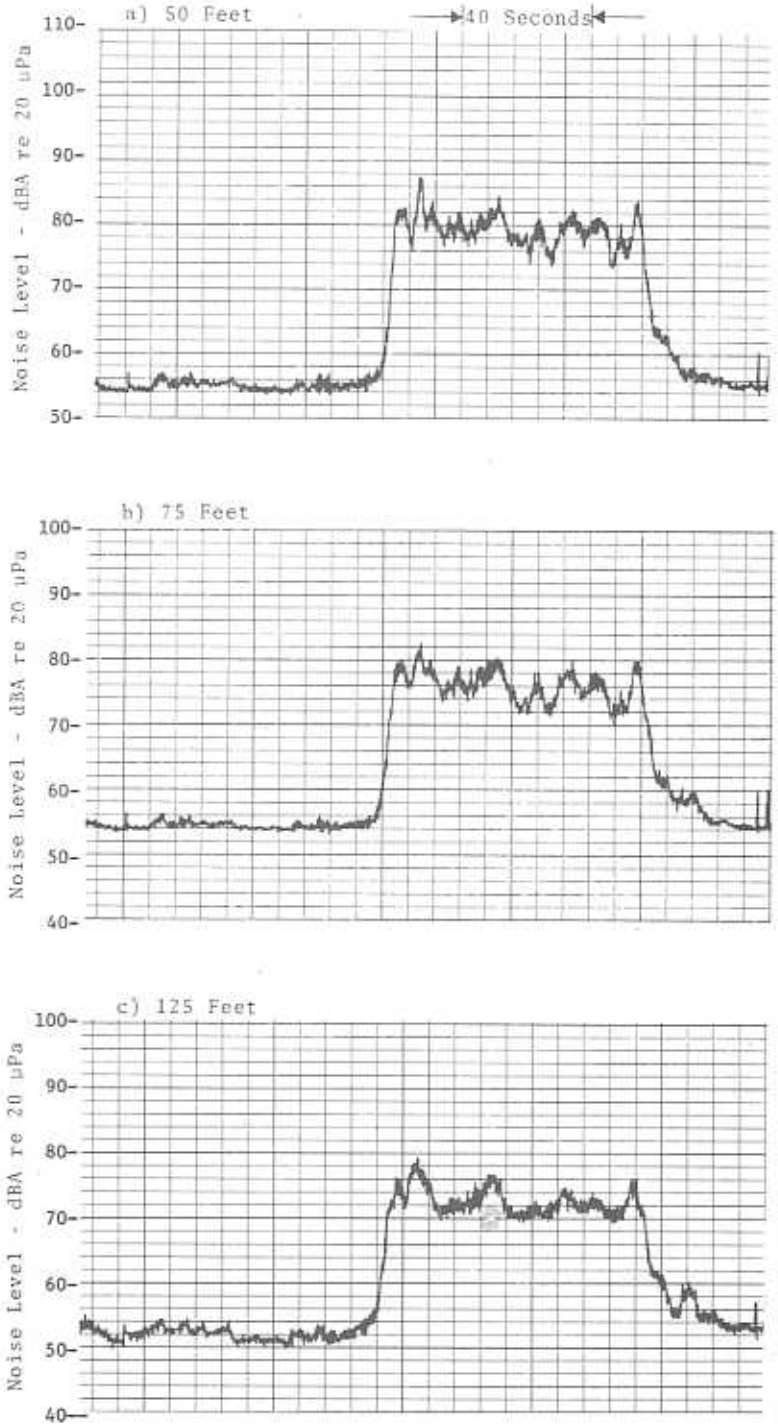


Figure C-15. Coincident Time Histories - Wayside noise Levels at 50, 75, and 125 Feet from Center-line of Track 4. Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 3 Electric Locomotives Plus 71 Cars, 40 mph.

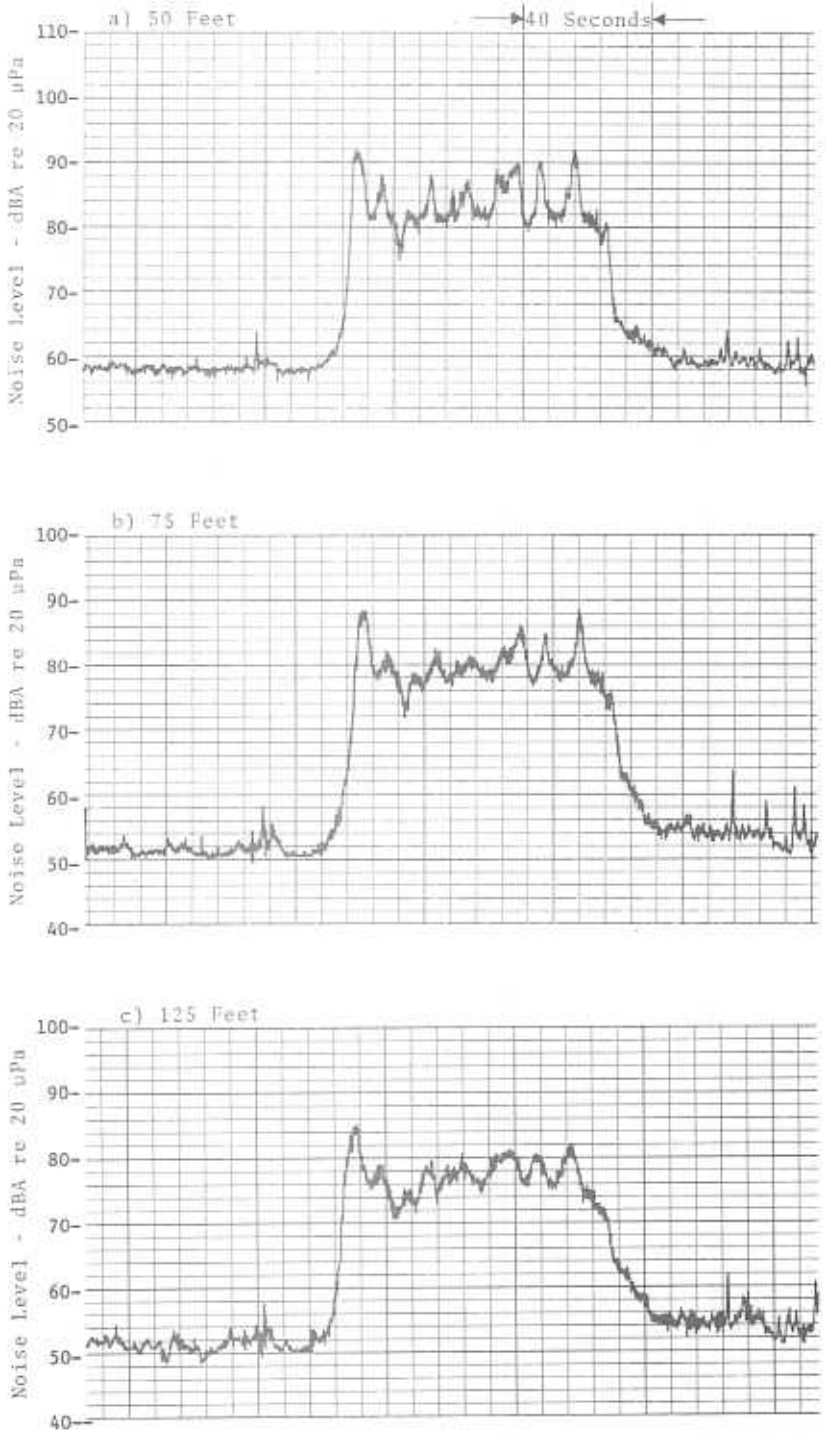


Figure C-16. Coincident Time Histories - Wayside Noise Levels at 50, 75, and 125 Feet from Center-line of Track 4, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 3 Electric Locomotives Plus 99 Cars, 48 mph.

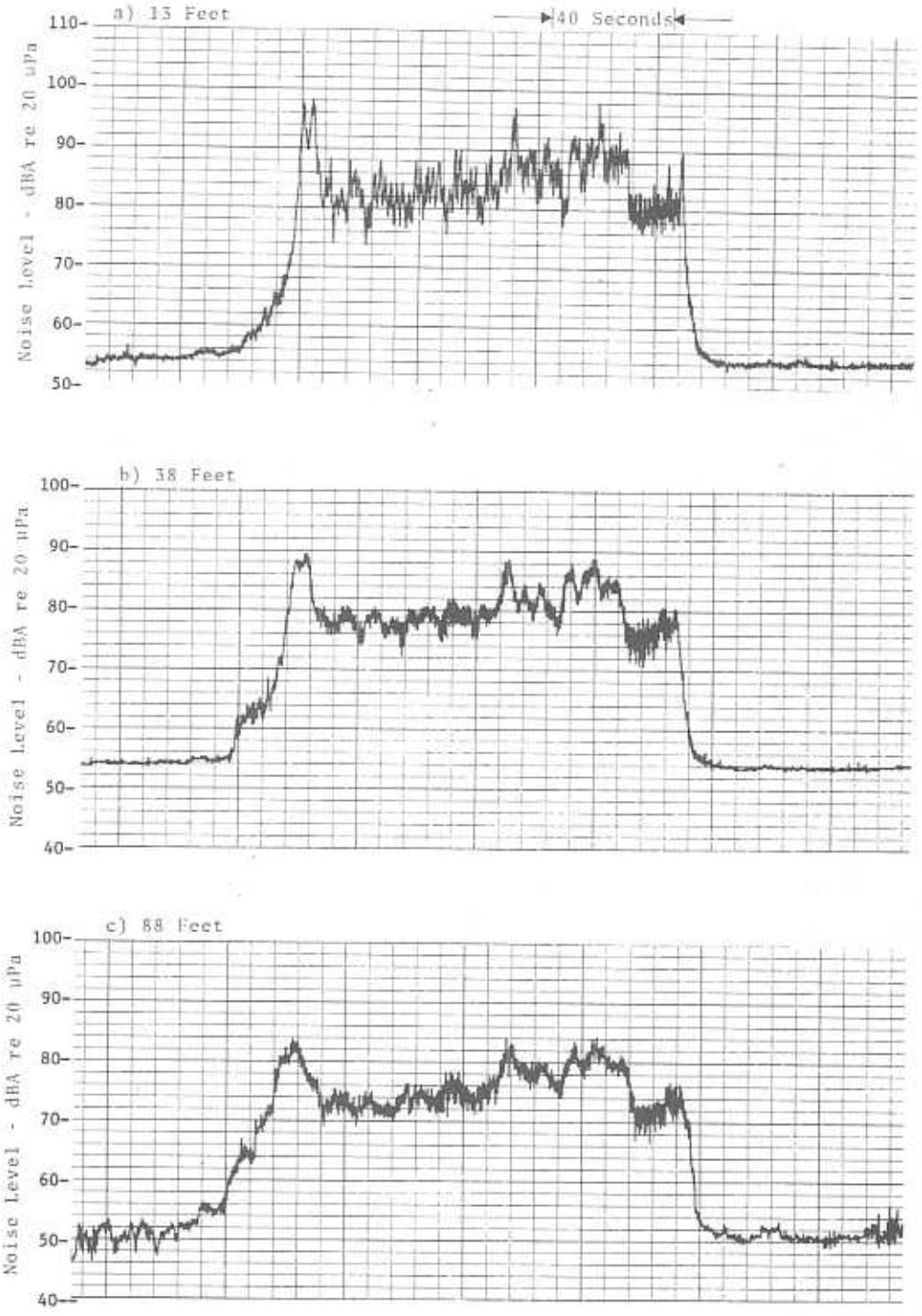


Figure C-17. Coincident Time Histories - Wayside Noise Levels at 13, 38, and 88 Feet from Center-line of Track 1, Penn Central RR, Plainsboro NJ, 5/23/72, Freight Train, 2 Electric Locomotives Plus 79 Cars, 31 mph.

APPENDIX D

PASSENGER AND LINE-HAUL NOISE LEVEL DATA MEASURED AT THREE WAYSIDE LOCATIONS OF THE PENN CENTRAL RR, BOSTON-TO-NEW YORK LINE, WEST MANSFIELD MA

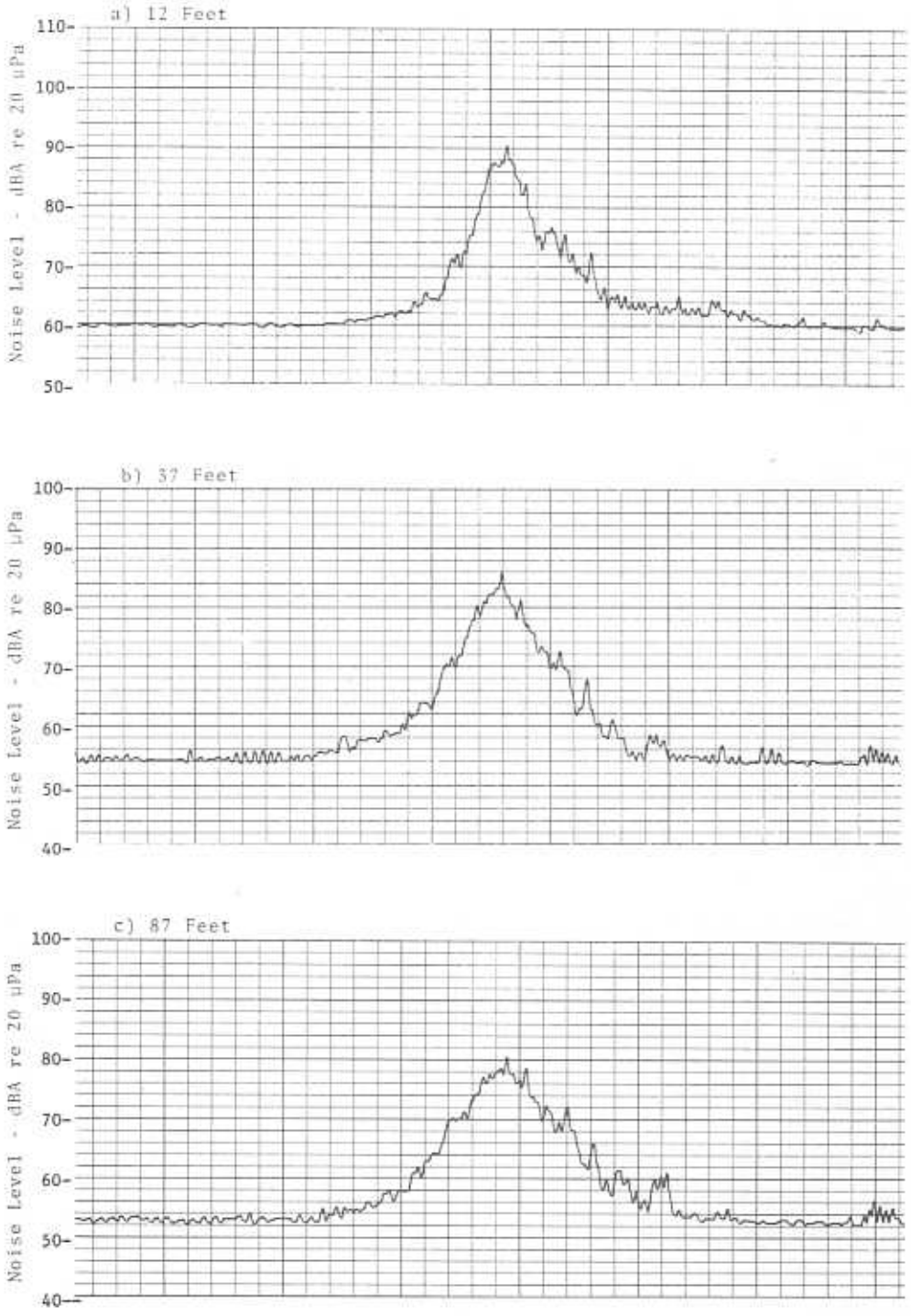


Figure D-1. Coincident Time Histories - Wayside Noise Levels at 12, 37, and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA. 9/26/72, Single Budd Liner, 65 mph

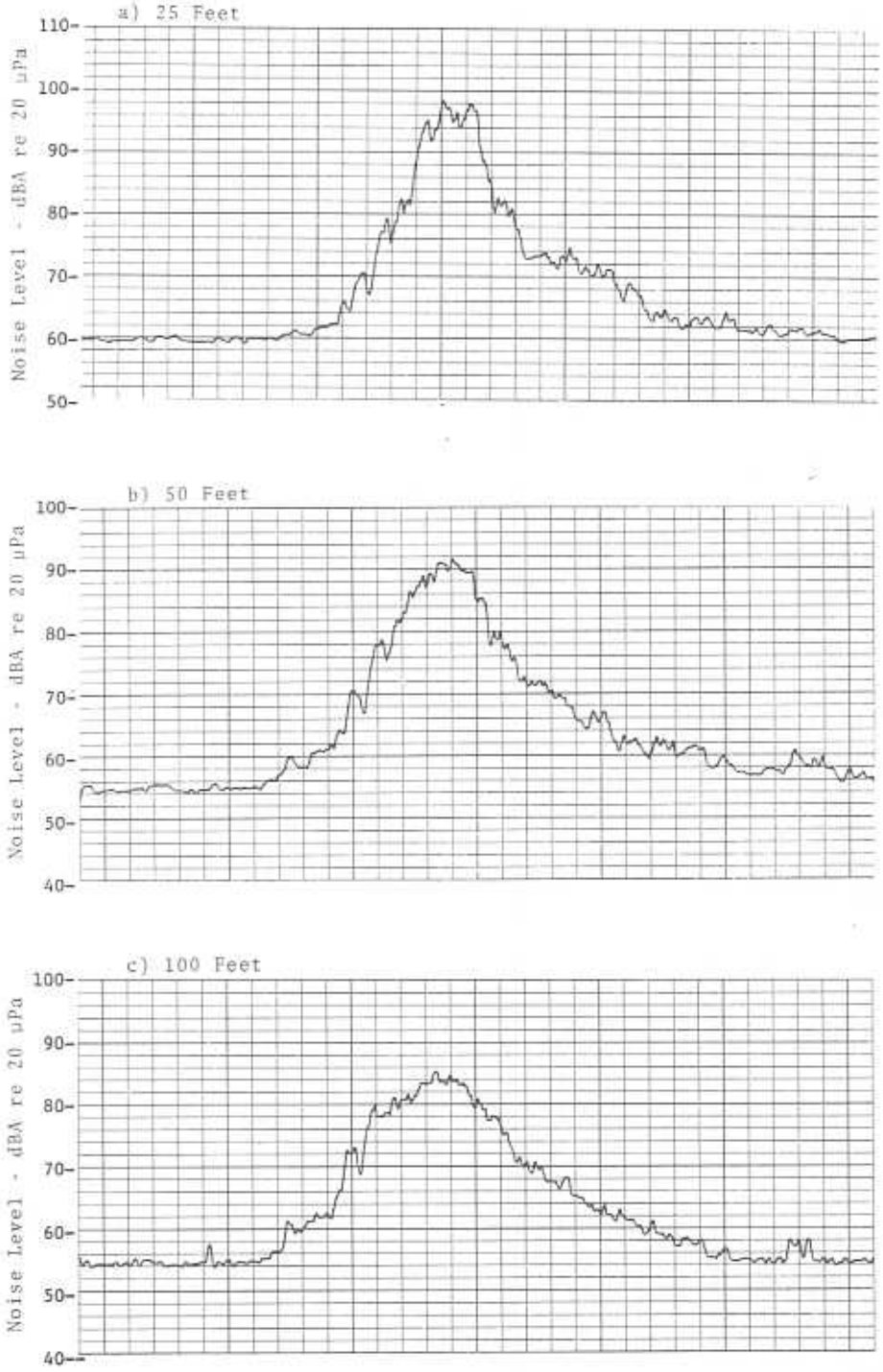


Figure D-2. Coincident Time Histories - Wayside Noise Levels at 25, 50, and 100 Feet from Center-line of Track 1, Penn Central RR, West Mansfield MA, 9/26/72 Two Coupled Budd Liners, 63 mph

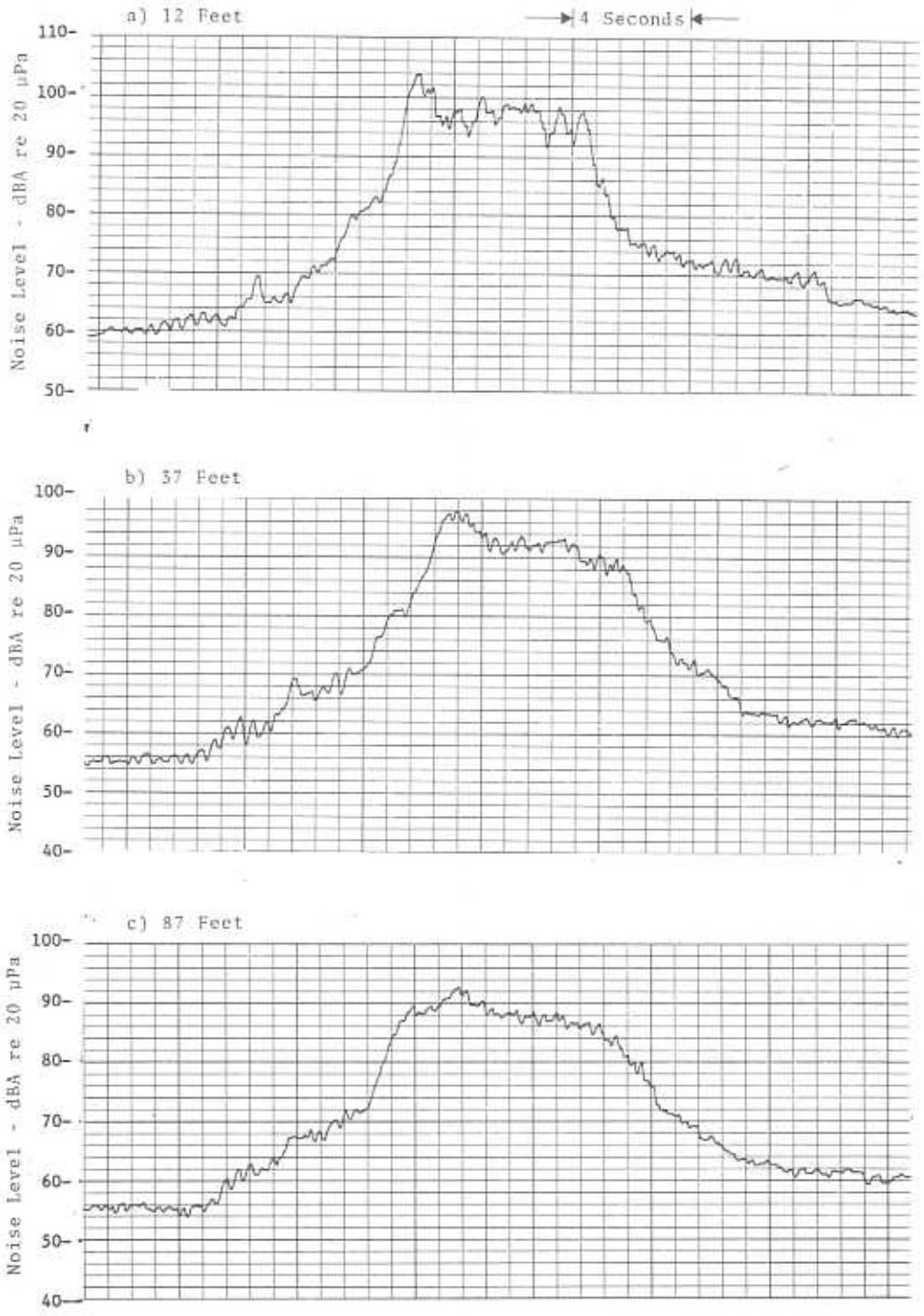


Figure D-3. Coincident Time Histories - Wayside Noise Levels at 12, 37, and 87 Feet from Center-line of Track 2, Penn Central RR, in West Mansfield MA, 9/26/72, Passenger Train, Diesel Locomotive Plus 6 Cars, 66 mph

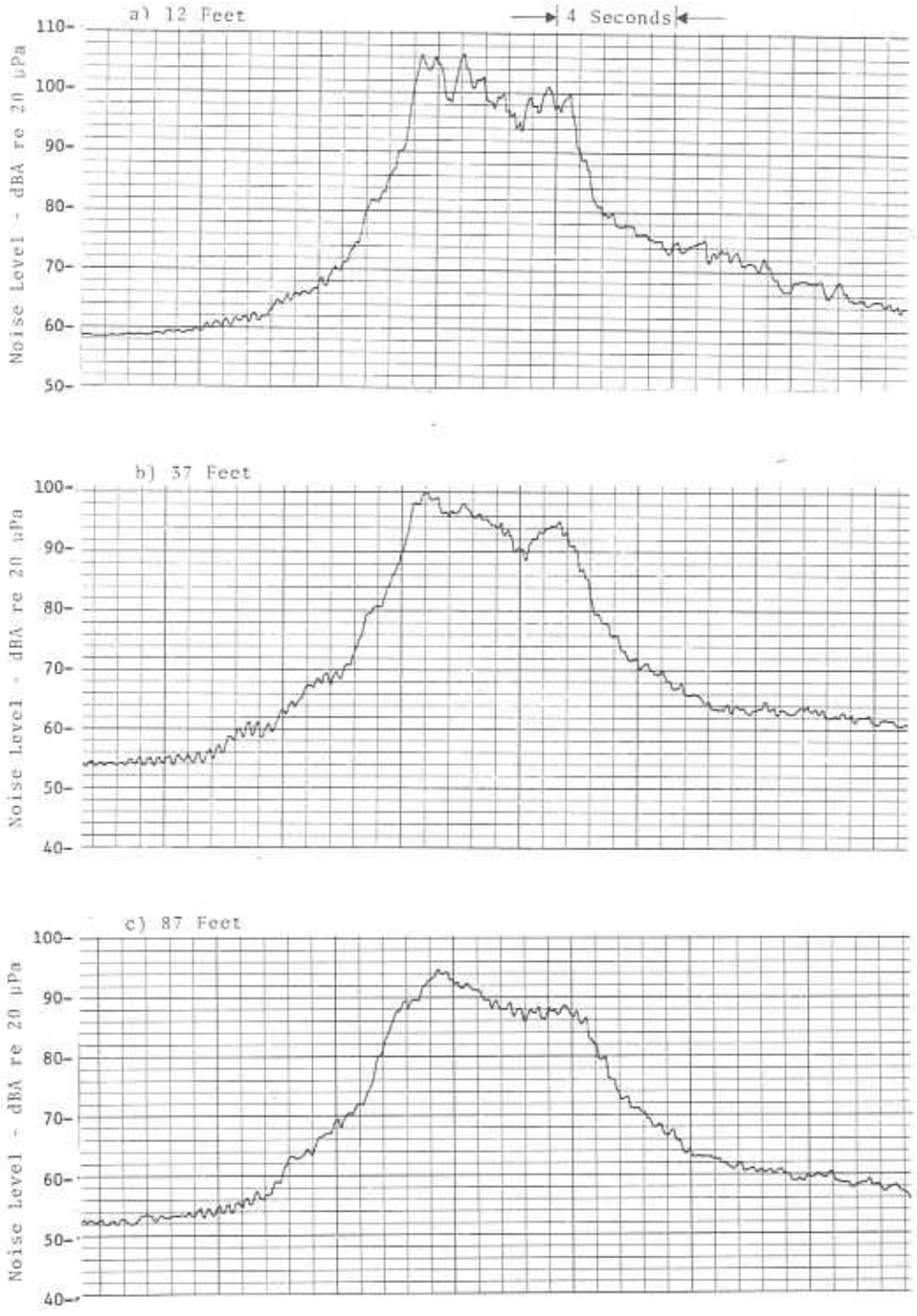


Figure D-4. Coincident Time Histories - Wayside Noise Levels at 12, 37, and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Passenger Train, 2 Diesel Locomotives, Plus 6 Cars, 79 mph

