FINAL REPORT

FOR

FHWA WORK ORDER NO. DTFH71-83-3610-IA-12

# Effectiveness of Parallel Noise Barriers
# An Iowa Study

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## DISCLAIMER

ABSTRACT

Traffic noise monitoring using FHWA's Demonstration Projects Division Mobile Noise Laboratory at free field, single wall and parallel barrier site on I-380 in Evansdale, Iowa is described. Access to I-380 prior to its being open to traffic afforded a controlled pass-by monitoring phase involving different vehicle types. A subsequent second phase entailed identical measurement methodology to monitor "real world" I-380 traffic noise. Phase I data indicated increases in noise were significant under the parallel barrier conditions for light duty vehicles operating in the far lane. Phase II results showed that the actual I-380 traffic mix largely offset the earlier observed effect, but minor increases in traffic noise under the parallel system were noted. These differences in noise barrier system effectiveness are judged to be insignificant at this particular study location.

## INTRODUCTION

The Iowa Department of Transportation (Iowa DOT) is one of a number of state highway agencies (SHA) which have constructed parallel noise barriers. In the fall of 1982, 2600 feet of parallel steel noise barriers were constructed adjacent to Interstate 380 in the City of Evansdale, Iowa. It was determined during the initial noise impact analysis for this project that some type of parallel noise barriers would have to be constructed. The preliminary barrier design concept called for the construction of an earthen barrier on one side of the highway and a solid wall on the opposite side. It was felt that the berm would not only reduce barrier costs, but virtually eliminate any problems due to reflected noise. However, because of restricted available right of way and other highway design considerations the berm and wall concept had to be eliminated in the final design. Using the best prediction models available at the time (2,3), it was concluded that although the insertion loss may not be as high if the parallel walls were built, instead of the original berm and wall concept, the effective insertion loss would still be significant enough to be of benefit to the impacted receivers.

It was during the development of the I-380 noise barrier project that the Iowa DOT noise analysis staff first became aware of the difficulties in analyzing the effectiveness of parallel barriers. Unlike for the single barrier analysis, there were no computerized prediction models available for parallel barrier analysis. The Federal Highway Administration (FHWA) had provided the SHA's with a simple "parallel barrier nomograph" (3) for the analysis of parallel barriers. Because the staff was not totally confident in the results of a simple nomograph prediction, a literature search was made for data related to parallel barrier analysis. It was discovered that although most noise abatement specialists concede that some reduction in the insertion loss does occur when parallel barriers are built, there is no consensus over just how significant the reduction could be. Most of the data relating to the degradation problem is based on theoretical acoustical analysis or scale model studies. Many of the "laboratory" studies show that the effective insertion loss of one barrier can be significantly reduced or even eliminated by the presence of an opposite parallel barrier (4,5,6). At the same time the limited number of full scale field measurements which have been made (5,6,8) have provided no clear cut data which can be used to predict the potential reduction in the insertion loss when parallel barriers are built.

In early 1983 the Iowa DOT received copies of two papers (1,7) which not only provided much needed information on the subject of parallel noise barriers, but also rekindled the noise analysis staff's concern over just how effective the recently completed I-380 parallel barriers would be. The Bowlby and Cohn paper (1) described the development of an algorithm and a computer program called IMAGE-3 for the analysis and design of parallel barriers. This paper emphasized however, that although models which are developed for analyzing the effectiveness of parallel barriers may be mathematically and acoustically sound, few if any, well documented field validation studies have been performed.

Because the Iowa DOT is always interested in the performance of any noise barriers constructed along Iowa highways "before" and "after" noise level data is often obtained for analysis. This data is used to not only determine overall barrier performance, but to also test the accuracy of the model used to predict barrier effectiveness. Although no formal study was originally being proposed, the noise analysis staff was preparing to undertake a more extensive than normal noise monitoring effort after I-380 was opened to traffic.

In August, 1983, noise analysis staff members attended the annual summer meeting of the Transportation Research Board's (TRB) Transportation Noise Committee in Boston, Massachusetts. Although no formal discussions were held concerning the problem of parallel noise barriers during the course of the meeting, it was learned that there has still been very little field data collected in the vicinity of parallel barriers. The FHWA personnel present at the meeting made it known that the FHWA was concerned about the parallel barrier reflection problem and were in the process of funding some experimental field work in this area. Upon hearing of the increased involvement of the FHWA, Iowa DOT staff inquired as to the possibility of having the FHWA provide support in obtaining noise data along the I-380 parallel barrier segment. The FHWA indicated that assistance for this type of work was available.