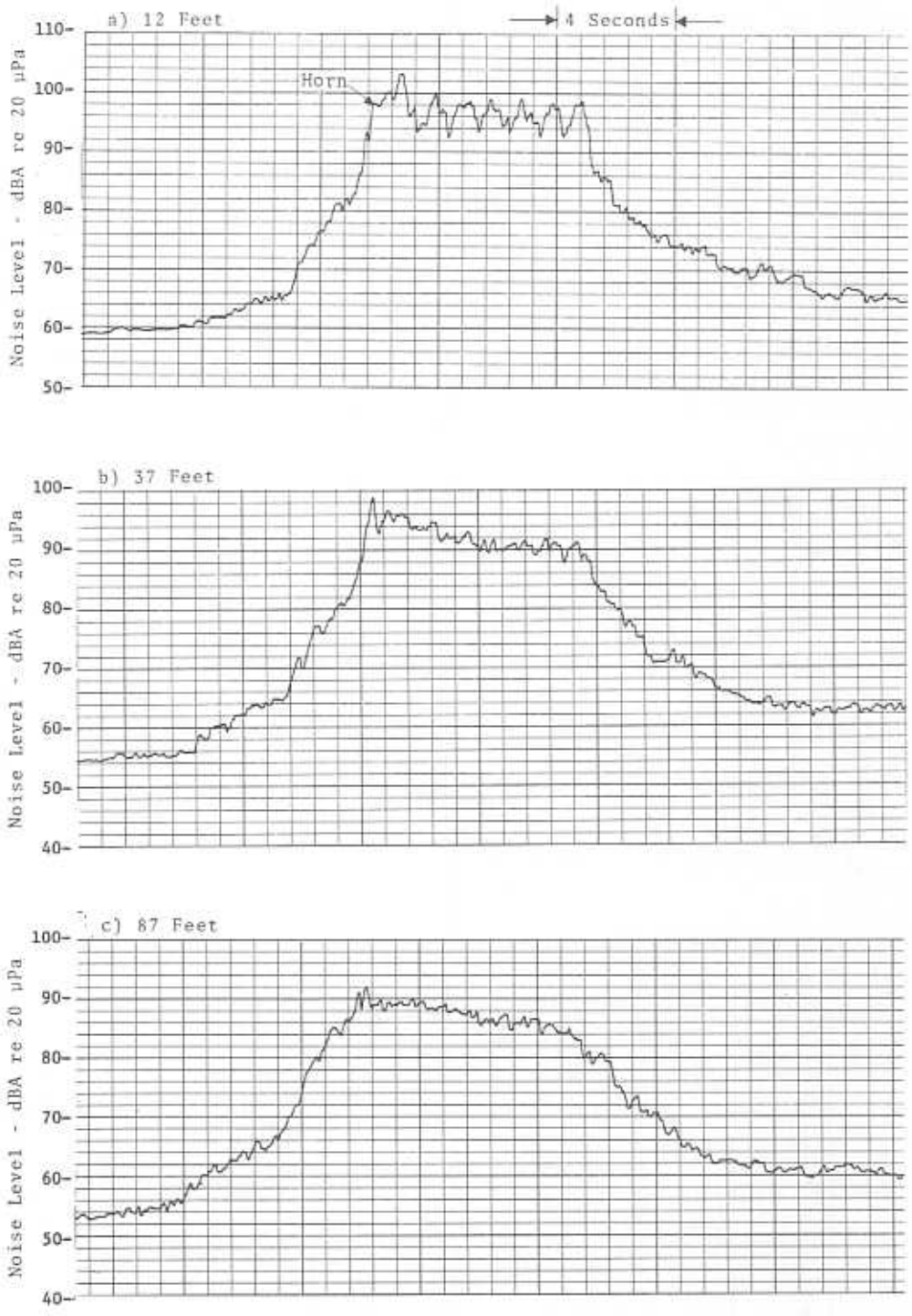


Figure D-5. Coincident Time Histories - Wayside Noise Levels at 12, 37, and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Passenger Train, Diesel Locomotive Plus 6 Cars, 57 mph

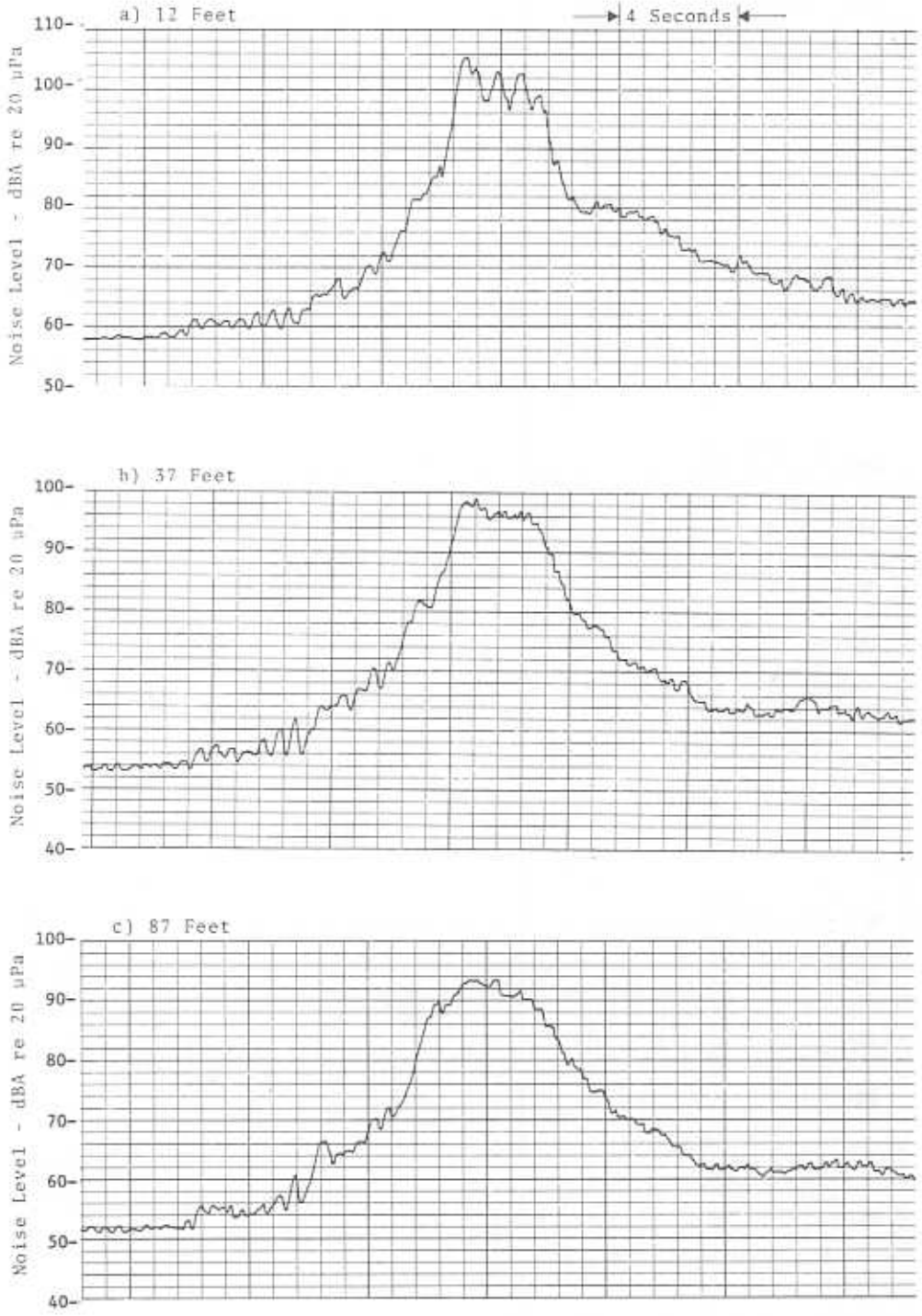


Figure D-6. Coincident Time Histories - Wayside Noise Levels at 12, 37, and 87 feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Passenger Train, Diesel Locomotive Plus 3 Cars, 78 mph

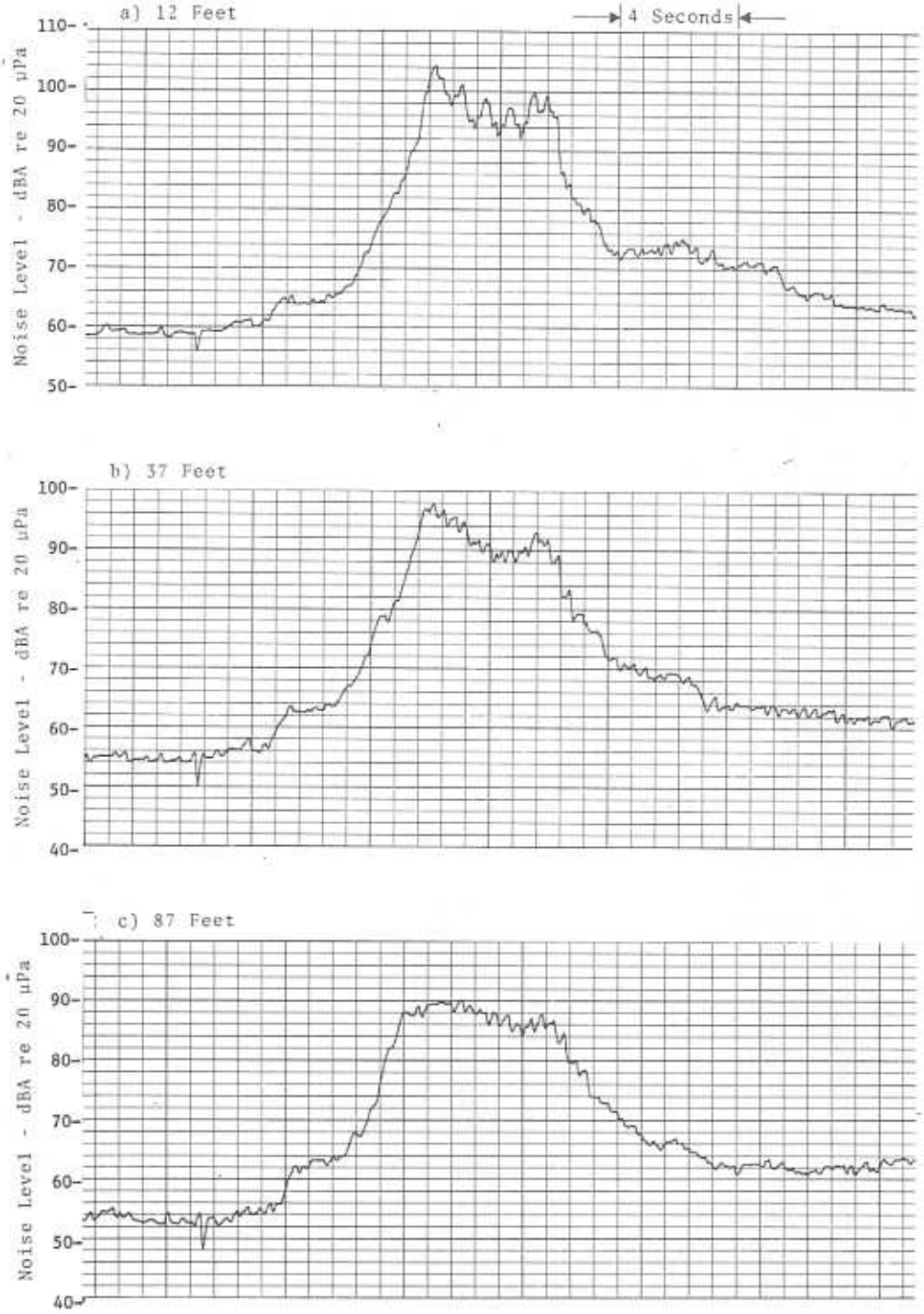
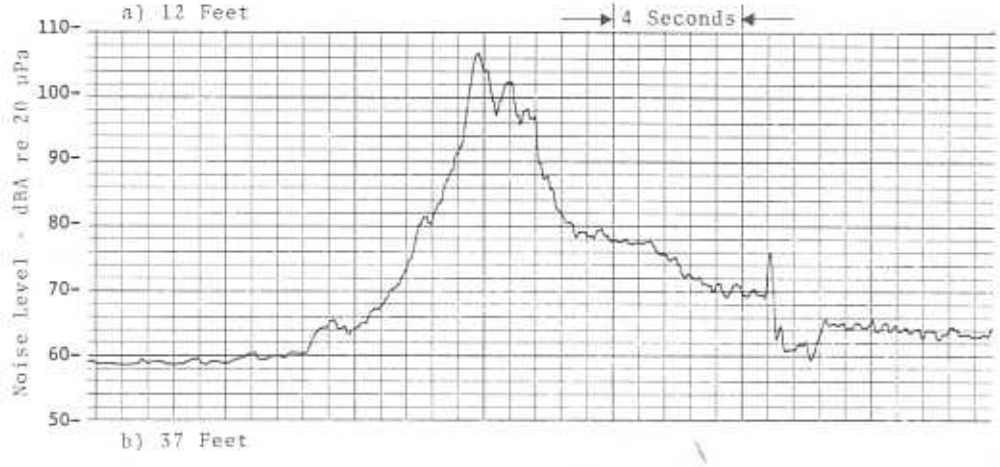


Figure D-7. Coincident Time Histories - Wayside Noise Levels at 12, 37 and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72 Passenger Train, Diesel Locomotive Plus 5 Cars, 74 mph



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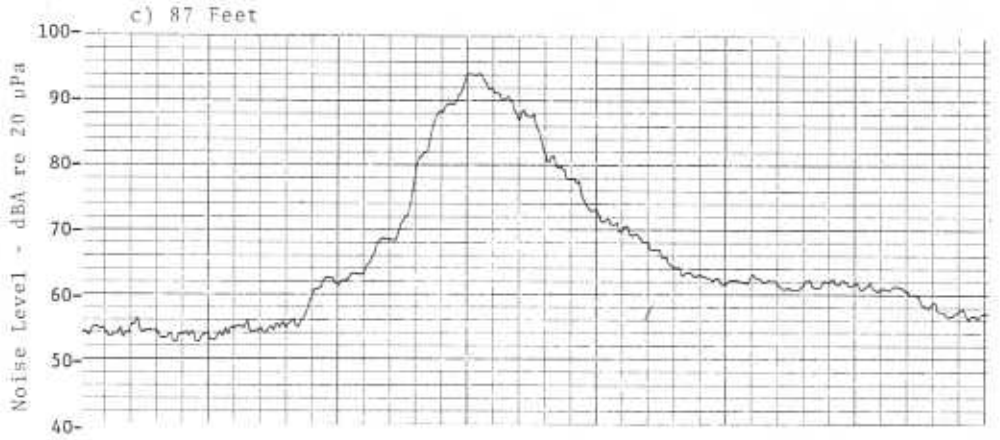


Figure D-8. Coincident Time Histories - Wayside Noise Levels at 12 and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Passenger Train, Diesel Locomotive Plus 2 Cars, 79 mph

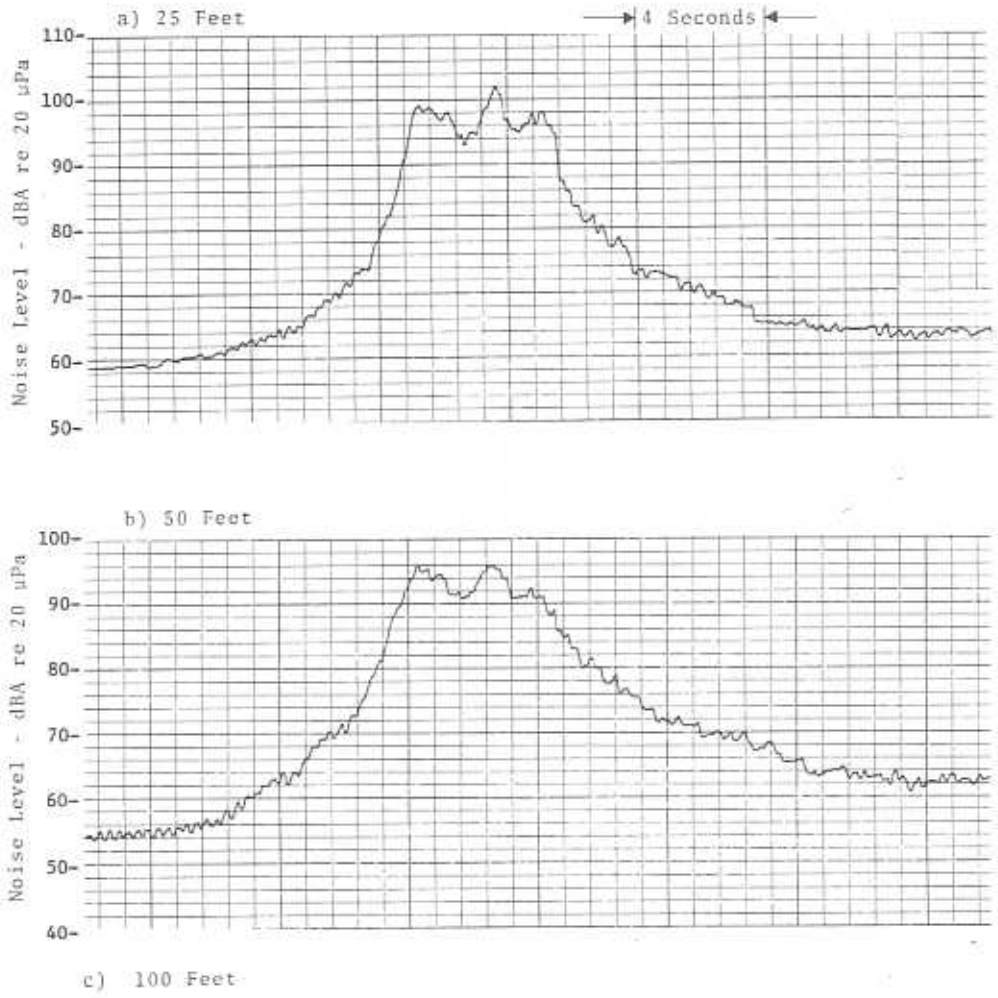


Figure D-9. Coincident Time Histories - Wayside Noise Levels at 25 and 50 Feet from Center-line of Track 1, Penn Central RR, West Mansfield MA, 9/20/72, Passenger Train, Diesel Locomotive Plus 5 Cars, 78 mph

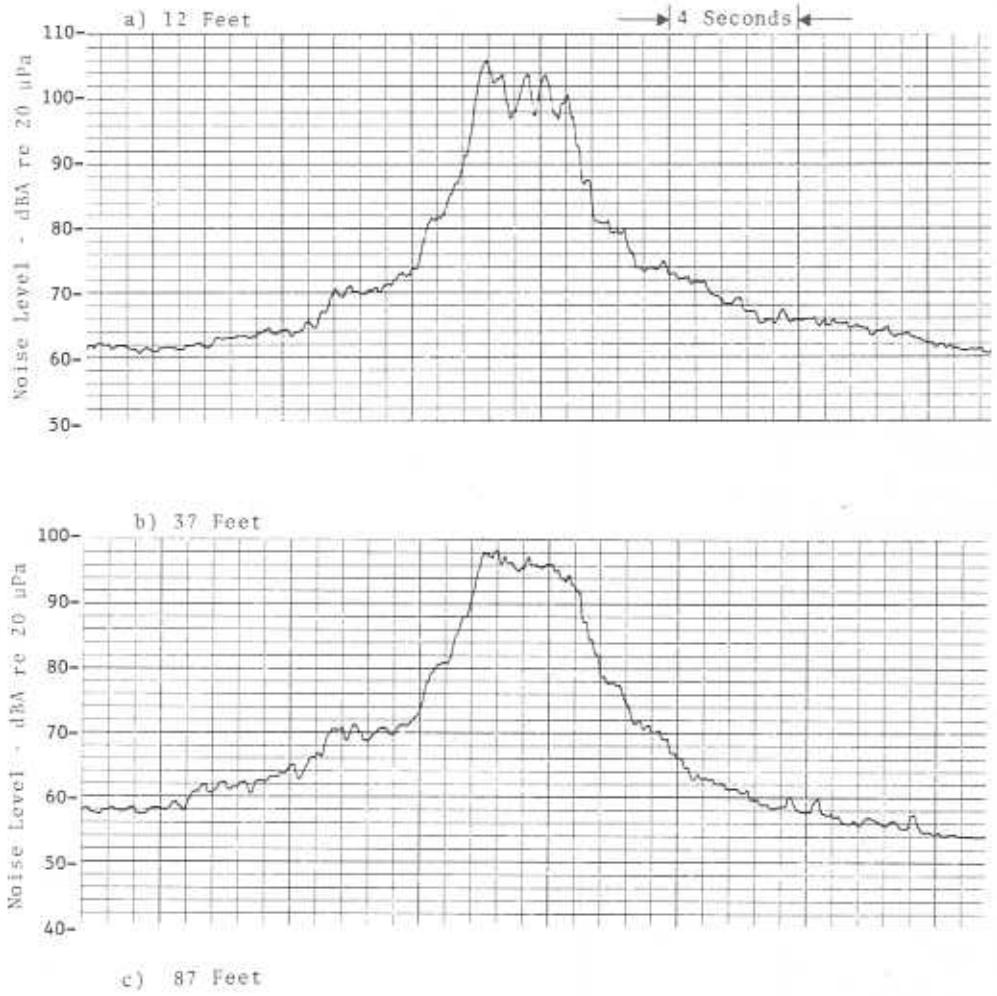


Figure D-10. Coincident Time Histories - Wayside Noise Levels at 12 and 37 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/20/72, Passenger Train Diesel Locomotive Plus 3 Cars, 80 mph

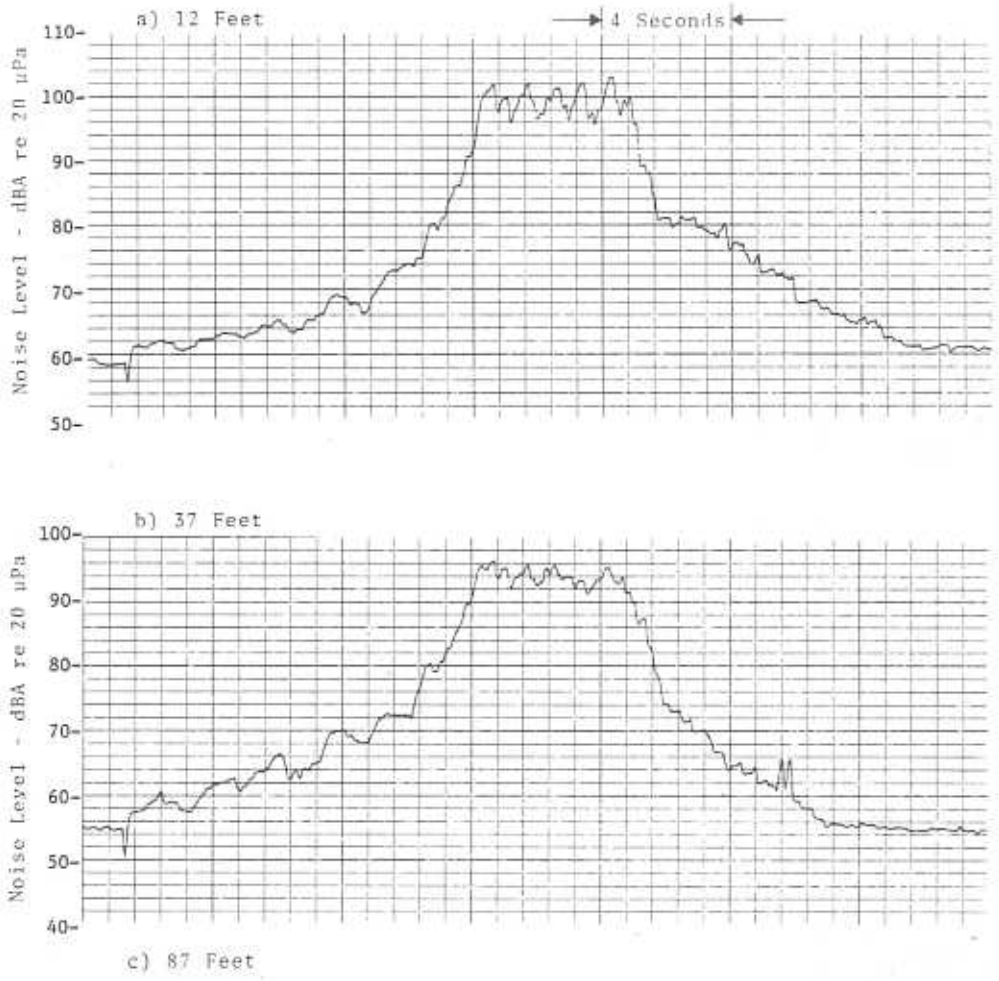


Figure D-11. Coincident Time Histories - Wayside Noise Levels at 12 and 37 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/20/72, Passenger Train, Diesel Locomotive Plus 5 Cars, 72 mph

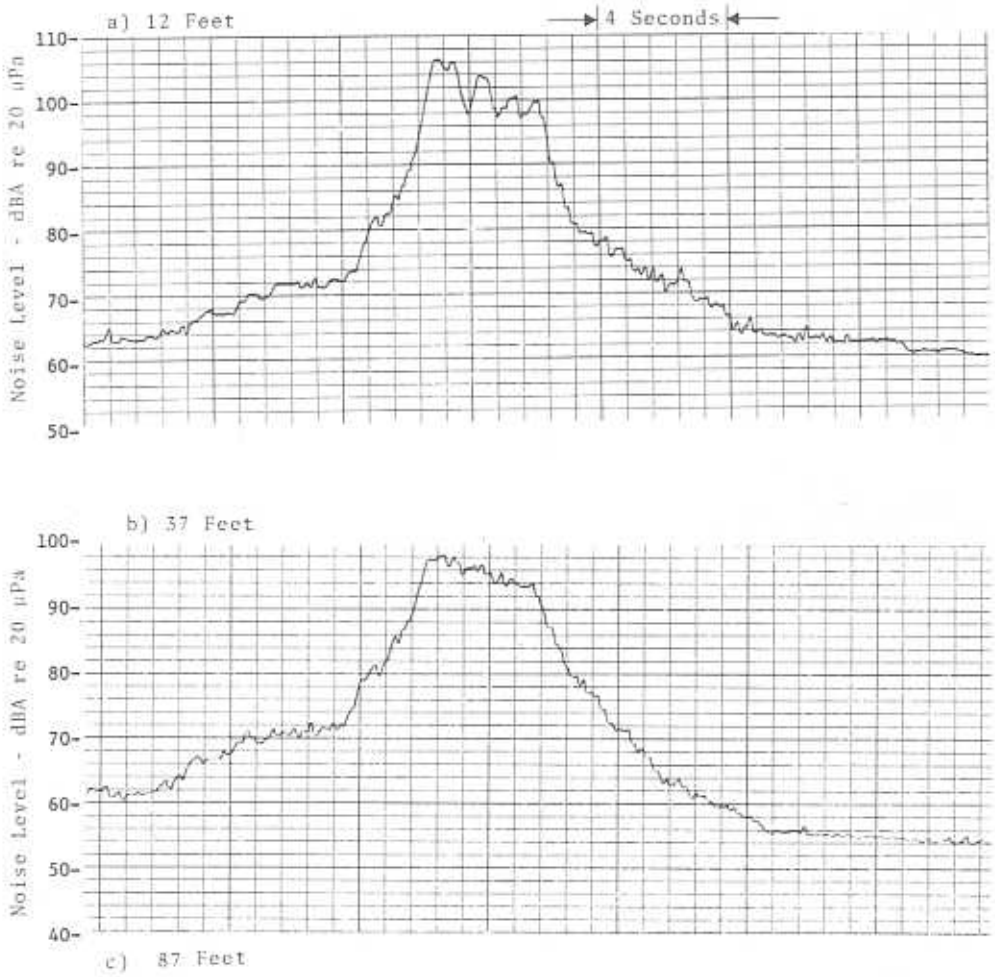
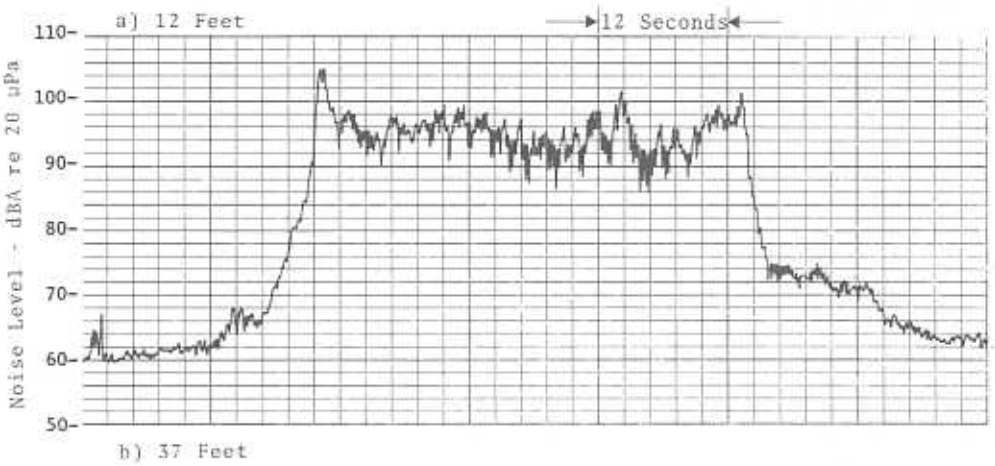


Figure D-12. Coincident Time Histories - Wayside Noise Levels at 12 and 37 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/20/72, Passenger Train, Diesel Locomotive Plus 3 Cars, 61 mph



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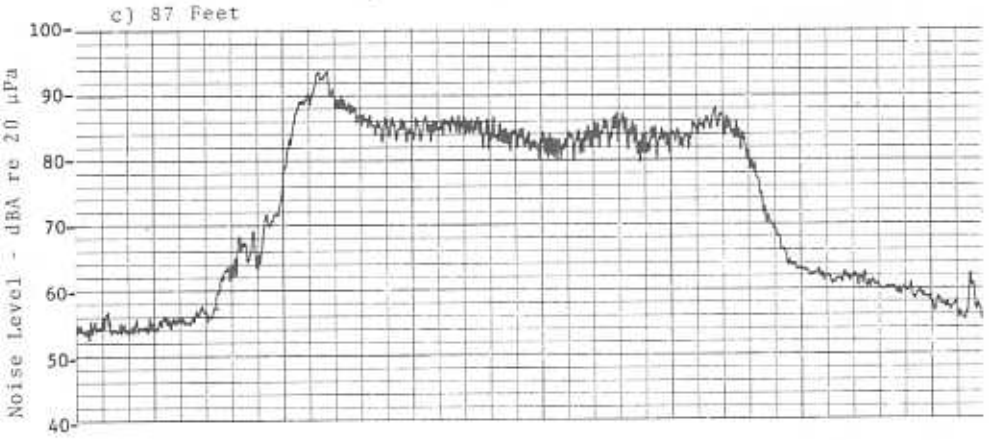
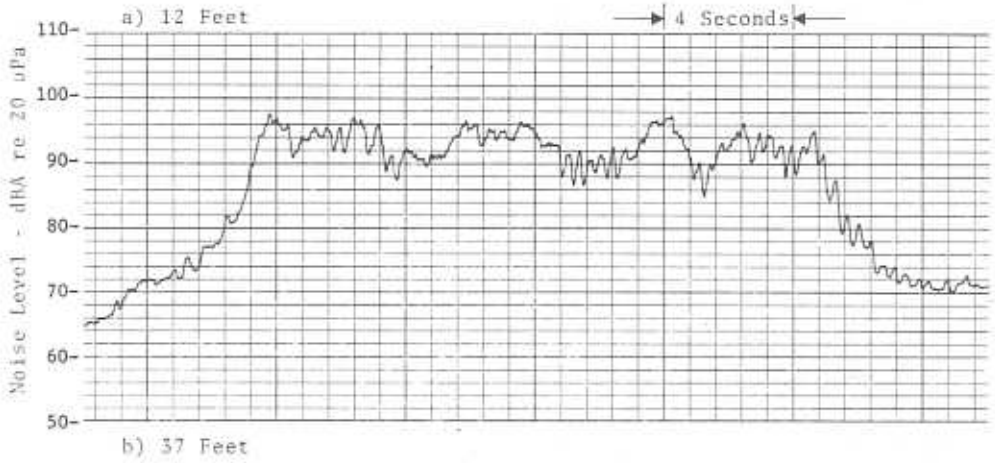


Figure D-13. Coincident Time Histories - Wayside Noise Levels at 12 and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Freight Train, 2 Diesel Locomotives Plus 47 Cars, 46 mph



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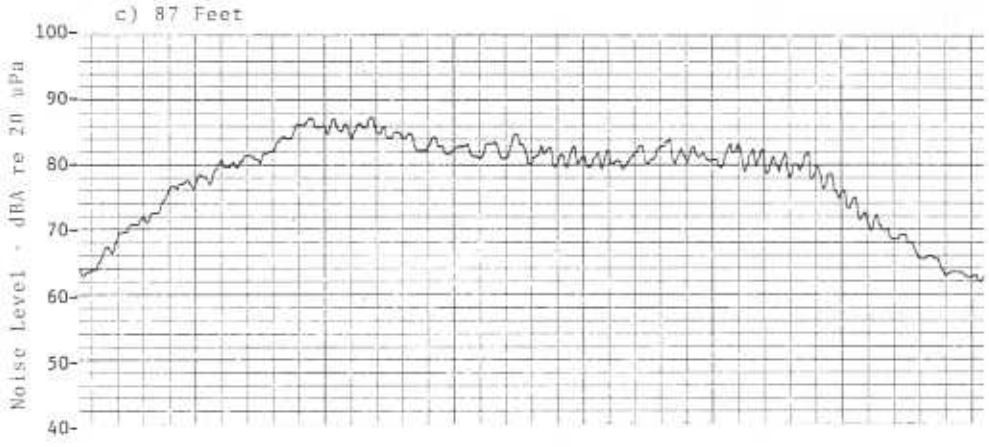
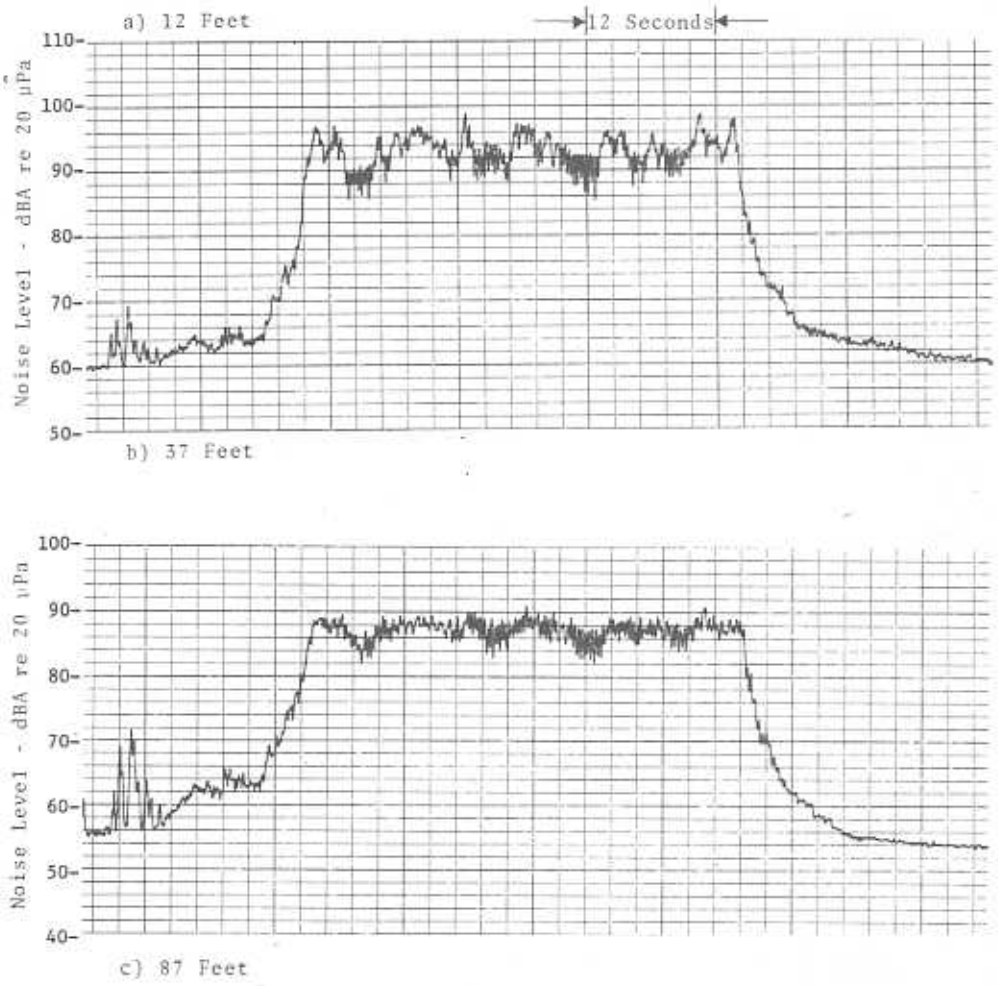
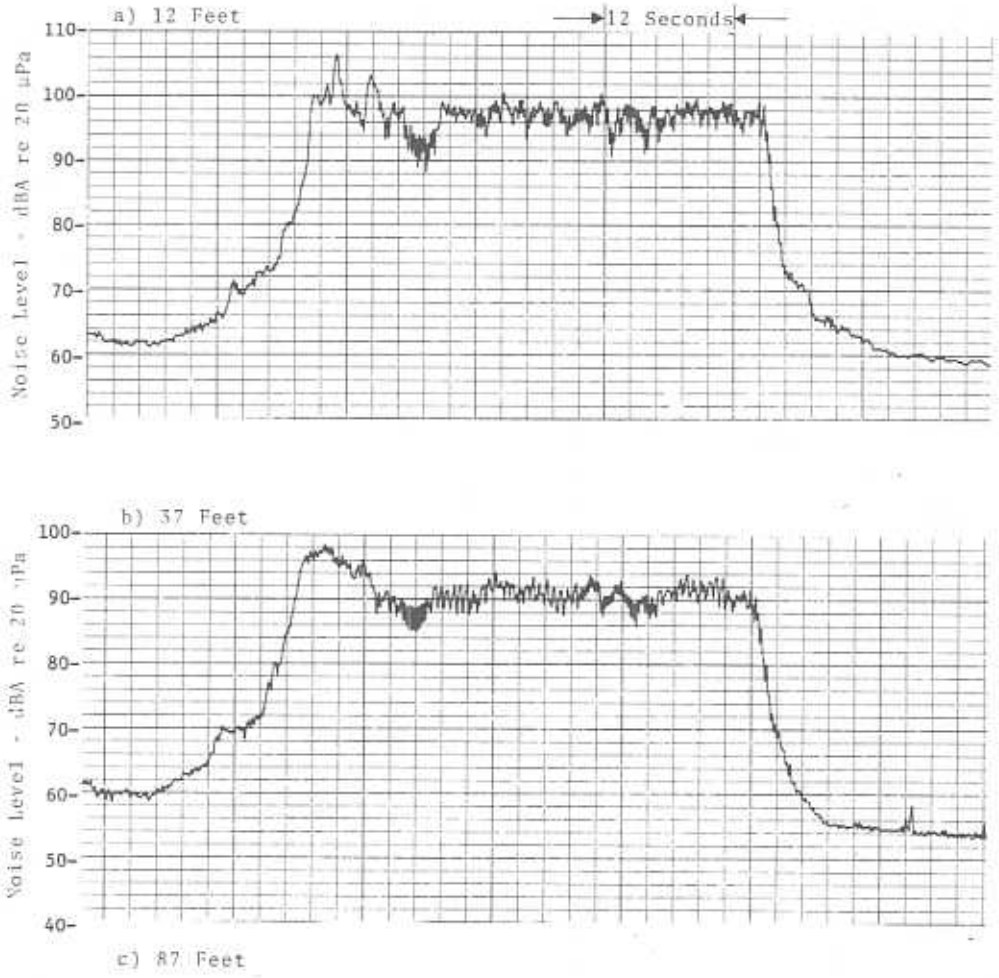


Figure D-14. Coincident Time Histories - Wayside Noise Levels at 12 and 87 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/26/72, Freight Train, Diesel Locomotive Plus 18 Cars, 38 mph



No Data

Figure D-15. Coincident Time Histories - Wayside Noise Levels at 12 and 37 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/20/72, Freight Train, 2 Diesel Locomotives Plus 45 Cars, 40 mph



No Data

Figure D-16. Coincident Time Histories - Wayside Noise Levels at 12 and 37 Feet from Center-line of Track 2, Penn Central RR, West Mansfield MA, 9/20/72, Freight Train, 5 Diesel Locomotives Plus 57 Cars, 54 mph

APPENDIX E
MEASURING STATION LOCATIONS AND PHOTOGRAPHS

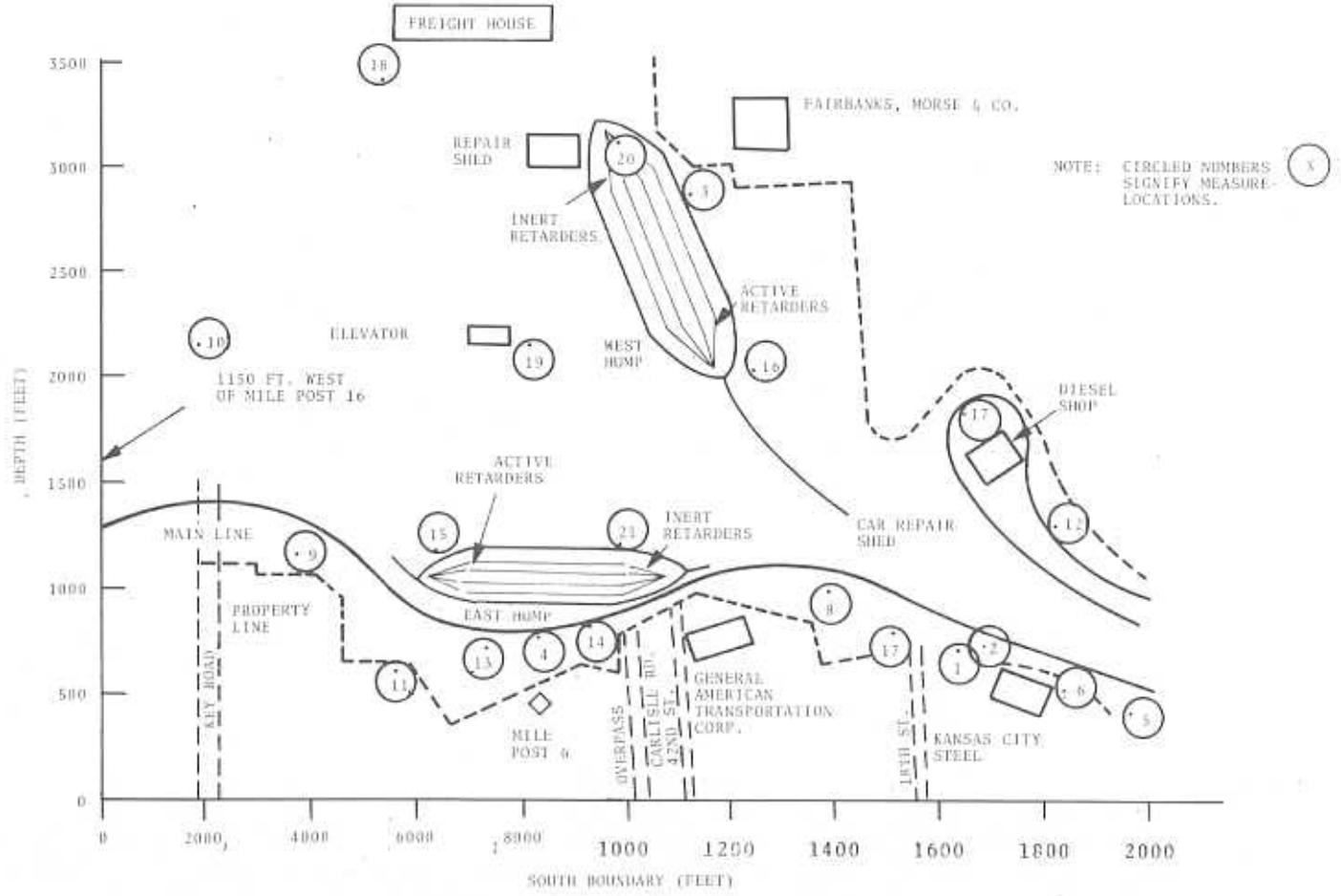


Figure E-1. Schematic Layout (Measurement Locations), Argentine Freight Yard, Santa Fe RR Kansas City KS

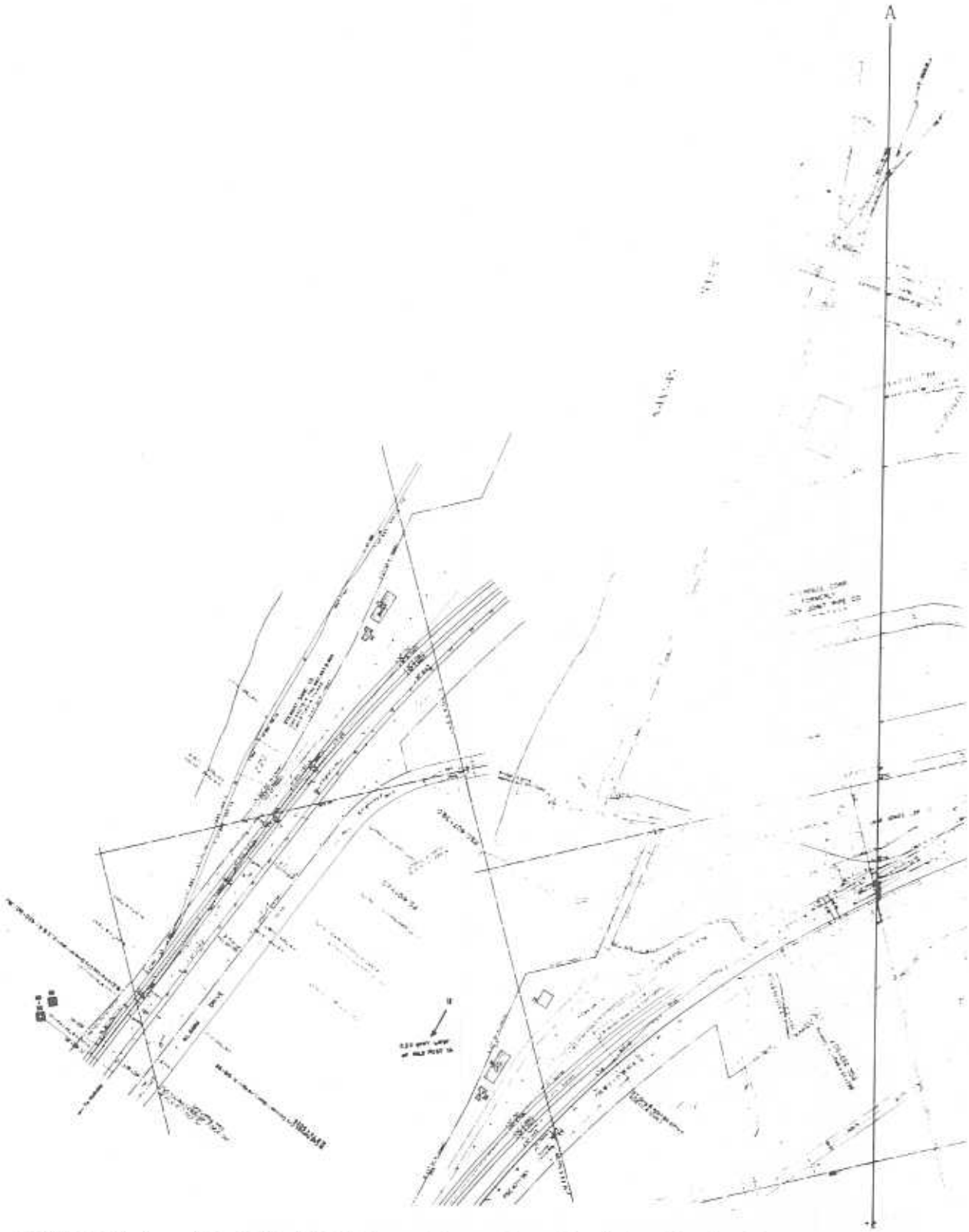


Figure E-2. Freight Yard Map, Argentine Freight Yard, Santa Fe RR Kansas City KS

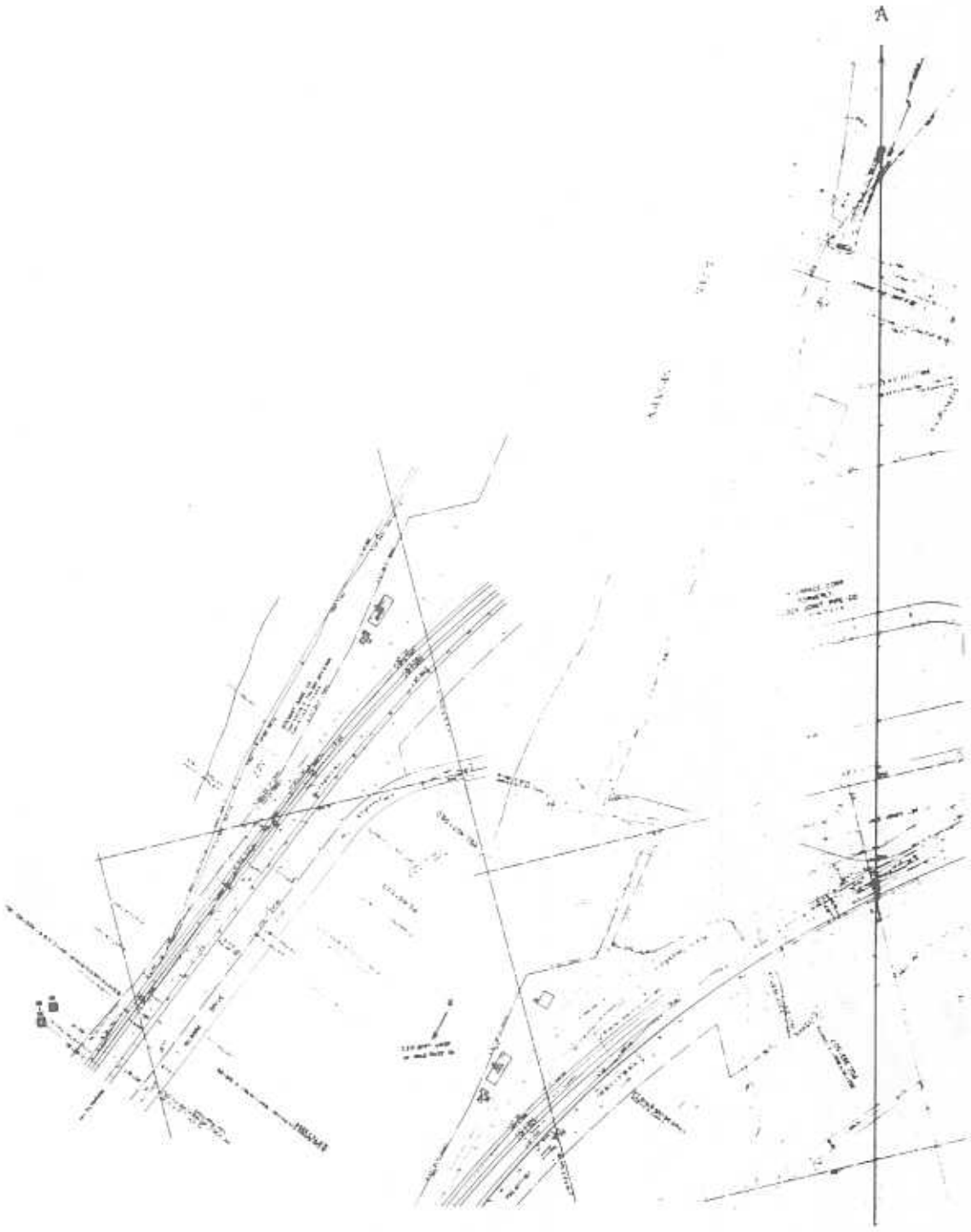


Figure E-2. (Continued) Freight Yard Map, Argentine Freight Yard, Santa Fe RR Kansas City KS

Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

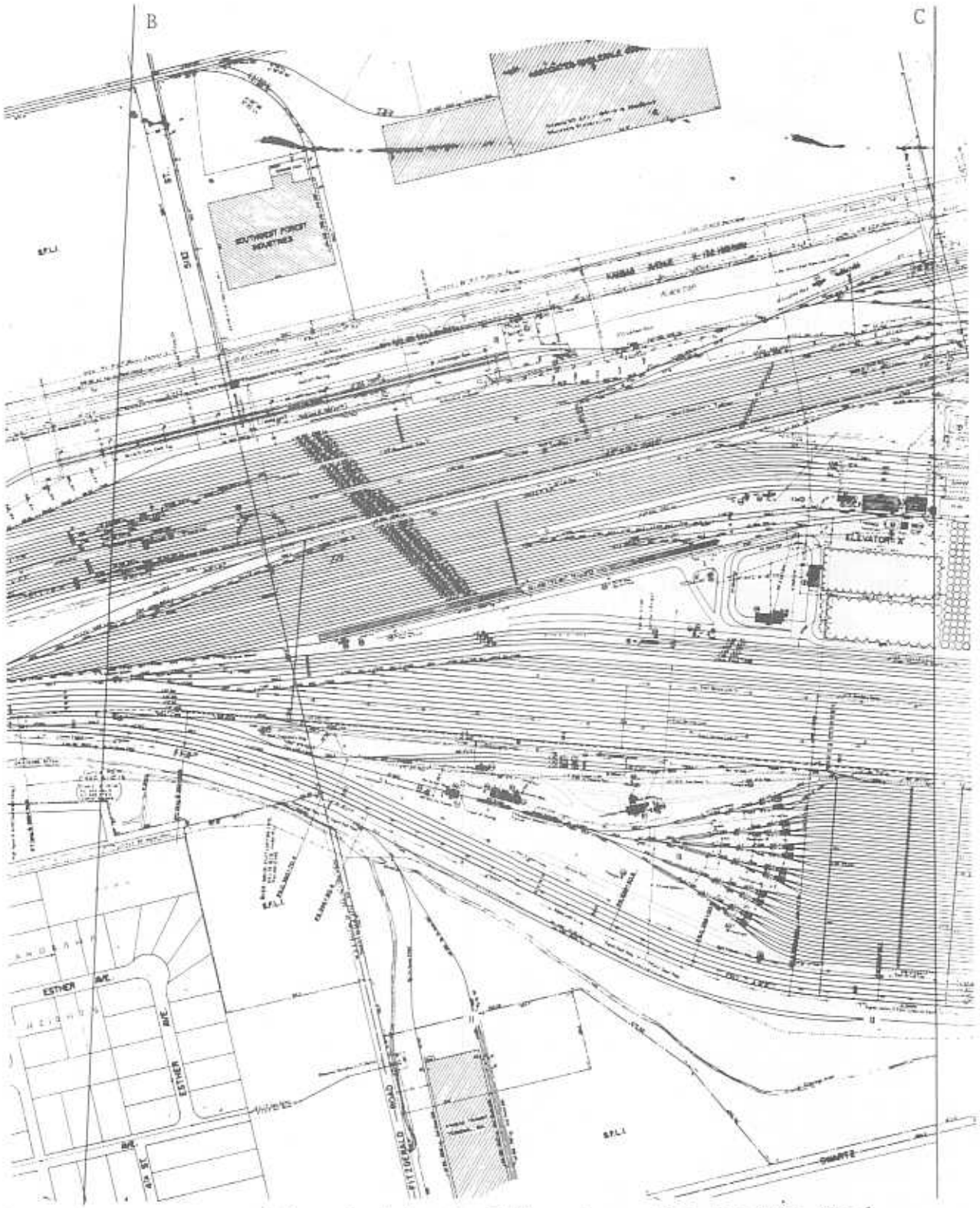


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

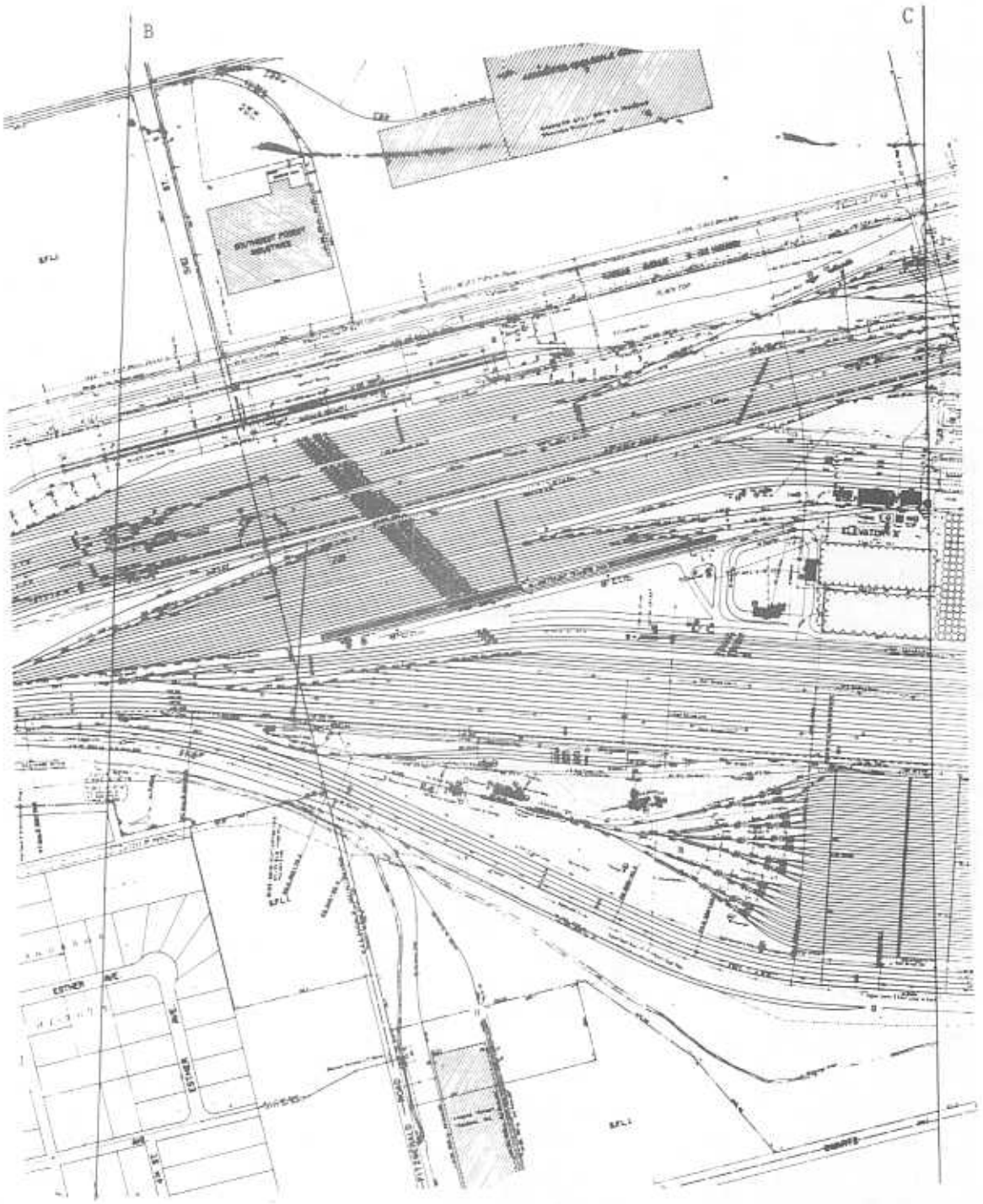


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

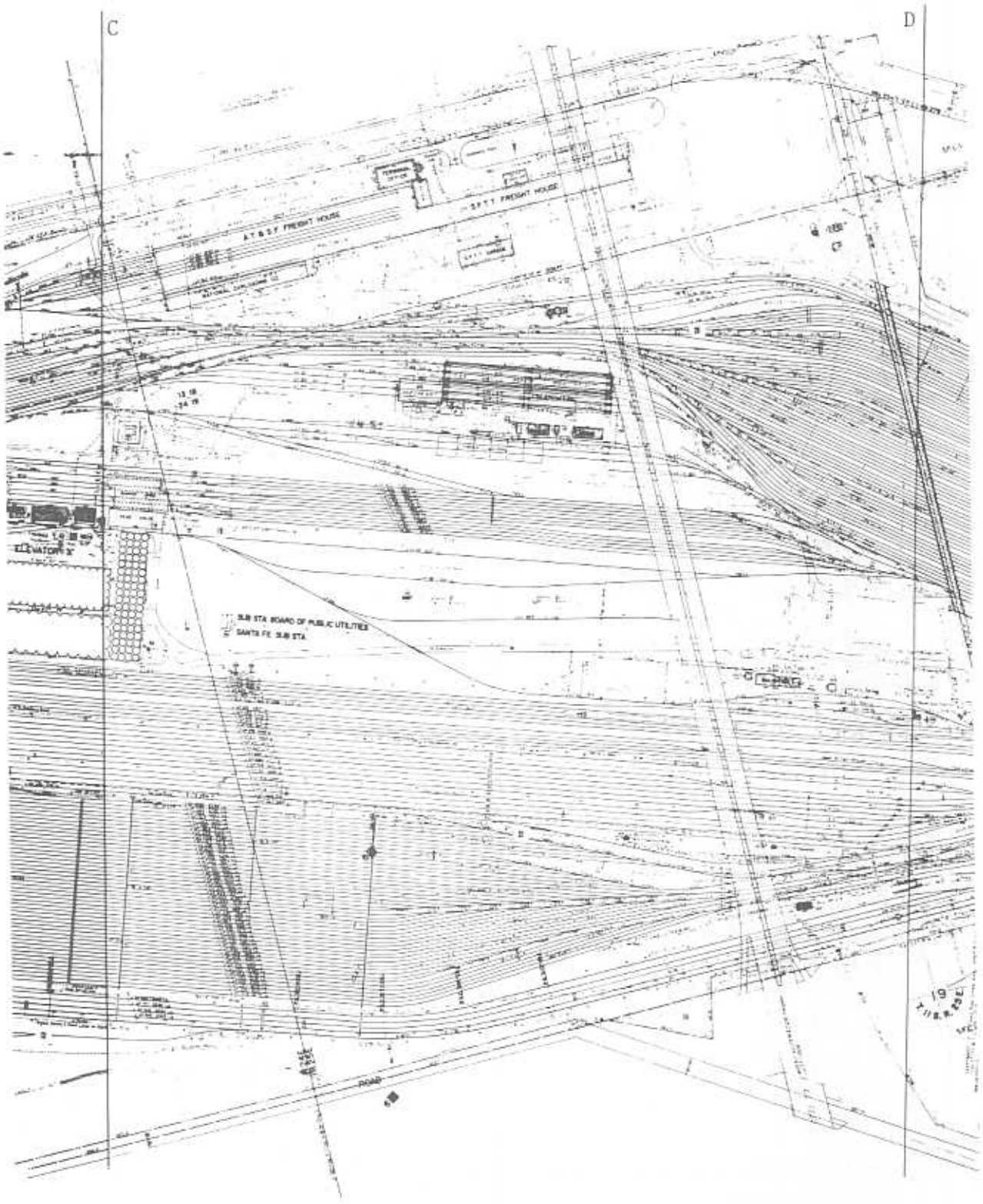


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

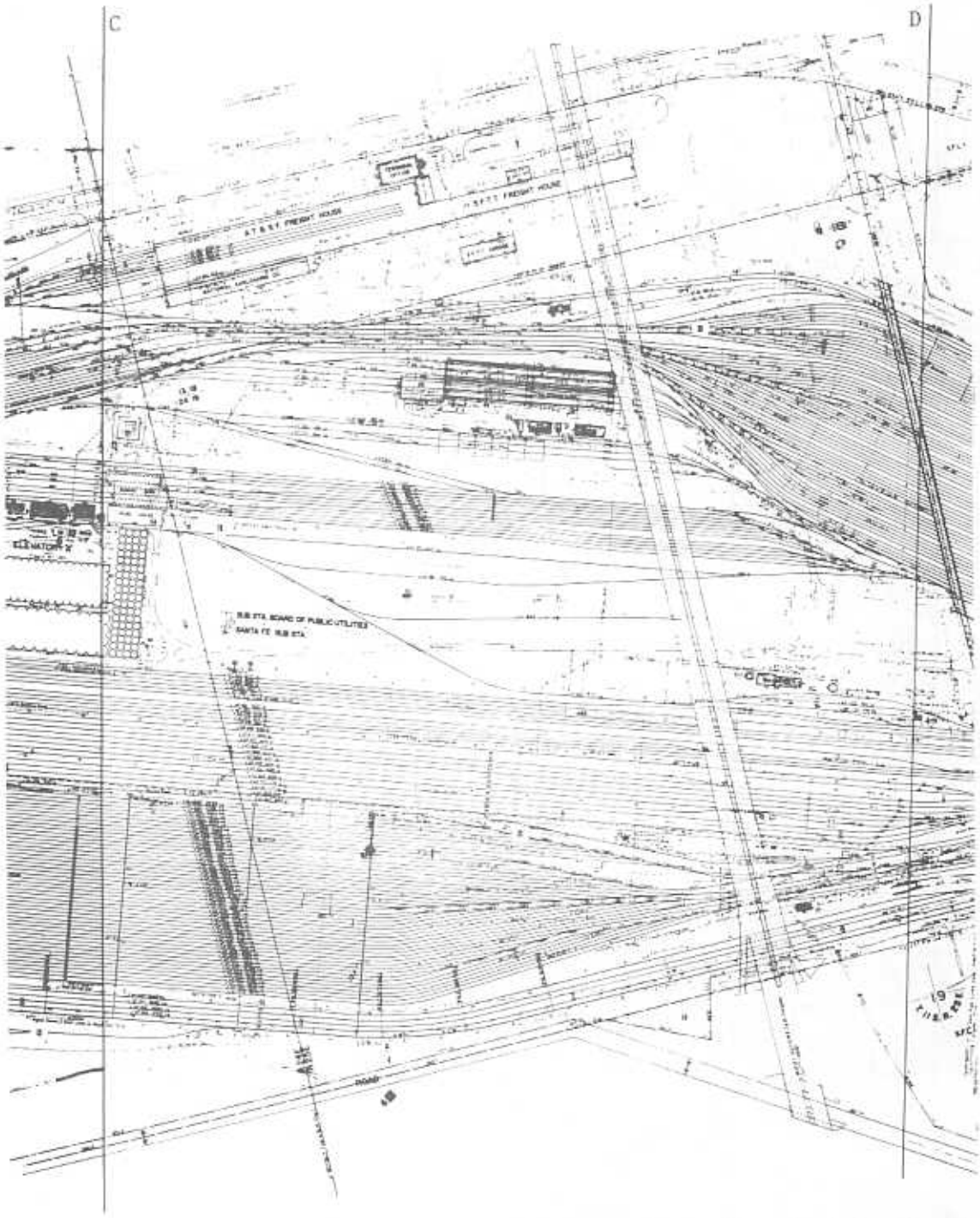


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

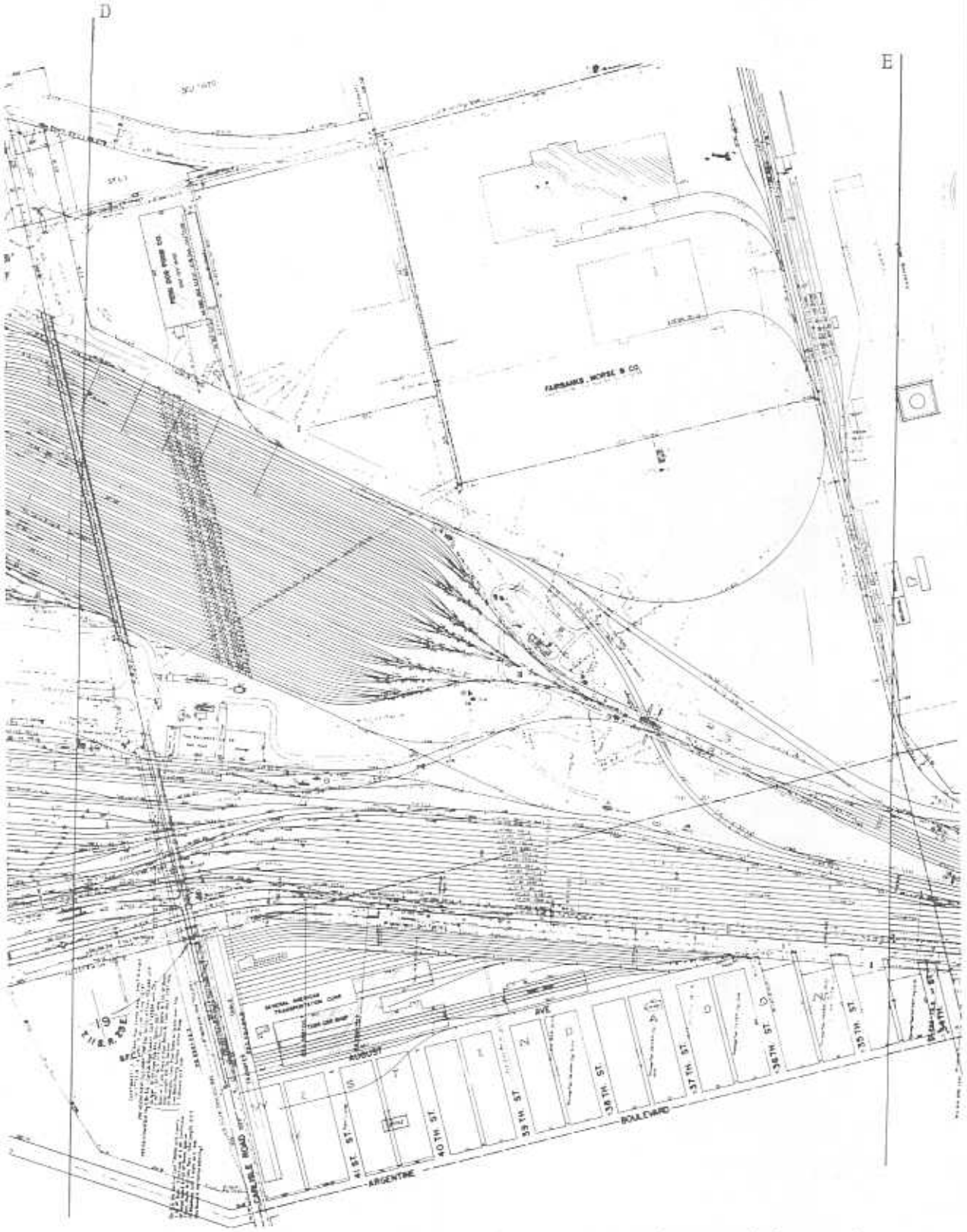


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

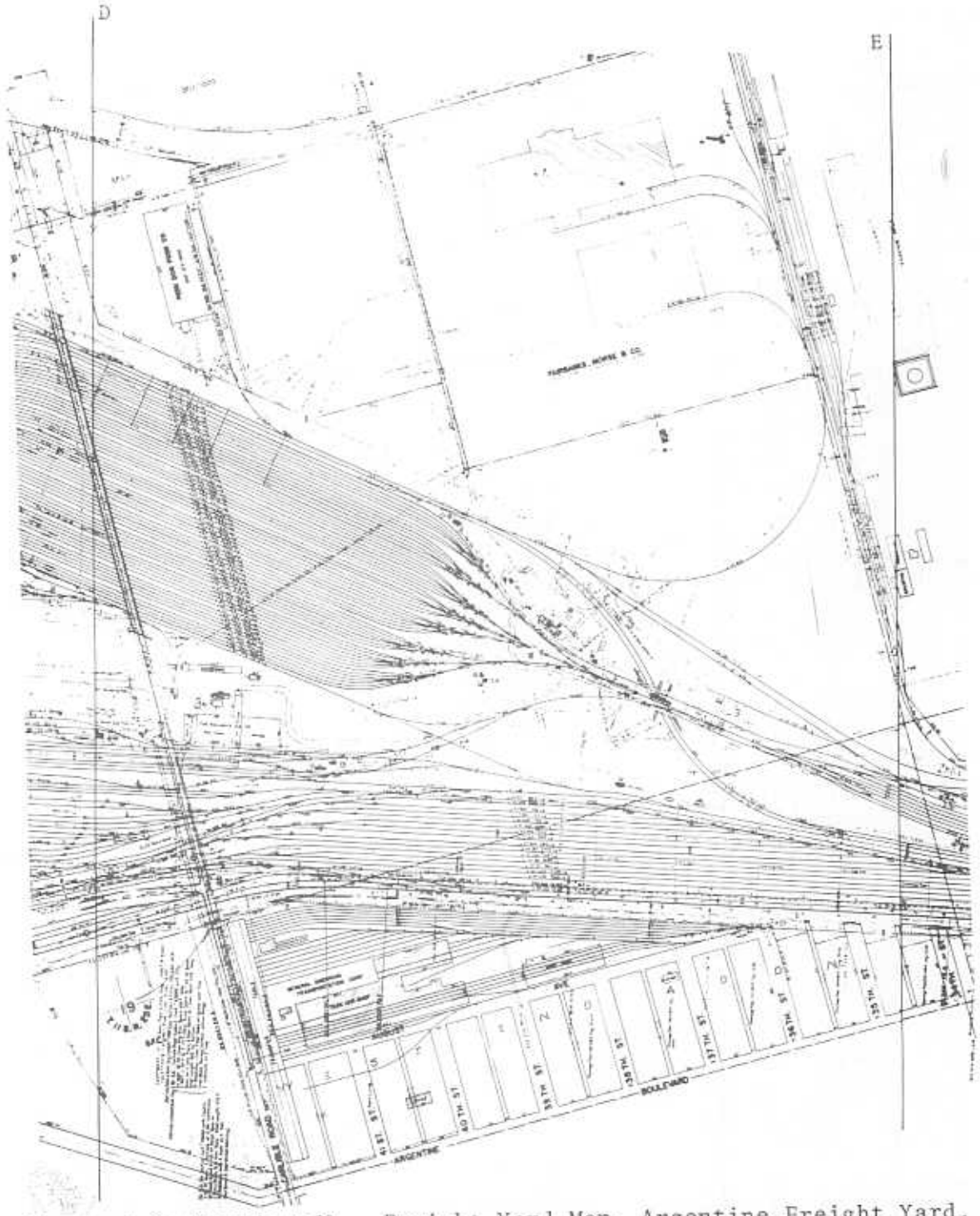


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

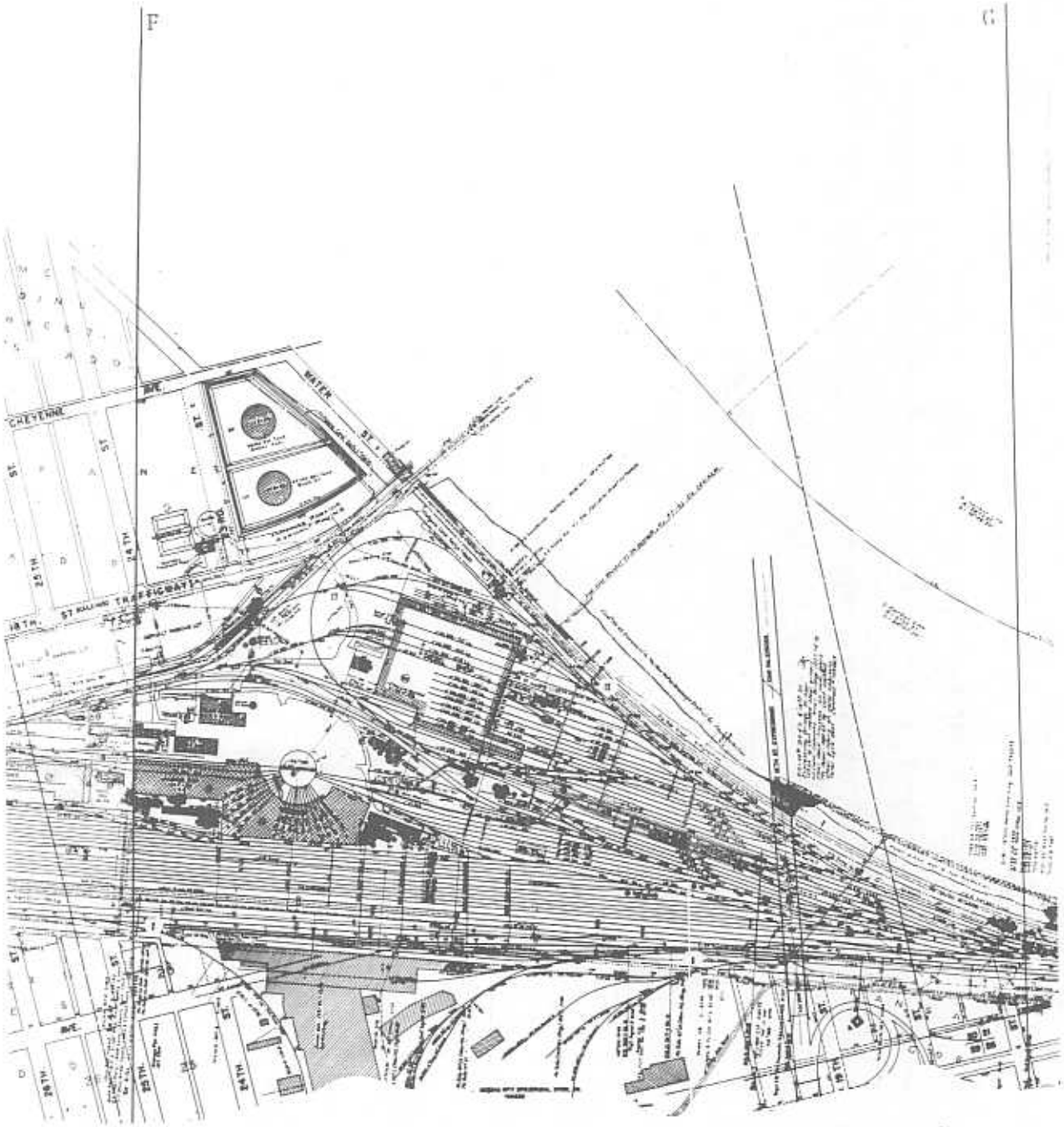
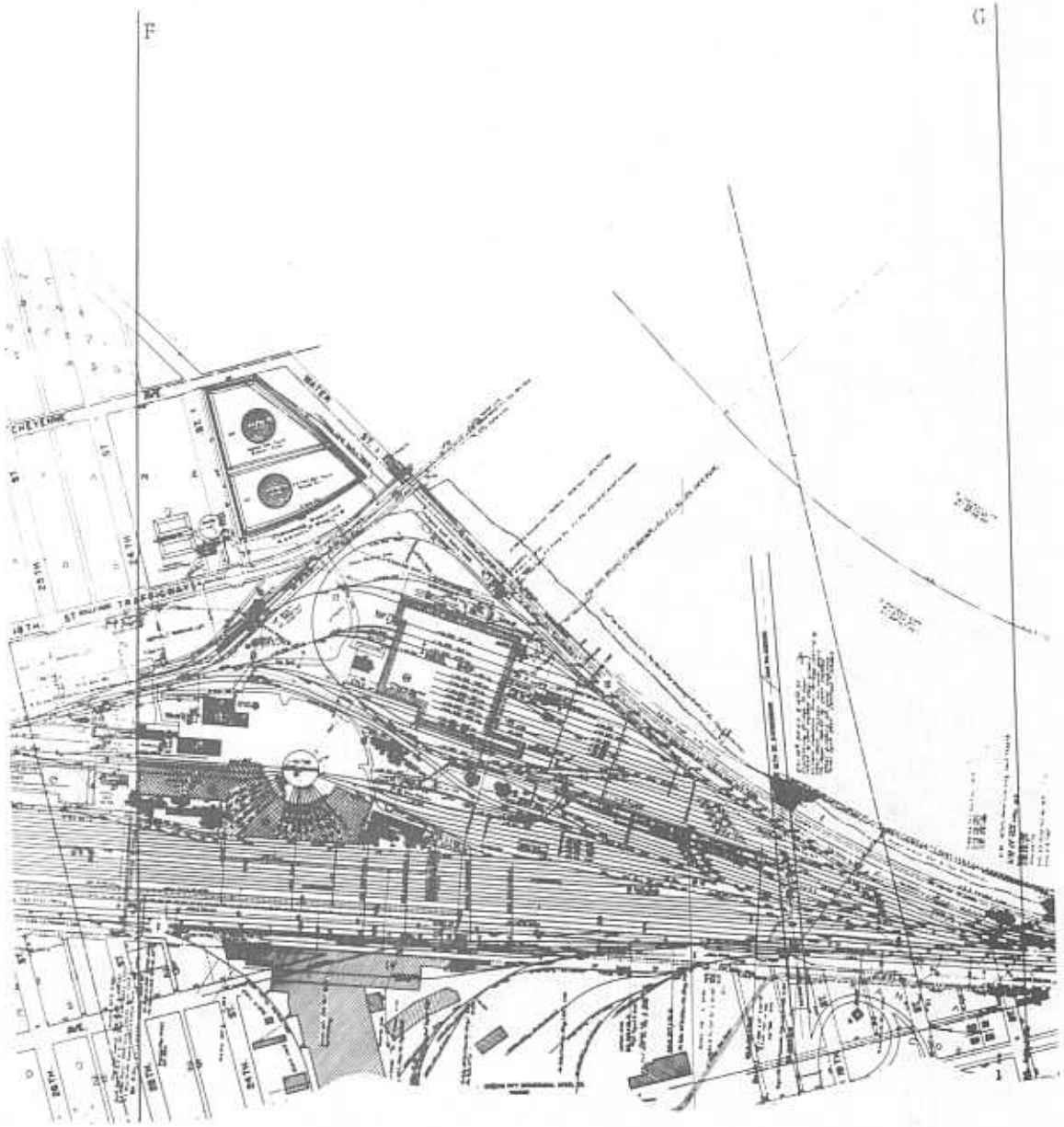


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS



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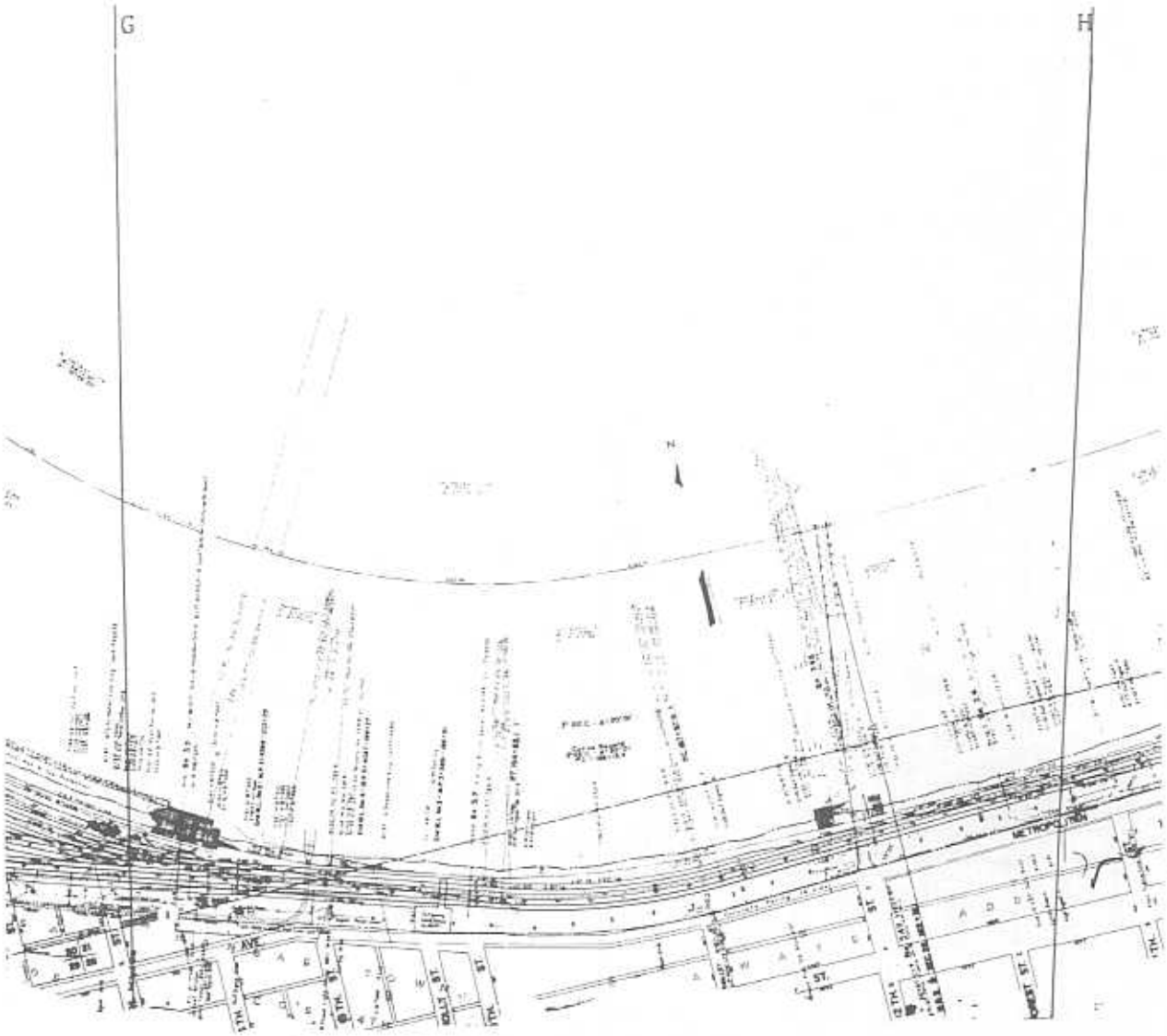


Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS

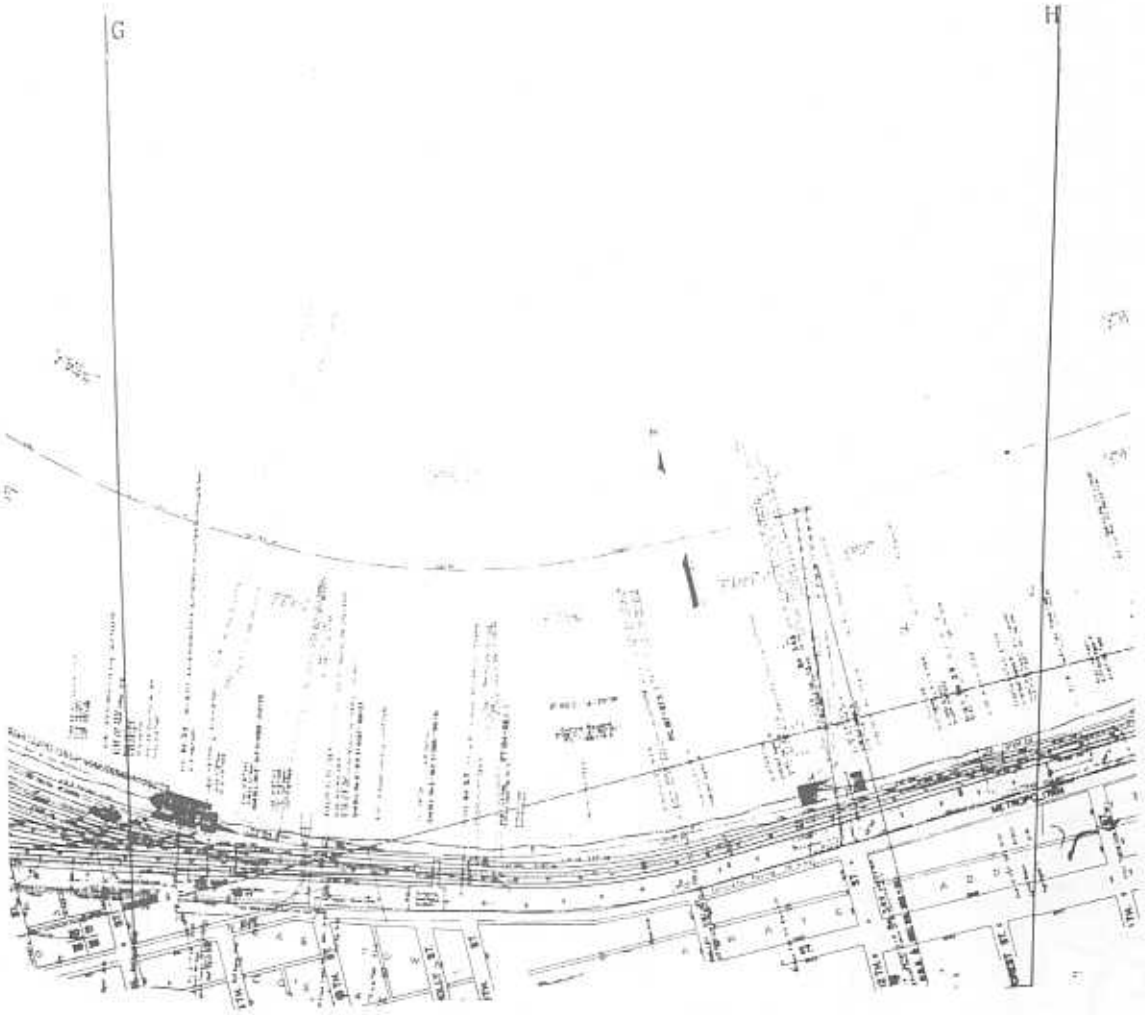