Shortly after returning from Boston, the noise analysis staff submitted a Research Work Plan (Appendix A) to the FHWA for the proposed I-380 barrier study. Acting expeditiously, the FHWA approved the work plan in September 1983.

The following interim report describes the procedures used in the initial controlled passby phase of the project and discusses the noise data collected.

## II. COORDINATION WITH THE FEDERAL HIGHWAY ADMINISTRATION

The work plan submitted to the FHWA Iowa Division office described a two-phase study at the I-380 site in Evansdale. The first phase would entail noise measurements from controlled vehicle passbys at each of three barrier conditions - free field (no barrier), single wall and parallel walls. A second phase to be undertaken after the highway is open to traffic would collect noise data from the normal traffic mix at the same three locations.

Federal Highway Administration participation was to consist of providing the Demonstration Projects Division's noise analysis trailer along with a technician and a project manager to oversee the use of the FHWA equipment. A $10,000 grant was requested to be administered through The Demonstration Projects Division to cover costs incurred by the State.

A preliminary report was to be prepared by the State upon completion of the first phase of the study and a final report was to be prepared upon completion of the phase two monitoring.

Provisions were also agreed upon to provide the study site details and noise measurement data to Vanderbilt University for application of the IMAGE-3 parallel barrier model.

## III. STUDY SITES

The three barrier conditions are located in a single mile-long section of I-380 as shown on Figure 1 and in the following photos:

1) The free field site was an open field location with no major obstructions (Figure 2)

2) The single wall site was a state-owned parcel lying between the highway right-of-way and residential land use. (Figure 3)

3) The parallel wall site was the midpoint of the parallel wall section of I-380 in an established residential area (Figures 4 and 5)

Remote Microphones from the FHWA Demo Projects noise analysis system were positioned at the following locations:

<u>Free Field</u>

1. 40' From centerline N.L. (Near Lane) 5' above roadway
2. 40' From centerline N.L. 15' above roadway
3. 90' From centerline N.L. 10' above roadway
4. 90' From centerline N.L. same elevation as roadway
5. 140' From centerline N.L. 5' above ground, same elevation as roadway
6. 190' From centerline N.L. 5' above ground, same elevation as roadway
7. In Middle of median 50' from centerline of each far lane, 5' above roadway