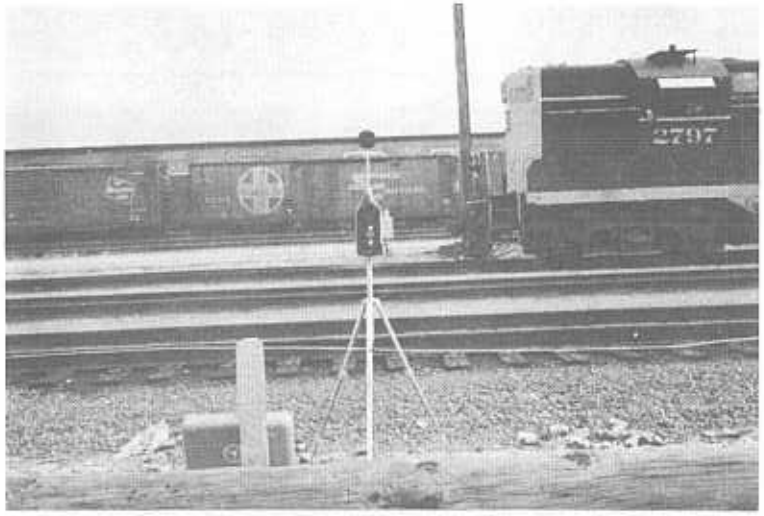


Figure E-2. (Continued) Freight Yard Map, Argentine Freight Yard, Santa Fe RR Kansas City KS

Figure E-2 (Continued). Freight Yard Map, Argentine Freight Yard, Santa Fe RR, Kansas City KS



a) Northerly

c) Easterly

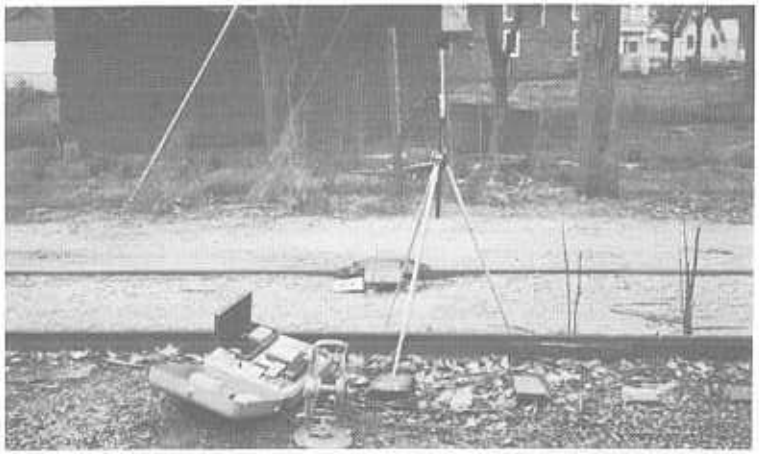
b) Southerly

d) Westerly

Figure E-3. Photographs of Measurement Location 1, Argentine Freight Yard, Sante Fe RR

a) Northerly

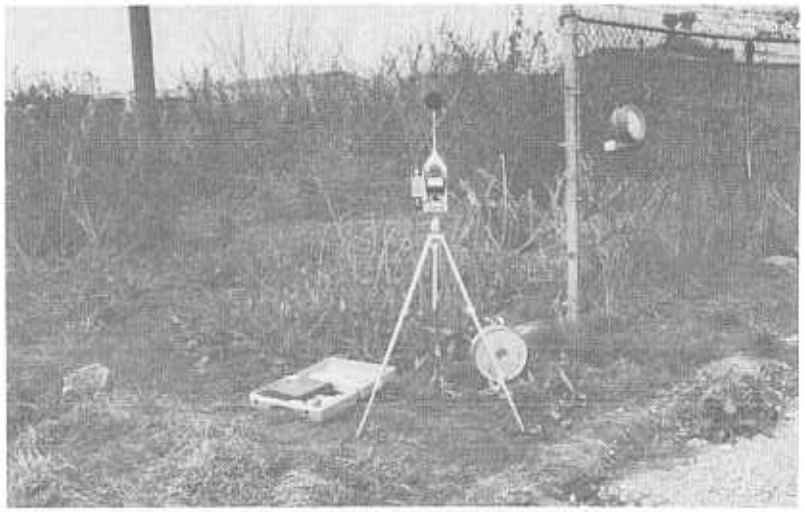
c) Easterly



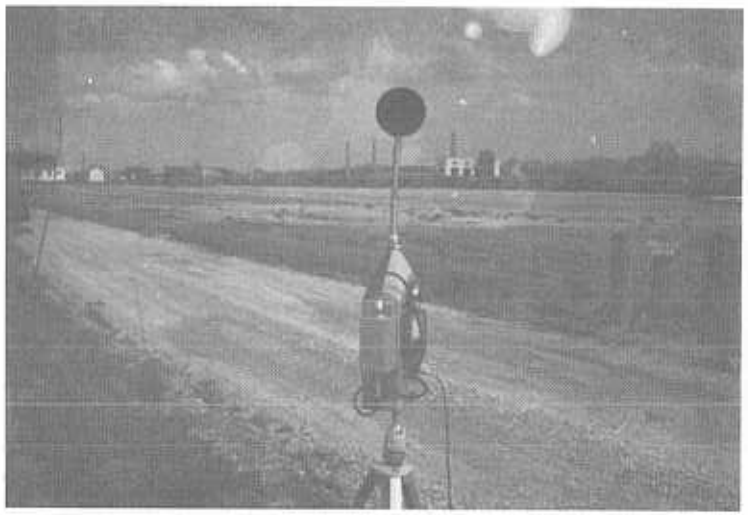
b) Southerly

d) Westerly

Figure E-4. Photographs of Measurement Location 2, Argentine Freight Yard, Santa Fe RR

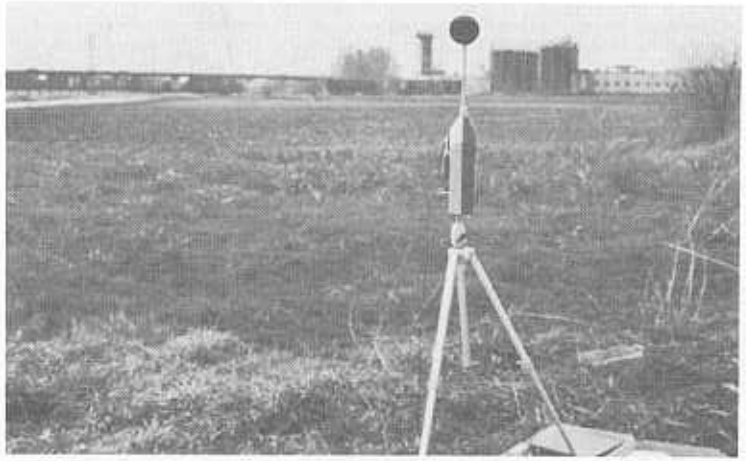


a) Northerly



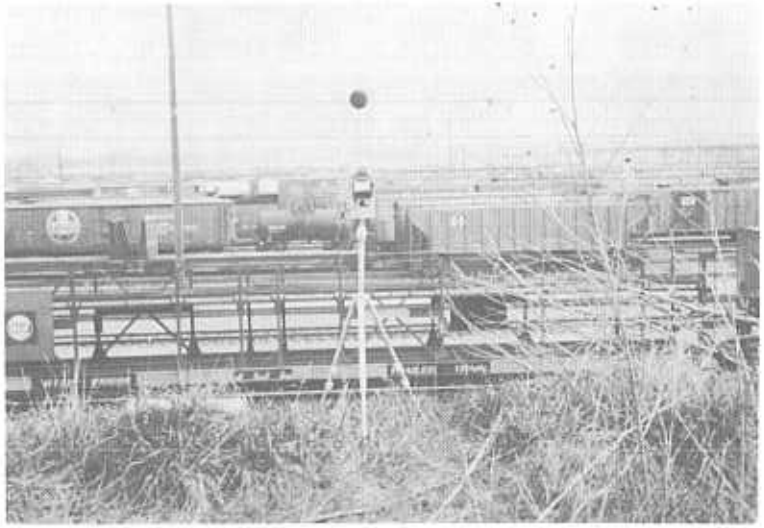
c) Easterly

b) Southerly

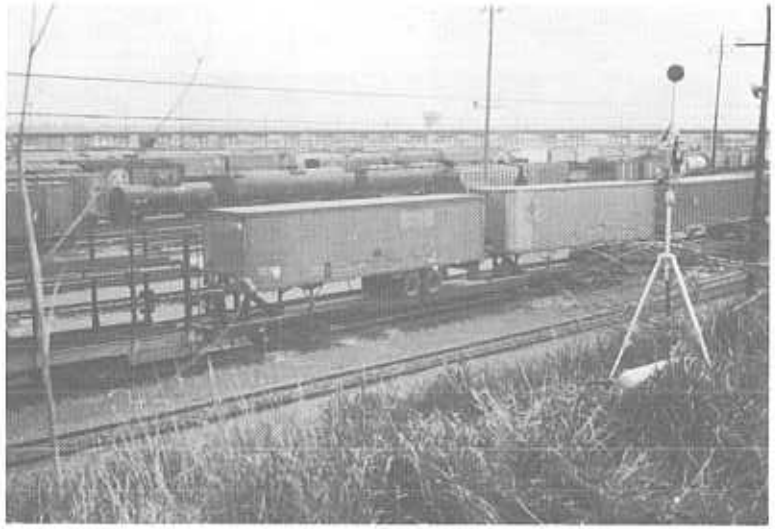


d) Westerly

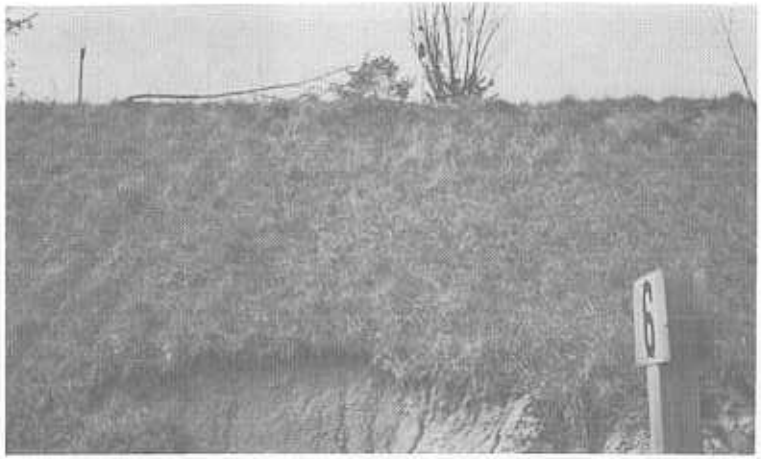
Figure E-5. Photographs of Measurement Location 3, Argentine Freight Yard, Santa Fe RR



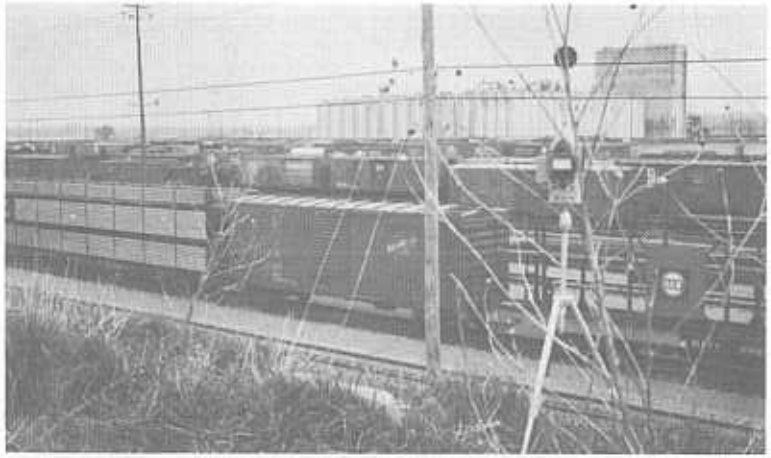
a) Northerly



c) Easterly



b) Southerly



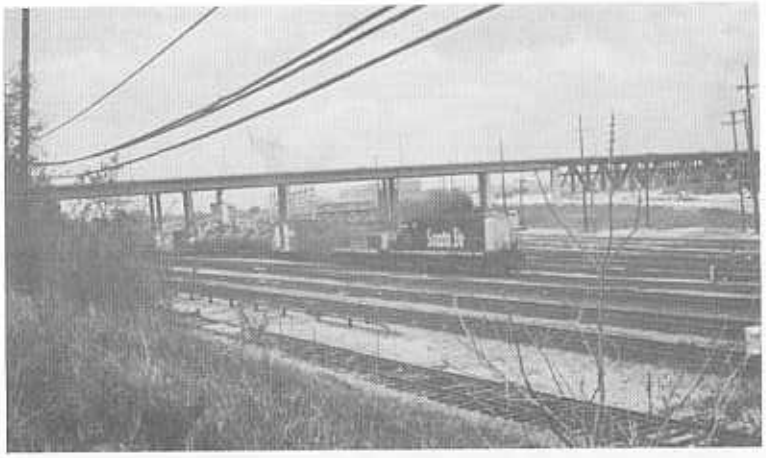
d) Westerly

Figure E-6. Photographs of Measurement Location 4, Argentine Freight Yard, Santa Fe RR

a) Northerly

c) Easterly

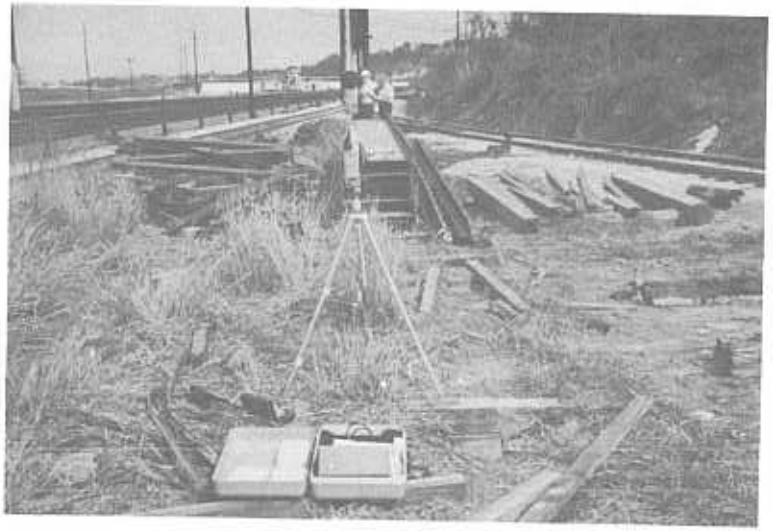
b) Southerly



d) Westerly

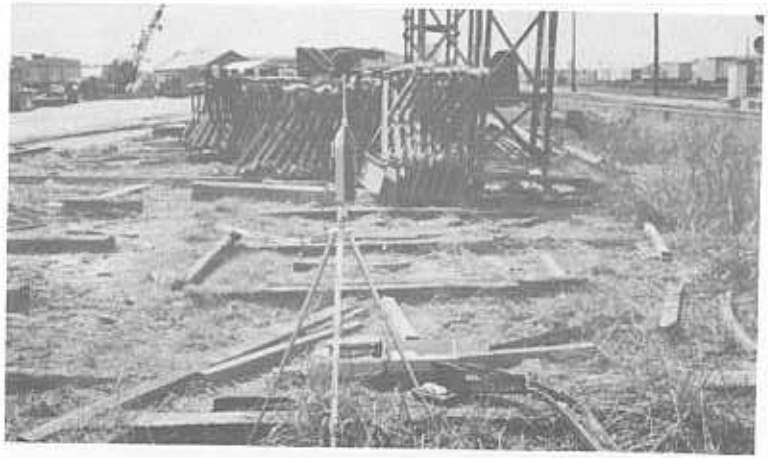
Figure E-7. Photographs of Measurement Location 5, Argentine Freight Yard, Santa Fe RR

a) Northerly



c) Easterly

b) Southerly



d) Westerly

Figure E-8. Photographs of Measurement Location 6, Argentine Freight Yard, Santa Fe RR

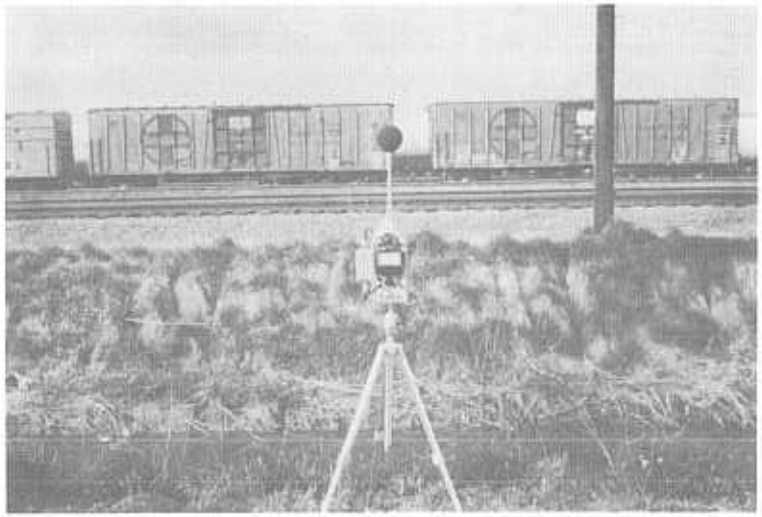
a) Northerly

c) Easterly

b) Southerly

d) Westerly

Figure E-9. Photographs of Measurement Location 7, Argentine Freight Yard, Santa Fe RR



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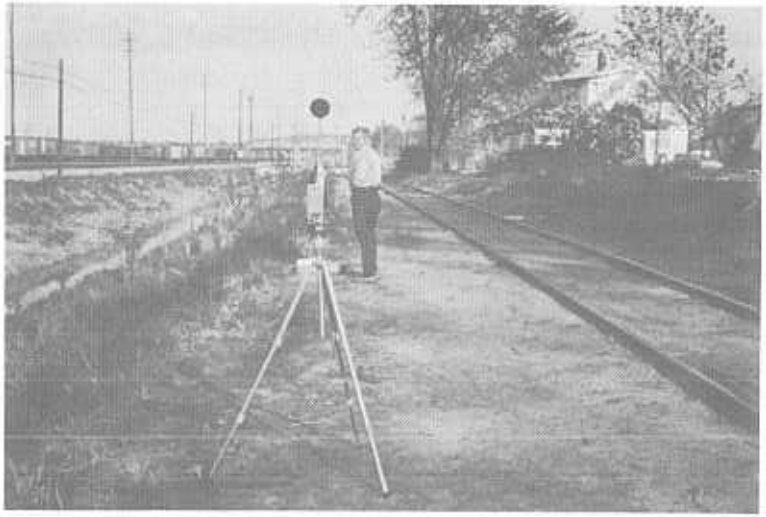
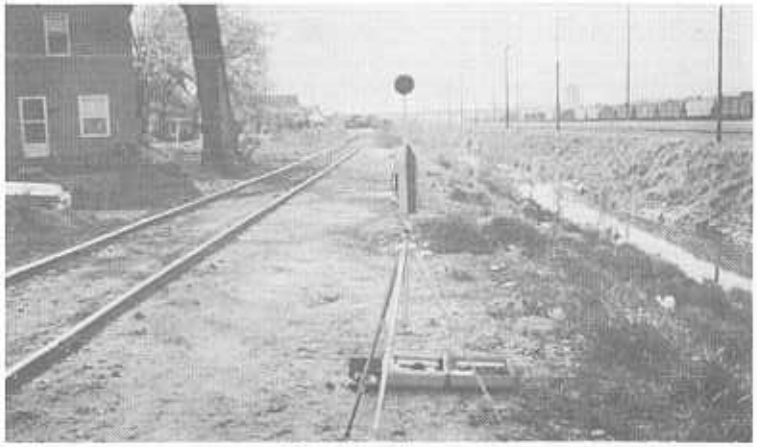
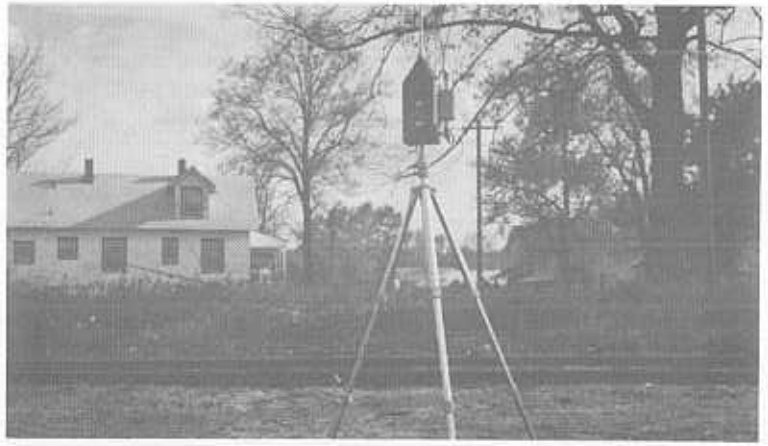


c) Easterly



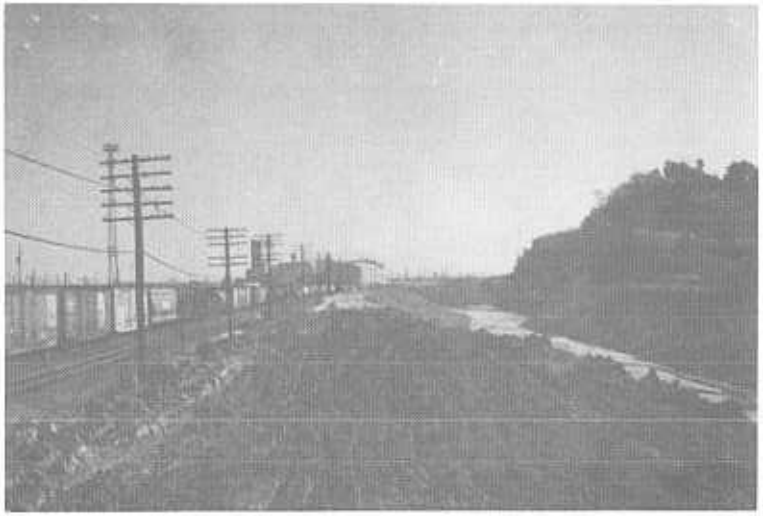
b) Southerly



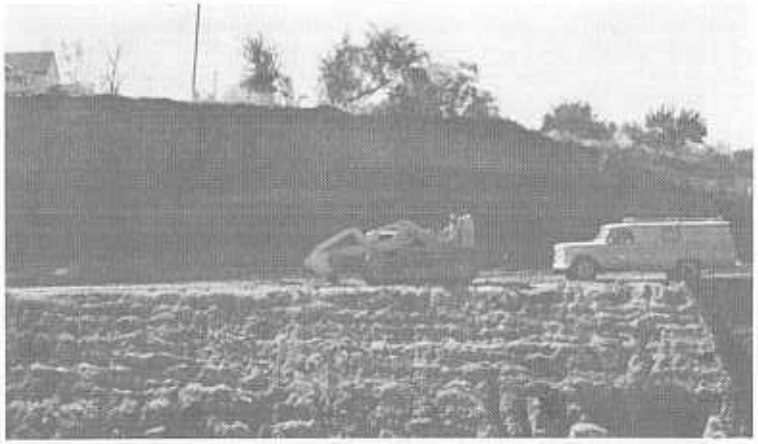
d) Westerly

Figure E-10. Photographs of Measurement Location 8, Argentine Freight Yard, Santa Fe RR

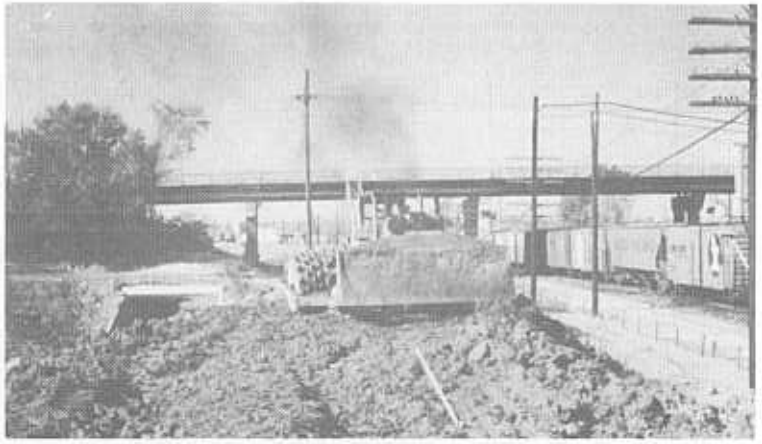
a) Northerly



c) Easterly



b) Southerly



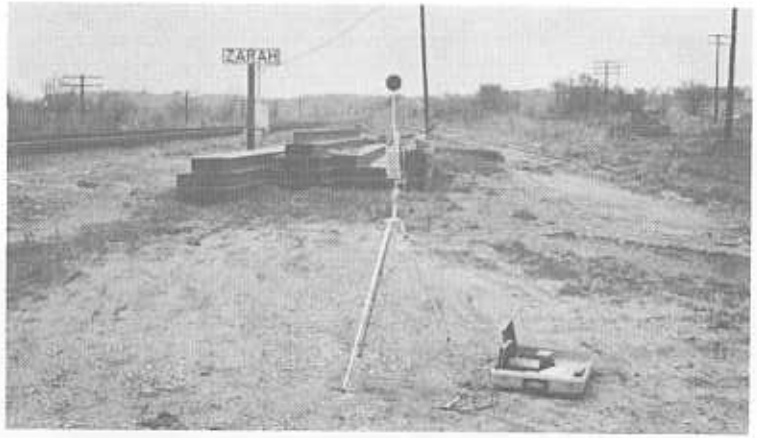
d) Westerly

Figure E-11. Photographs of Measurement Location 9, Argentine Freight Yard, Santa Fe RR

a) Northerly

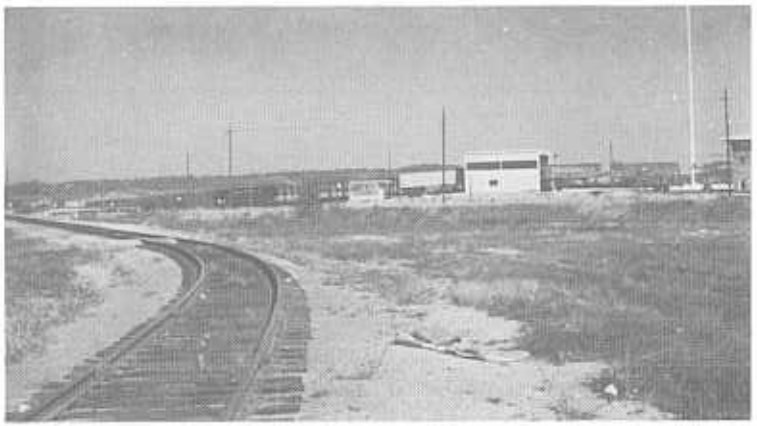
c) Easterly

b) Southerly



d) Westerly

Figure E-12. Photographs of Measurement Location 10, Argentine Freight Yard, Santa Fe RR



Northeasterly

Northwesterly

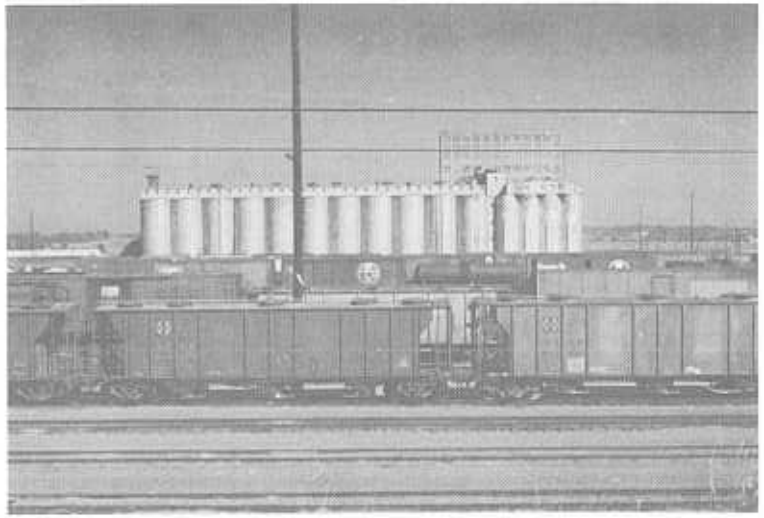
Figure E-13. Photographs of Measurement Location 11, Argentine Freight Yard, Santa Fe RR

b) Easterly

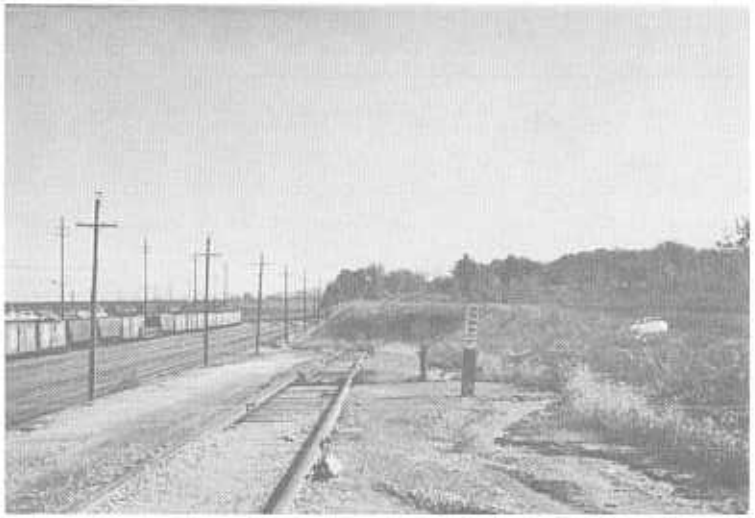
a) Southerly

c) Westerly

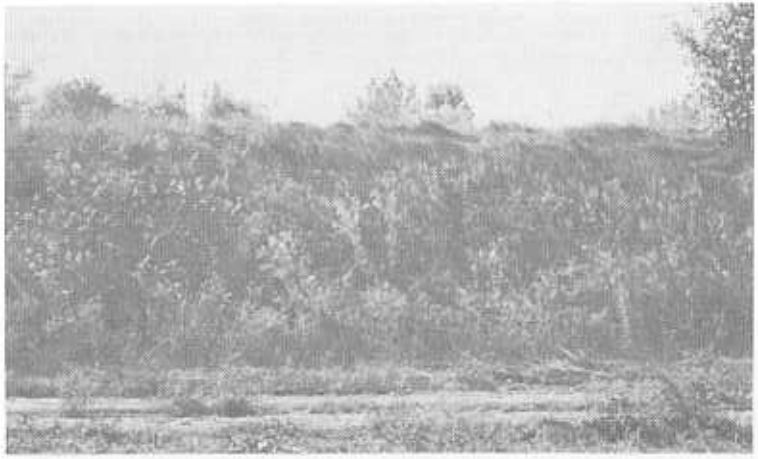
Figure E-14. Photographs of Measurement Location 12, Argentine Freight Yard, Santa Fe RR



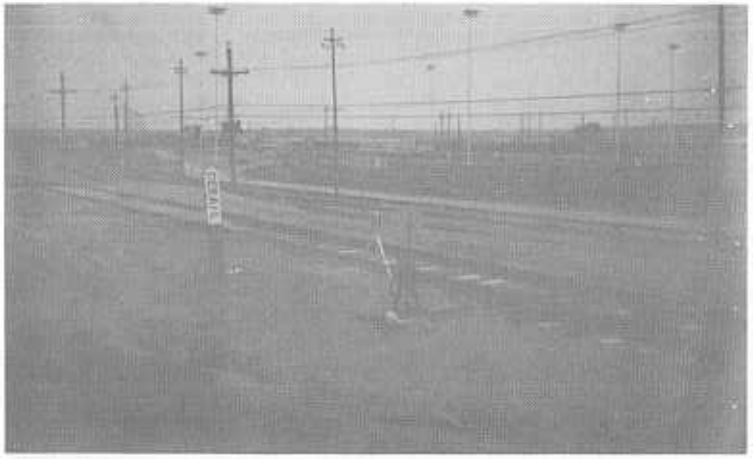
a) Northerly



c) Easterly

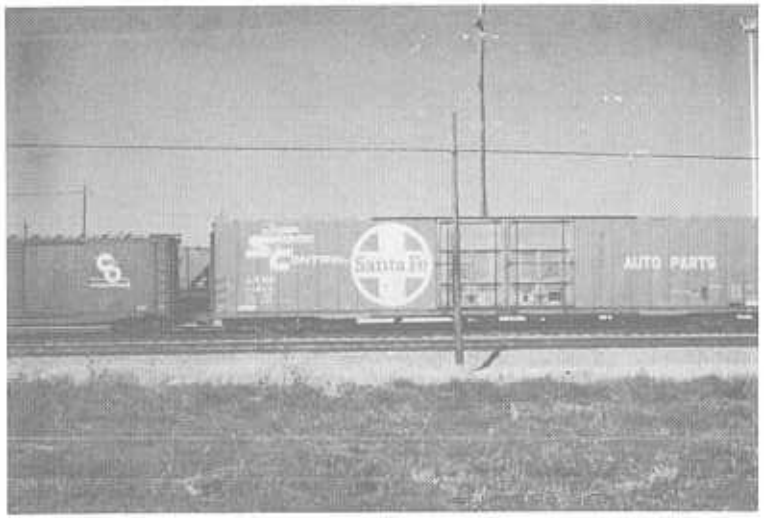


b) Southerly

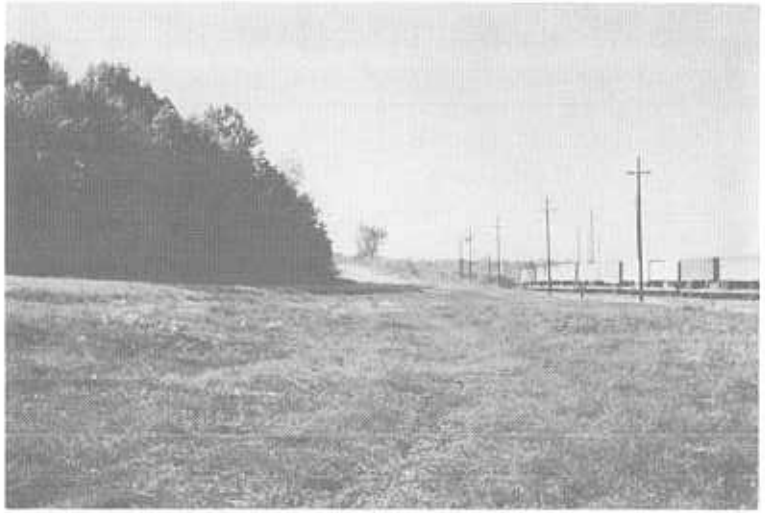


d) Westerly

Figure E-15. Photographs of Measurement Location 13, Argentine Freight Yard, Sante Fe RR

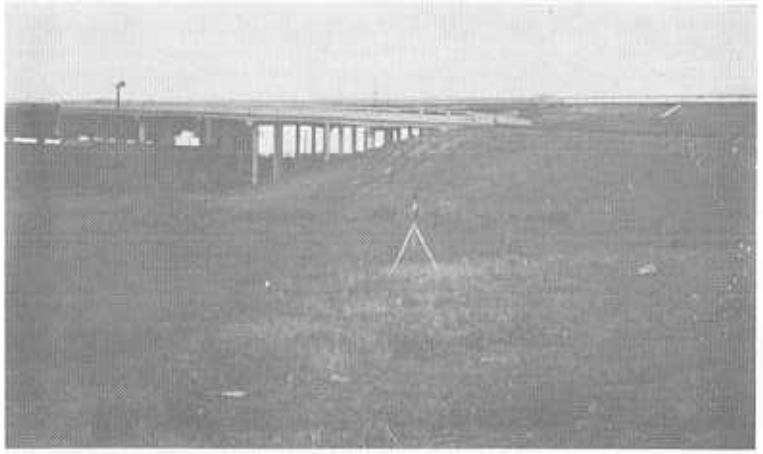


a) Northerly



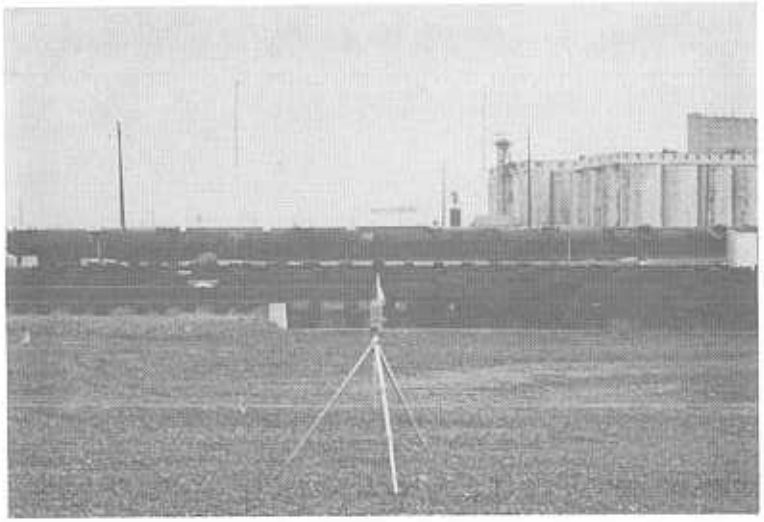
c) Easterly

b) Southerly



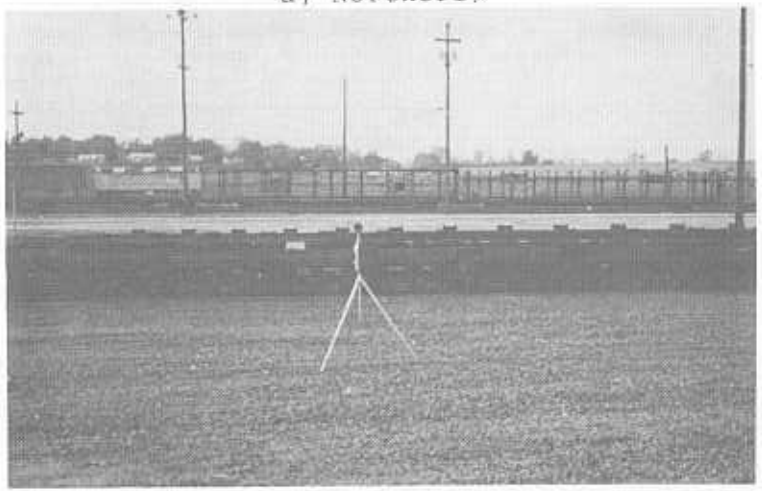
d) Westerly

Figure E-16. Photographs of Measurement Location 14, Argentine Freight Yard, Santa Fe RR

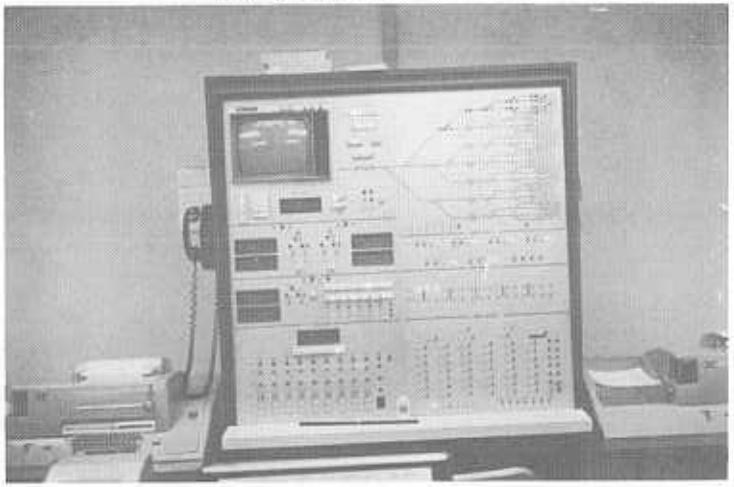


a) Northerly

c) Easterly

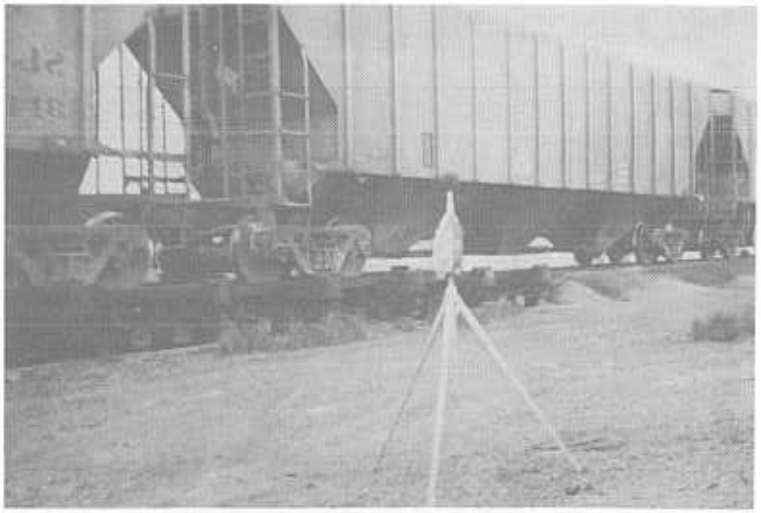


b) Southerly

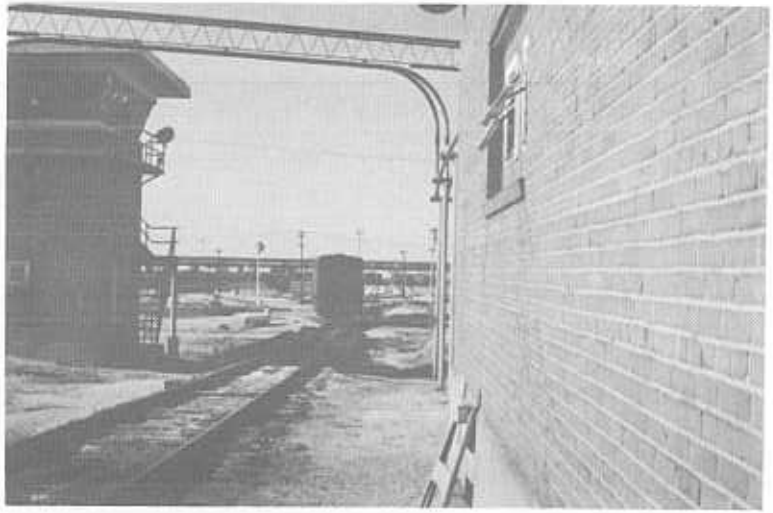


d) Computer Display

Figure E-17. Photographs of Measurement Location 15, Argentine Freight Yard, Santa Fe RR

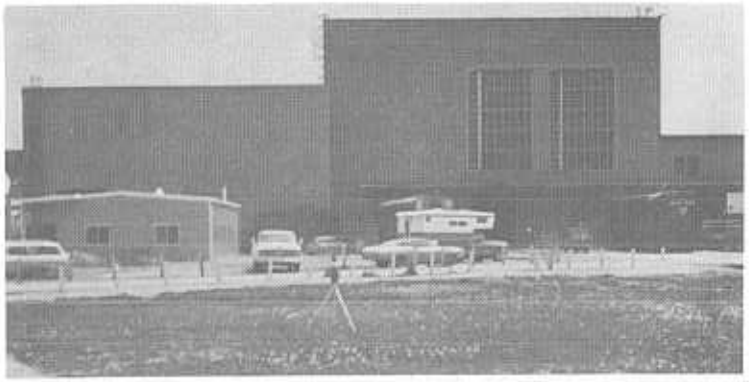


b) Southerly



d) Westerly

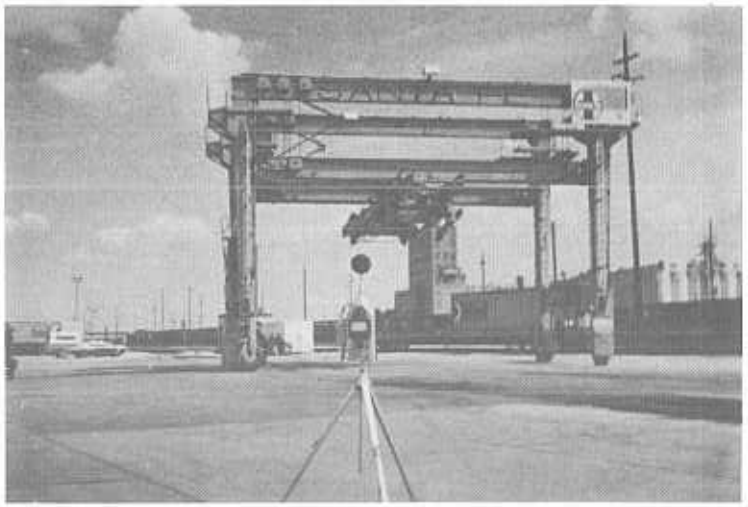
Figure E-18. Photograph of Measurement Location 16, Argentine Freight Yard, Santa Fe RR



a) Northerly

b) Southerly

Figure E-19. Photographs of Measurement Location 17, Argentine Freight Yard, Santa Fe RR



a) Moving into Position

b) Lifting Box Off Trailer

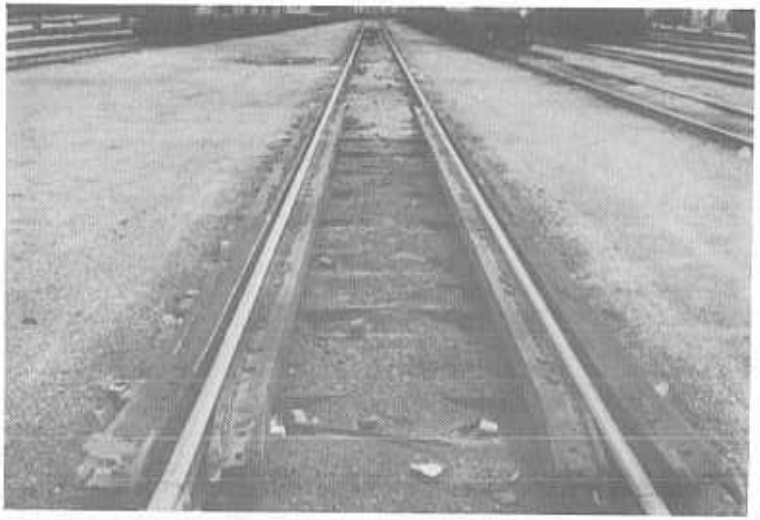
Figure E-20. Photographs of Measurement Location 18, Argentine Freight Yard, Santa Fe RR

a) Northerly - Point of Impact

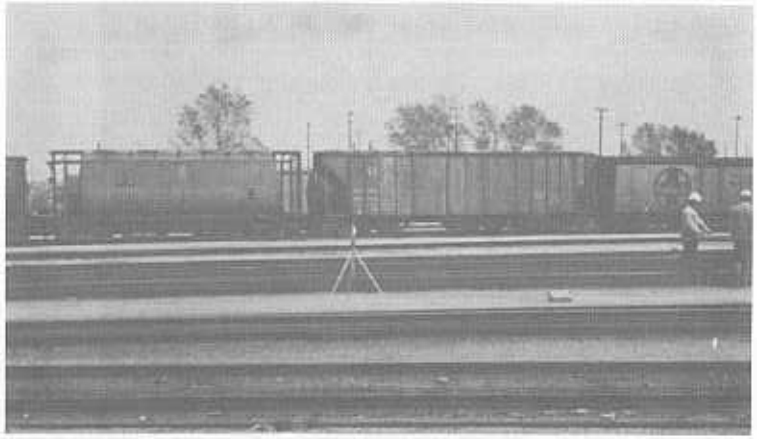
d) Westerly Toward Dumper Shed

Figure E-21. Photographs of Measurement Location 19, Argentine Freight Yard, Santa Fe RR

a) Northerly

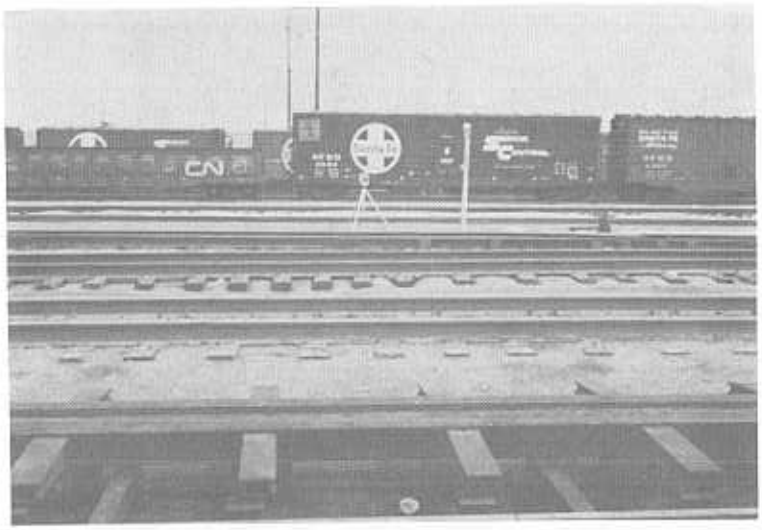


c) Spring-loaded Inert Retarder

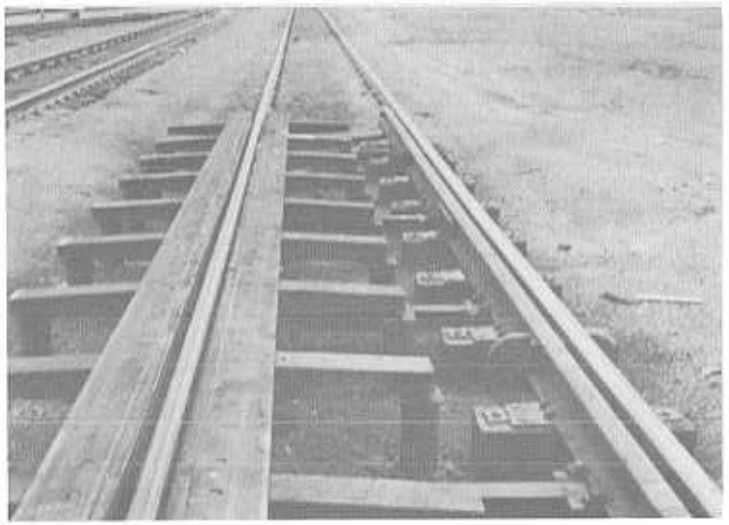


b) Southerly

Figure E-22. Photographs of Measurement Location 20, Argentine Freight Yard, Sante Fe RR



a) Northerly



c) Weight-Balanced Inert Retarder

b) Southerly

Figure E-23. Photographs of Measurement Location 21, Argentine Freight Yard, Santa Fe RR

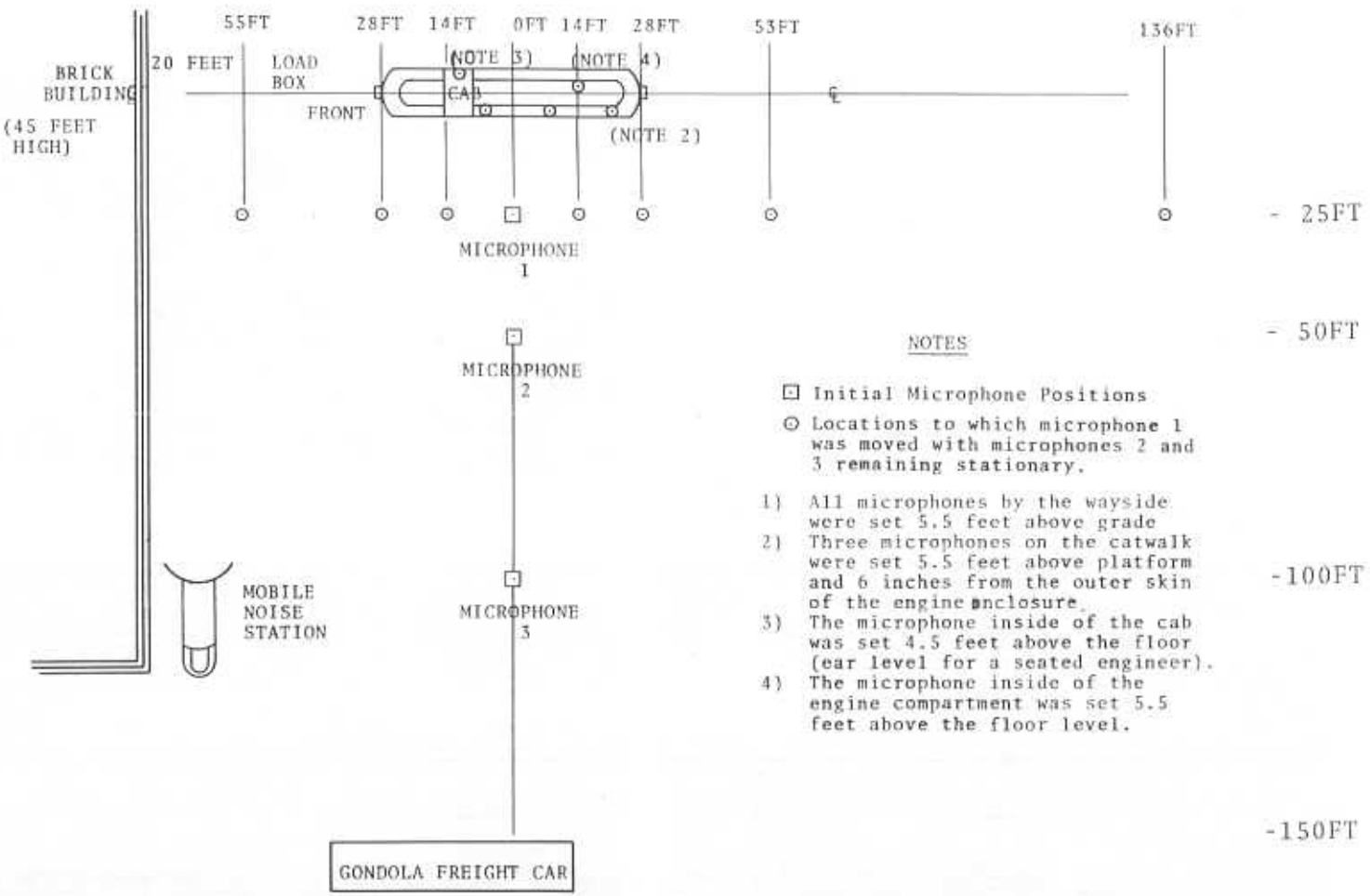
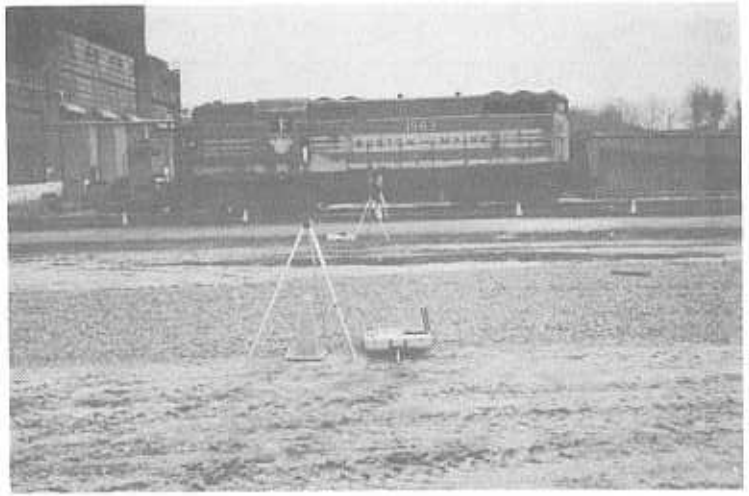
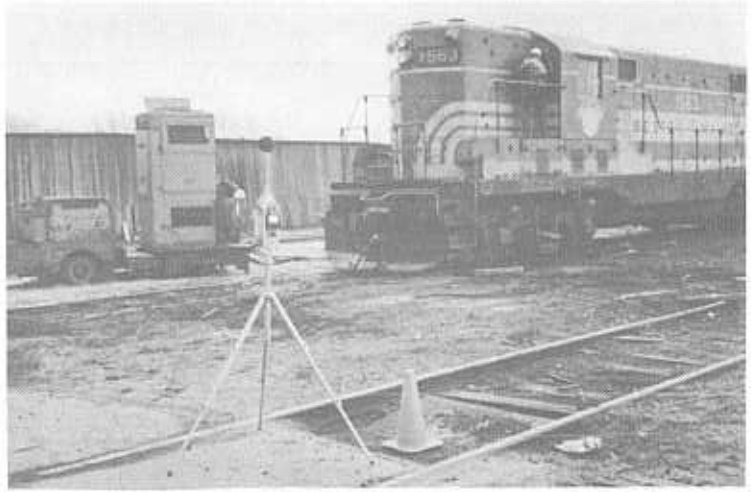


Figure E-24. Measuring System Locations, Static-Locomotive Noise-Level Measurements, B&MRR, Iron Horse Park, Billerica MA, 3/21/73



a) Three Microphones Offset 25, 50, and 100 Feet



b) Moveable Microphone 55 Feet to Left of its Position

c) Moveable Microphone on Catwalk Platform

Figure E-25. Photographs of Measurement Site, Static-Locomotive Measurements, B&MRR, Locomotive-Repair Facility, Iron Horse Park, Billerica MA

Figure E-26. Photograph of Somerville Hump Yard, B&MRR, Somerville MA, View from Control Tower

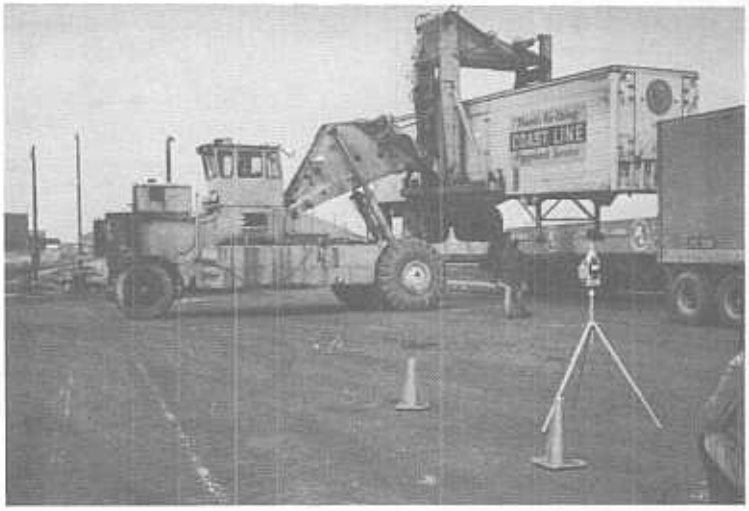


Figure E-27. Photograph of FWD Wagner Model P-70, Fork-Lift Truck, B&MRR, Piggyback Yard 7, Charlestown MA

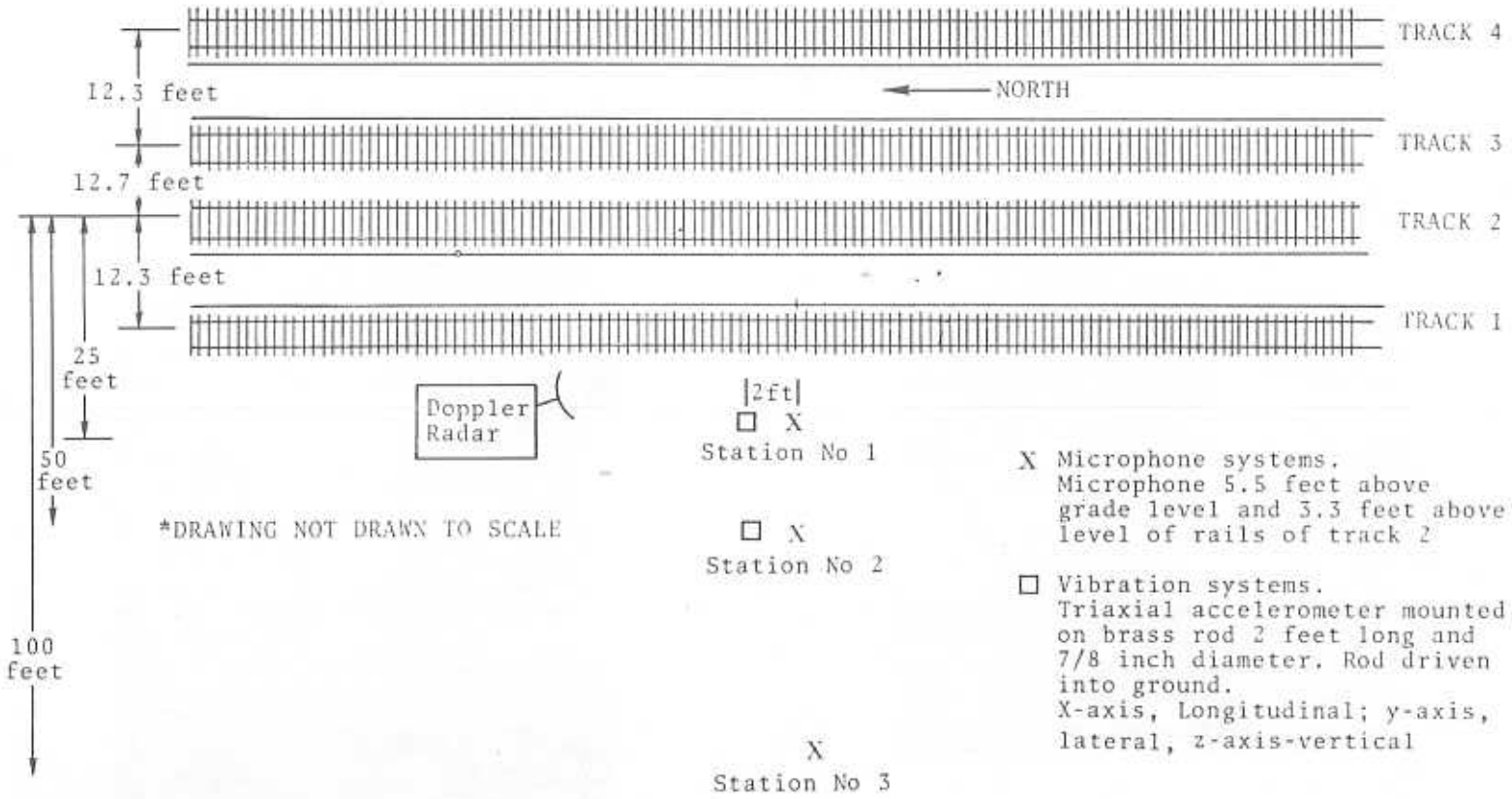


Figure E-28. Measuring System Locations Trackside, Penn Central RR, New York-to-Washington Line, Plainsboro NJ, 2600 feet North of Milepost 46, 5/23/72

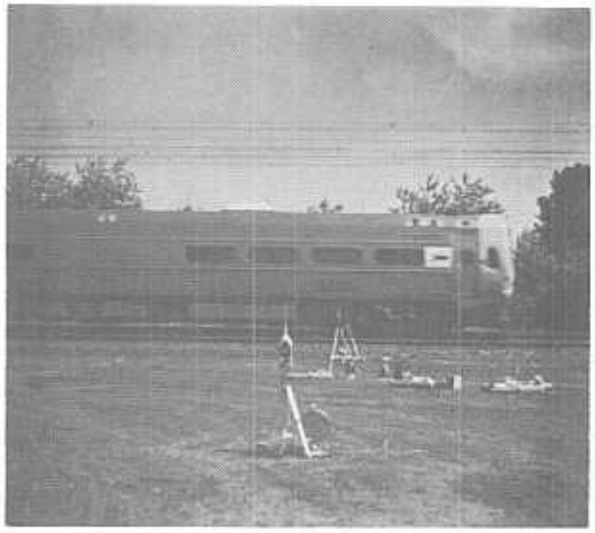


Figure E-29. Photograph of Easterly View of Measurement Site, Plainsboro NJ.

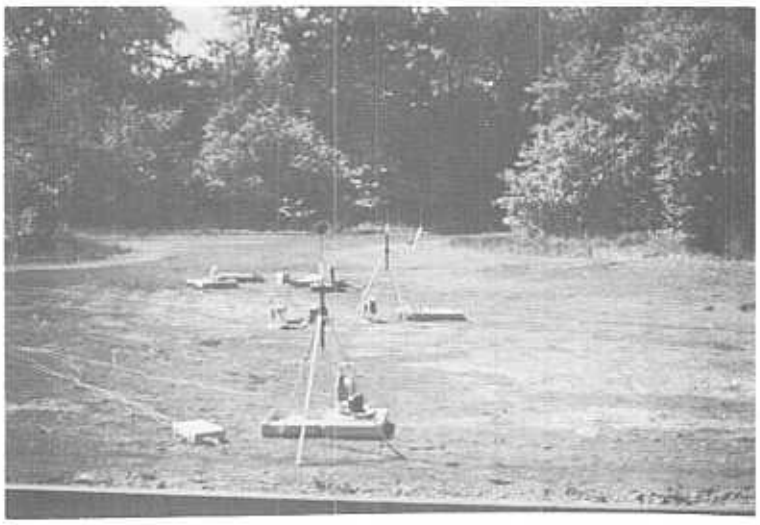


Figure E-30. Photograph of Westerly View of Measurement Site, Plainsboro NJ

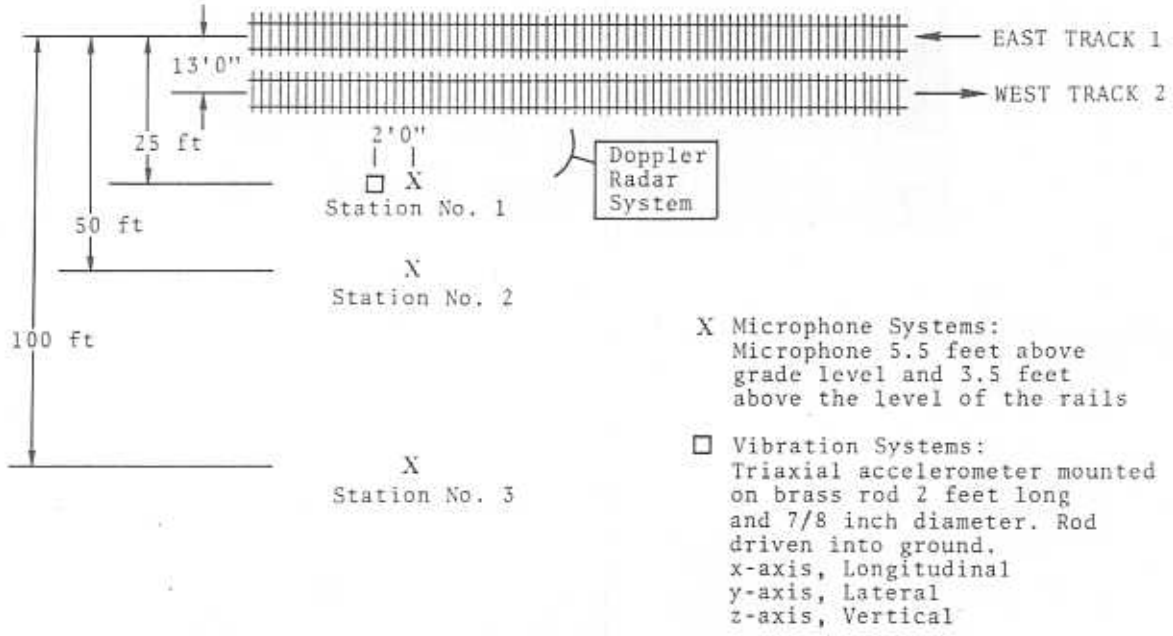


Figure E-31. Measurement System Locations, Trackside, Penn Central RR, Boston-to-New York Line, West Mansfield MA, 1310 feet East of Milepost 201, 9/20-26/72

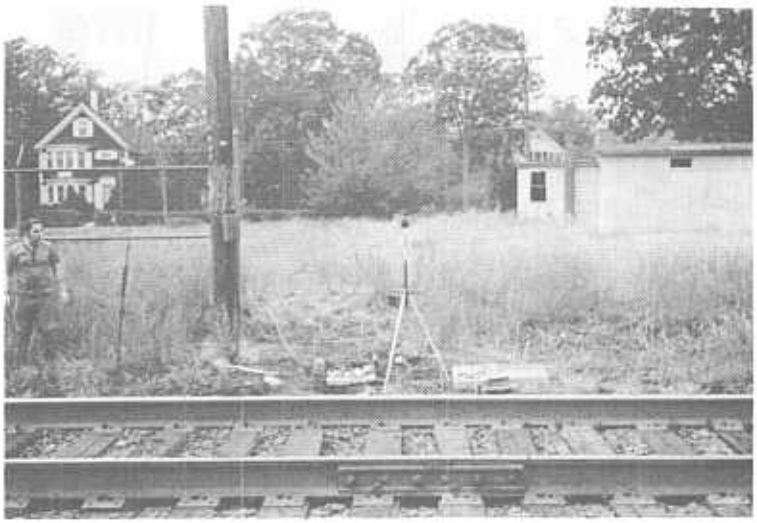


Figure E-32. Photograph of Northerly View of Measurement Site, West Mansfield MA

Figure E-33. Photograph of Southerly View of Measurement Site, West Mansfield MA

APPENDIX F
NOISE MEASUREMENT AND DATA-REDUCTION SYSTEMS

NOISE-MEASURING SYSTEM

Figure F-1 depicts the noise data-gathering equipment used at the wayside measuring stations in Plainsboro NJ, and West Mansfield and Billerica MA.

A 4-channel magnetic tape recorder, capable of essentially flat recordings from 30 Hz to 15 KHz, was used. The recorder was operated in the direct mode at a tape speed of 3-3/4 inches per second. The dynamic range of the recorder and measuring system was 50 dB.

Figure F-2 depicts the portable measuring systems used in all other areas. In this case, a 2-channel recorder was used operating at 7-1/2 inches per second in the direct mode.

Before each run, a short verbal annotation was recorded on tape giving the following: date, time, location, tape number, tape recorder channels used, and gain setting for each channel.

A calibration signal of 1000 Hz at a level of 114 dB re 20 microPascal was recorded on tape before and after each run to provide a reference level for the data reduction instrumentation and to detect any system instability. The calibrator used was a General Radio Model 1562A. In this calibrator, the signal is generated by a solid state oscillator driving a small magnetic loudspeaker. The calibrator is placed on the microphone, and the resultant signal at the specified sound pressure level is fed through the system and recorded on tape. In addition, a passive microphone simulator was substituted for the microphone to determine the minimum discernible sound pressure level (noise floor) for the system. This signal was also preserved on tape.

The measuring and analysis systems conforms to Society of Automotive Engineers' Standard SAE J184.

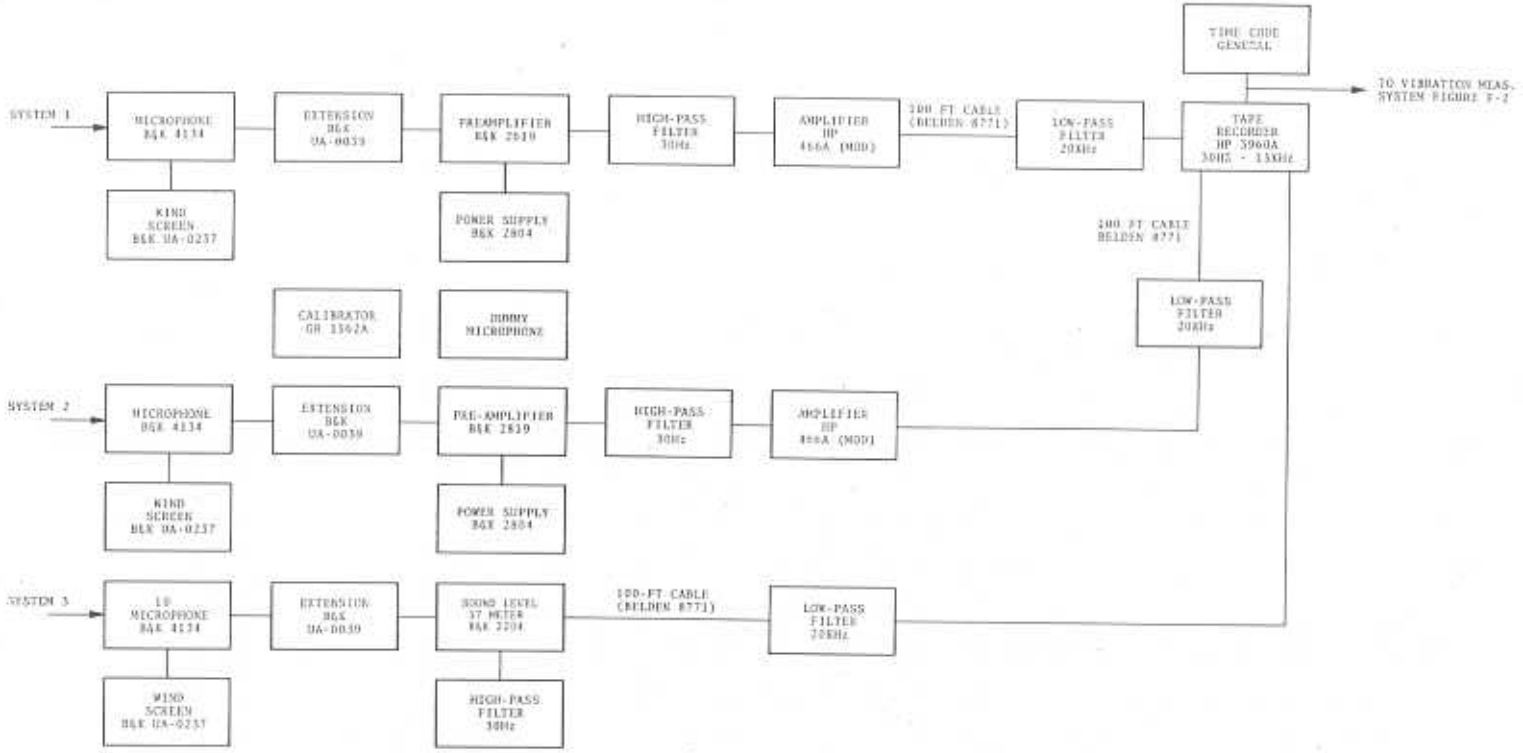


Figure F-1. Block Diagram - Three-Microphone Noise-Measuring System

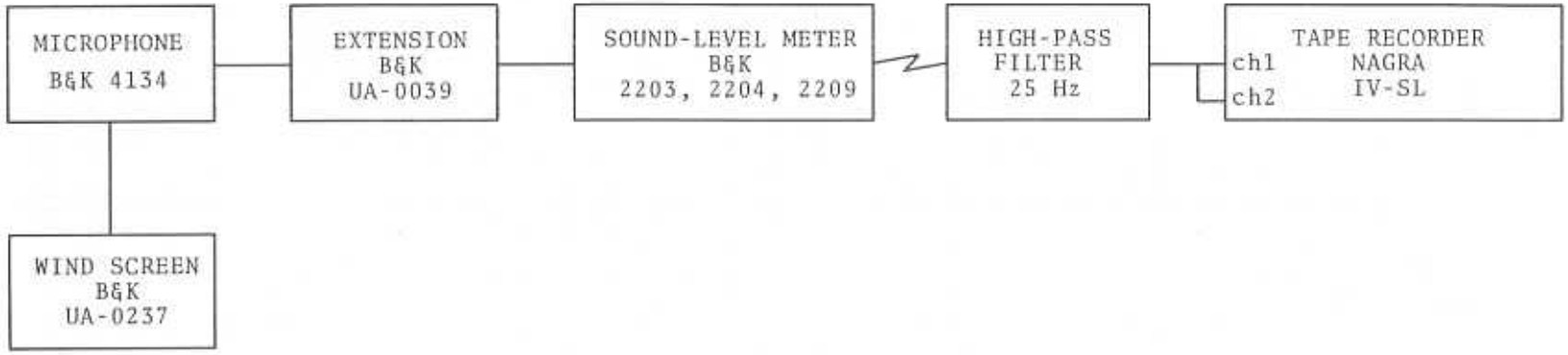


Figure F-2. Block Diagram - Portable Noise-Measuring System

Noise-Data Reduction

The configuration of the noise data reduction system is shown in figure F-3. The noise data plus the calibration signal recorded on magnetic tape at the test site were reproduced and fed to a General Radio (GR) 1921 Real Time Analyzing System made up of a GR 1925 Multifilter and a GR 1926 Multichannel RMS Detector. The necessary gain adjustments were made in the multifilter and graphic level recorder with the calibration signals.

The GR 1921 multifilter contains a set of 30 parallel one-third octave band filter channels ranging from 25 Hz to 20 kHz, plus additional channels with standard "A," "B," and "C" sound level meter weighting networks and an unfiltered channel with a flat frequency response "F." The output of the "A" weighted channel was selected and fed to the graphic level recorder to produce a chart of noise level versus time (time history) of all recorded data.

All 34 outputs from the multifilter are fed into the multichannel detector. The multichannel detector simultaneously computes the root-mean-square (rms) level for each channel and converts this level to a digital output. Single integration or measurement periods are adjustable from 1/8 to 32 seconds. A statistical analysis of the measured noise was obtained by programming the detector to integrate for one eighth second, compute the dB value of the "A" weighted filter output, and provide a binary-coded decimal signal to the Wang Computing Calculator eight times every second. This computer counted and totaled the number of samples at each sound level for a selected time period, and a punched tape was produced. These data were subsequently entered into a time-shared computer to produce statistical analysis printouts contained in Appendix A.

The statistical analyses contain a histogram presentation of dBA value versus frequency of occurrence and a probability distribution of level versus probability of exceedance. Selected indexes were also calculated and tabulated; e.g., average noise-level dBA, standard deviation, energy mean, range of values

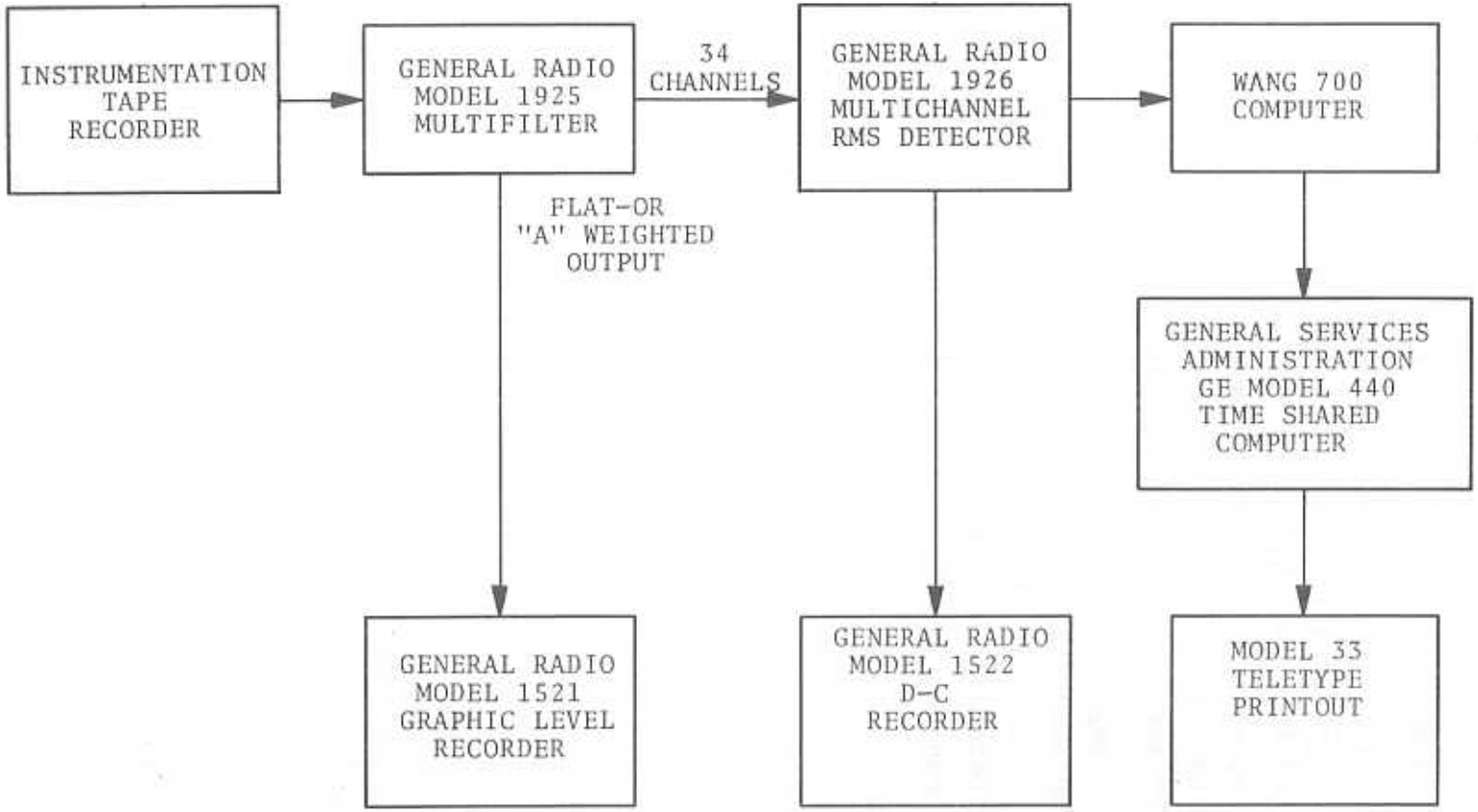


Figure F-3. Block Diagram - Noise Data-Reduction System

measured, median, selected percentiles and deciles, the noise pollution level, and the Walsh-Healey Exposure index. A complete description of these indexes is contained in Appendix H.

Special selected events are analyzed in detail for their one-third octave band frequency spectra using this equipment and the GR1522 dc Recorder which in conjunction with the GR1926 Multichannel rms Detector provides a hard copy bar graph of level (dB) versus one-third octave frequency bands from 25 Hz to 20 kHz including the flat "F" and "A" weighted outputs.

The multichannel detector is programmed to integrate over the time interval of the selected event or portion thereof, compute the level in dB for all 32 channels, and provide a DC output to the recorder. The recorder provides a hard copy of level (dB) versus one-third octave bands (frequency spectra) for the event.

APPENDIX G
METEOROLOGICAL DATA

METEOROLOGICAL DATA

LOCATION	DATE	TIME hours	TEMP. °F	RELATIVE HUMIDITY percent	BAROMETRIC PRESSURE mmHg	WIND VEL. mph	WIND DIR.	SKY
PLAINSBORO NJ	23 MAY 1972	1000-1710	70-78	20	742	0-5	NW	CLEAR, SUNNY
WEST MANSFIELD MA	20 SEP 1972	1800-2100	40	92	742	CALM		CLEAR
WEST MANSFIELD MA	26 SEP 1972	1600-2100	63-65	90	726	3-5	SW	CLEAR
IRON HORSE PARK BILLERICA MA	21 MAR 1973	1000-1400	36-38	46-57	767	0-3	NE	CLOUDY, OVERCAST
SOMERVILLE MA	28 MAR 1973	0900-1200	45	53	770	5-10	NE	CLEAR, SUNNY
CHARLESTOWN MA	29 MAR 1973	0900-1200	40	50	775	5-8	E	CLEAR, SUNNY
KANSAS CITY KS Location - 1	24 APR 1973	0590-1010	63	61	734	5-8	E	SCATTERED CLOUDS
2	24 APR 1973	1151-1211	64	60	734	5-10	E	SCATTERED CLOUDS
3	24 APR 1973	1527-1547	65	63	735	5-10	NE	CLOUDY
4	25 APR 1973	0936-0956	66	68	735	8-13	NE	SCATTERED CLOUDS
5	25 APR 1973	1138-1158	66	68	735	8-10	NE	SCATTERED CLOUDS
6	25 APR 1973	1500-1520	68	48	718	15-20	E	SUNNY
7	25 APR 1973	1547-1607	67	42	727	15-20	NE	SUNNY
8	25 APR 1973	1648-1708	63	50	732	10-18	E	SUNNY
9	25 APR 1973	2251-2311	52	78	742	3-5	NE	CLEAR NIGHT
10	26 APR 1973	1045-1105	56	70	740	5-15	NE	CLOUDY
11	25 APR 1973	2302-2322	52	78	742	3-5	NE	CLEAR NIGHT
12	24 APR 1973	1054-1114	64	60	734	5-8	E	SCATTERED CLOUDS
13	26 APR 1973	0952-1012	56	70	740	8-10	NE	SCATTERED CLOUDS
14	26 APR 1973	1036-1056	56	70	740	8-10	NE	SCATTERED CLOUDS
15	25 APR 1973	0926-0943	66	68	735	5-8	NE	SCATTERED CLOUDS
16	24 APR 1973	1631-1645	65	63	735	5-8	NE	CLOUDY
17	25 APR 1973	1630-1645	67	42	727	5-8	NE	SUNNY
18	25 APR 1973	1400	66	68	735	8-10	NE	SUNNY
19	25 APR 1973	1500	66	68	735	8-10	NE	SUNNY.
20	25 APR 1973	1100	66	68	735	3-4	E	SUNNY
21	25 APR 1973	1000	66	68	735	3-4	E	SCATTERED CLOUDS

APPENDIX H
DEFINITION OF TERMS AND CALCULATED VALUES

DEFINITION OF TERMS

Term	Definition
A-weighted (dBA)	Sound level obtained by measuring the sound pressure through a filter network having a frequency response (A-weight) conforming to the American National Standards Institute (ANSI, S1.4, 1971)
Sound Level Reference	20 microNewton per square meter or 20 microPascal
Passby	Passage of vehicle by fixed measuring station
Time History	Graphic recording of variations of level measured versus time
Wayside	Along side of the railroad right-of-way
Line-haul	Freight operations
Retarder	A device used in a rail classification yard which exerts a frictional force against the wheels of a railroad car for the purpose of retarding (slowing) its speed
Active Retarder	A controlled retarder which exerts a varying force by electric or electric-pneumatic means
Inert Retarder	A non-controlled retarder which exerts a fixed preset force
Load Box	A resistive load in which the power generated by a locomotive during static testing is dissipated as heat. This power is normally supplied to the engine's traction motors

Term	Definition
Median Noise Level (L50)	Sound Level (dBA) exceeded 50-percent of the total measurement time
x-percent decile (Lx)	Sound Level dBA exceeded x-percent of the total measurement time
Noise-Pollution Level (L_{NP})	A composite index (see calculation B6)
L eq	"Energy mean" of the noise level (see calculation B5).
Temporal	Temporary, Transient

CALCULATIONS

To describe the temporal characteristics of the noise data gathered, a statistical analysis of sound pressure level samples was performed. RMS sound pressure level samples were taken using an integration time of one-eighth second at a sample rate of eight samples per second to obtain the information contained in Appendix A. The frequency response characteristics of the samples conformed to ANSI Standard for Type 1 Sound Level Meters, S1.4, 1971 for "A" weighted sound level.

The following terms and equations were used to compute the statistical and single-number indexes appearing in this report:

A. BASIC TERMS

1. Total samples obtained: N
2. Total number of Sound Pressure Levels (from lowest level containing samples to highest level containing samples, inclusive): M
3. Sound Pressure Level (lowest to highest) SPL_1, SPL_2, ..., SPL_M
4. Samples at each Sound Pressure Level: C_1, C_2, ..., C_M
5. Relationships

   a. $\sum_{i=1}^{M} C_i = N$

   b. $SPL_M - SPL_1 + 1 = M$

6. dB ("A" Weight). Sound level obtained by measuring through a filter network having a frequency response (A weight) conforming to American National Standards Institute (ANSI), S1.4, 1971. Reference sound level, 20 microNewtons per square meter.

B. STATISTICAL EQUATIONS

1. Cumulative Distribution, percent (D_c)

$$D_c\ i = \frac{CM + CM\text{-}1 + \ldots + Ci}{N} \quad (100)$$

2. Statistical Distribution, percent (D_s)

$$D_s\ i = \frac{Ci}{N} \quad (100) \qquad i = 1, 2, \ldots, M$$

3. Average (Arithemetic Mean, $\overline{SPL}$)

$$\overline{SPL} = \sum_{i=1}^{M} \frac{C_i\ SPL_i}{N}$$

4. Standard Deviation about Averages σ

$$\sigma = \sqrt{\frac{1}{N\text{-}1} \sum_{i=1}^{N} C_i\ (SPL_i - \overline{SPL})^2}$$

5. Energy Mean (L eq)

$$L\ eq = 10 \log_{10} \frac{\left[\sum_{i=1}^{M} C_i\ 10^{\frac{SPL_i}{10}}\right]}{N}$$

6. Noise-Pollution Level (L_{NP})

$$L_{NP} = L\ eq + 2.56\ \sigma$$

7. Percentile Noise Levels, dBA

   a. 1 percent Percentile (L_1) = Level exceeded by 1 percent of total samples

   b. 10 percent Decile (L_{10}) = Level exceeded by 10 percent of total samples

c. Median (L_{50}) = Level exceeded by 50 percent of total samples

d. 90 percent Decile (L_{90}) = Level exceeded by 90 percent of total samples

e. 99 percent Percentile (L_{99}) = Level exceeded by 99 percent of total samples.

These percentile levels are obtained from linear interpolation of the percentage-cumulative distribution values.

8. Range: Highest sound level containing samples minus the lowest sound level containing samples

$$\text{Range} = SPL_M - SPL_1$$

9. Occupational Safety and Health Act of 1970 (O.S.H.A.)

a. The O.S.H.A. is a Federal regulation setting standards to assure safe and healthful working conditions for working men and women. One of the standards set by O.S.H.A. is concerned with the noise an employee may be exposed to during an eight-hour workday. The noise standards published by the Secretary of Labor in the Federal Register, date 29 May 1971, are identical to those of the Walsh-Healey Act of 1969.

The O.S.H.A. exposure percentage is a measure of the noise levels in terms of Walsh-Healey exposures normalized to an eight-hour workday. When the percentage reaches or exceeds 100, it means that exposure of a worker to that same noise climate for 8 hours would be in violation of the Act. Additionally, when any one-time exposure over 115 dBA is exceeded during the measurement period, the exposure percentage number will be followed by a "V" indicating a violation even if the number is less than 100 percent.

b. The equation used to calculate the O.S.H.A. exposure percentage is as follows:

$$W1 = \left[\frac{W2}{6} + \frac{W3}{4} + \frac{W4}{3} + \frac{W5}{2} + \frac{W6}{1.5} + \frac{W7}{1} + \frac{W8}{0.5} + \frac{W9}{0.25} \right] \times \frac{800}{N}$$

where

W1 = O.S.H.A. exposure in percent

W2 = Number of samples in the 90 to 92 dBA band

W3 = Number of samples in the 92 to 95 dBA band

W4 = Number of samples in the 95 to 97 dBA band

W5 = Number of samples in the 97 to 100 dBA band

W6 = Number of samples in the 100 to 102 dBA band

W7 = Number of samples in the 102 to 105 dBA band

W8 = Number of samples in the 105 to 110 dBA band

W9 = Number of samples in the 110 to 115 dBA band

N = Total number of samples where one sample represents one-eight second.

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