Figure 1. Study site locations

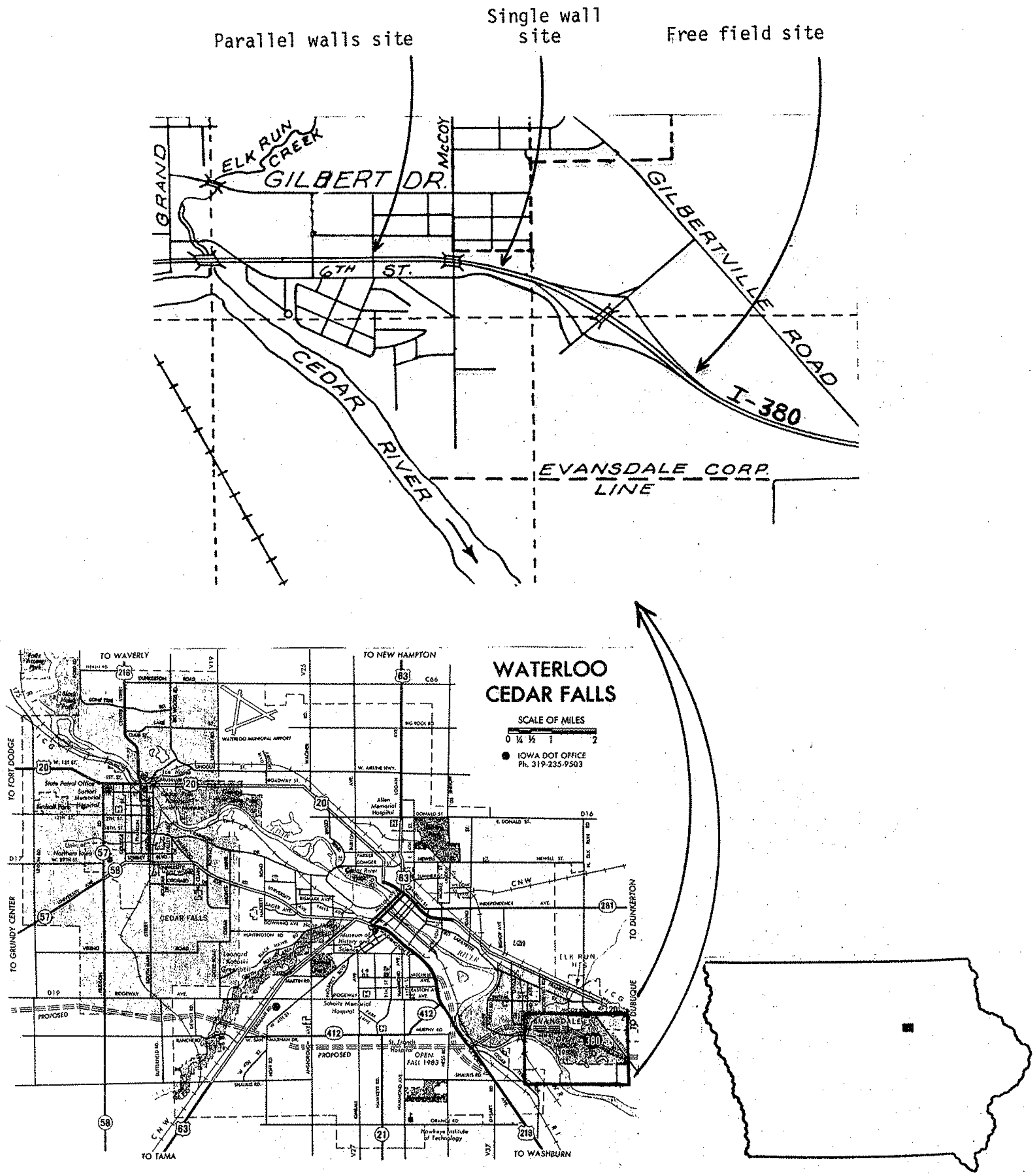


Figure 2. Free field study site

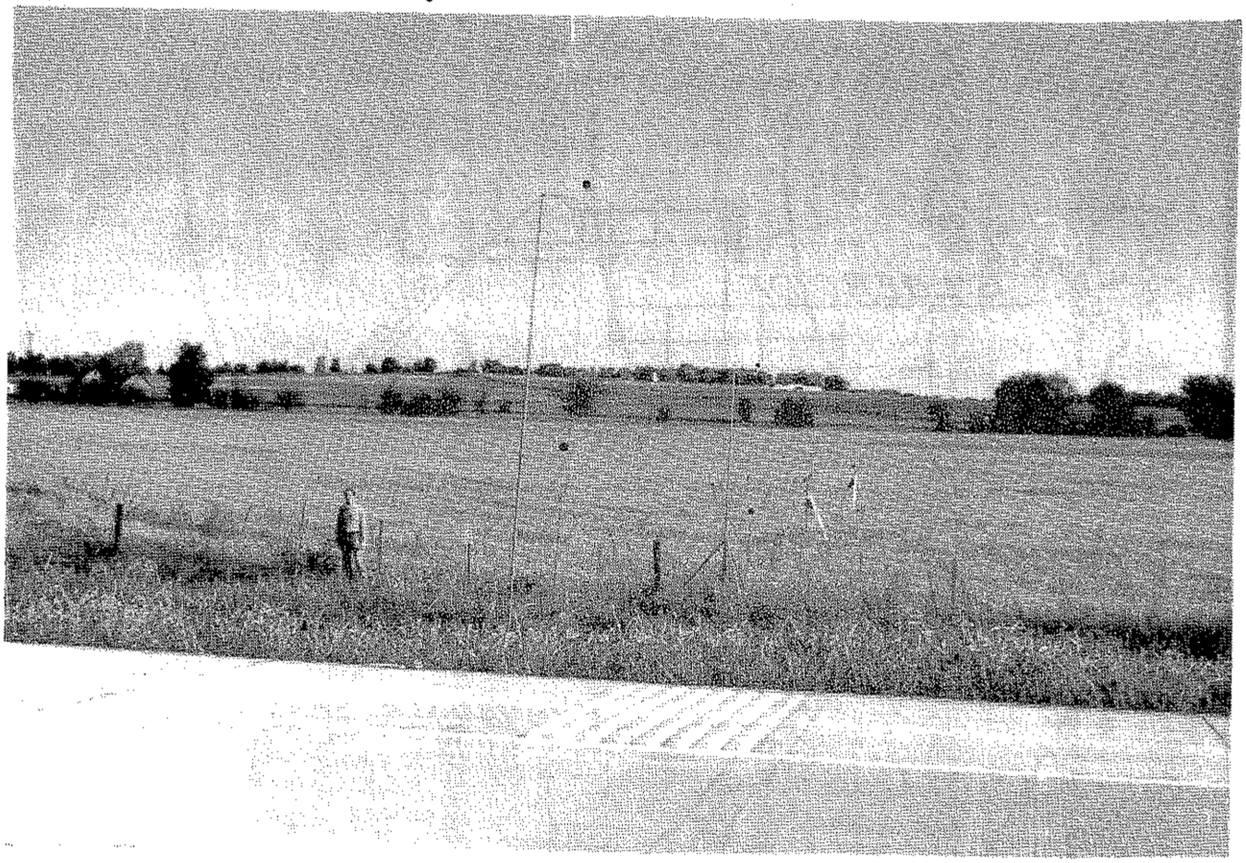


Figure 3. Single wall study site

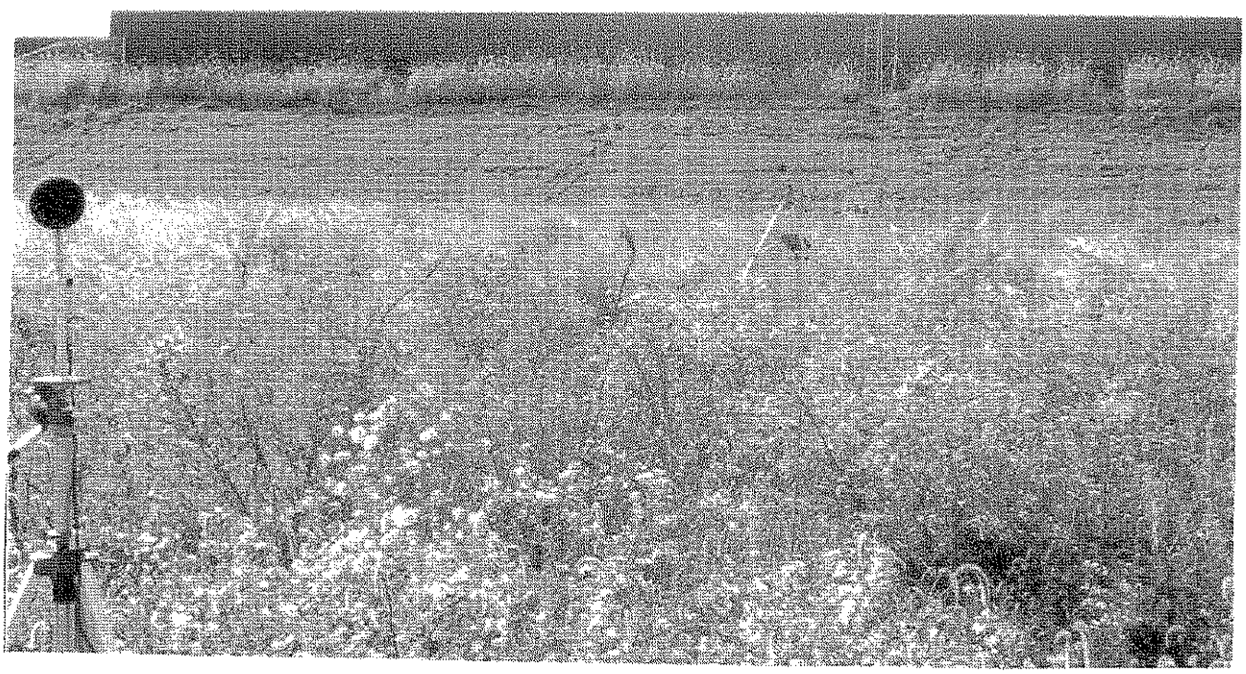


Figure 4. Parallel walls study site

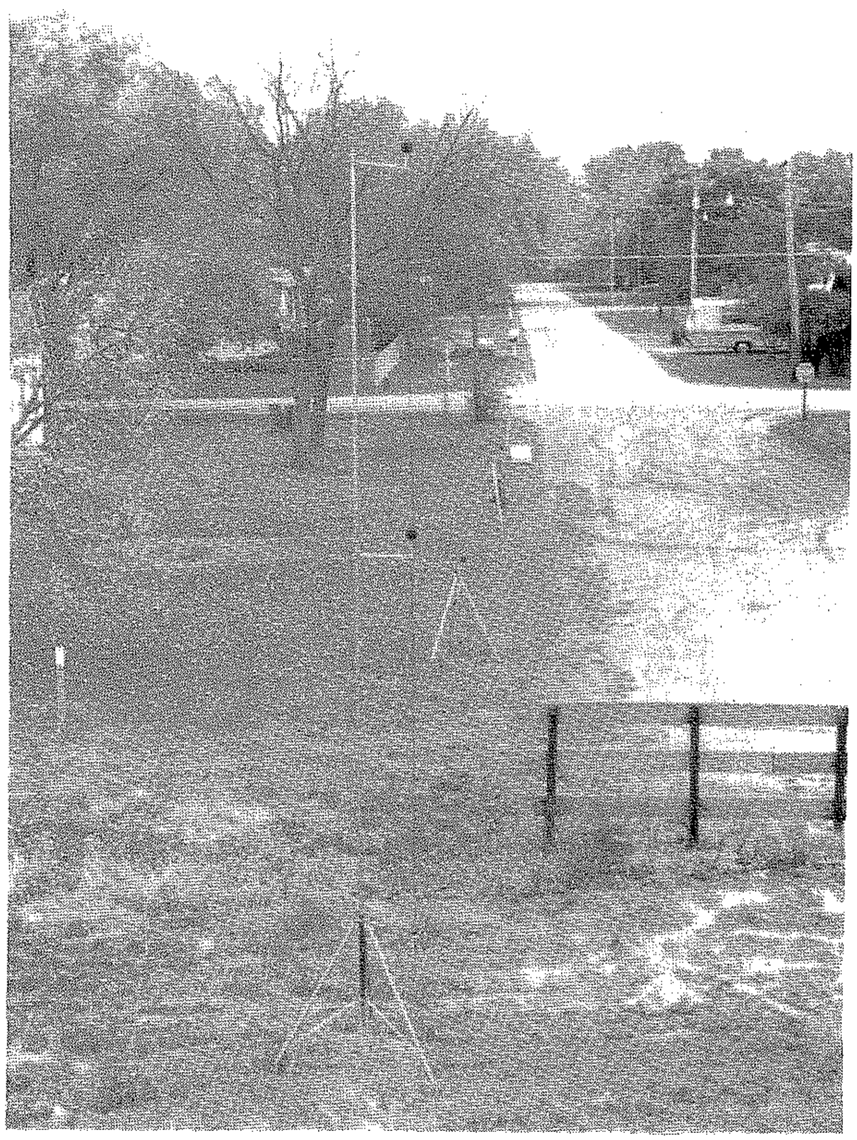


Figure 5. Parallel walls study site

## Single Barrier

1. 40' From centerline N.L. 1' Behind wall, 5' above roadway
2. 40' From centerline N.L. 1' Behind wall, 5' above top of wall, 17' above roadway
3. 90' From centerline N.L. 15' above roadway
4. 90' From centerline N.L. 6' above roadway
5. 140' From centerline N.L. 5' above ground, 5' below roadway
6. 190' From centerline N.L. 5' above ground, 5' below roadway
7. 240' From centerline N.L. 5' above ground, 5' below roadway
8. In Middle of median 50' from centerline of each far lane, 5' above roadway

## Parallel Barriers

1. 40' From centerline N.L. 1' behind wall, 5' above roadway
2. 40' From centerline N.L. 1' behind wall, 5' above top of wall, 17' above roadway
3. 90' From centerline N.L. 15' above roadway
4. 90' From centerline N.L. 6' above roadway
5. 140' From centerline N.L. 5' above ground, 3' below roadway elevation
6. 190' From centerline N.L. 5' above ground, 3' below roadway elevation
7. 240' From centerline N.L. 5' above ground, 3' below roadway elevation
8. 290' From centerline N.L. 5' above ground, 1' below roadway elevation
9. In Middle of median, 5' above roadway
10. On south side of south barrier 140' From centerline N.L. 5' above ground, 3' below roadway

Additionally, an independent microphone was located on the highway centerline in the median at a height of 5 feet above the roadways. The cross sections of the monitoring sites and microphone locations are shown on Figures 6 and 7. All sites are considered "soft" with low growing grasses being the primary ground cover.

Figure 6. Cross section and plan view of free field site
X = microphone location

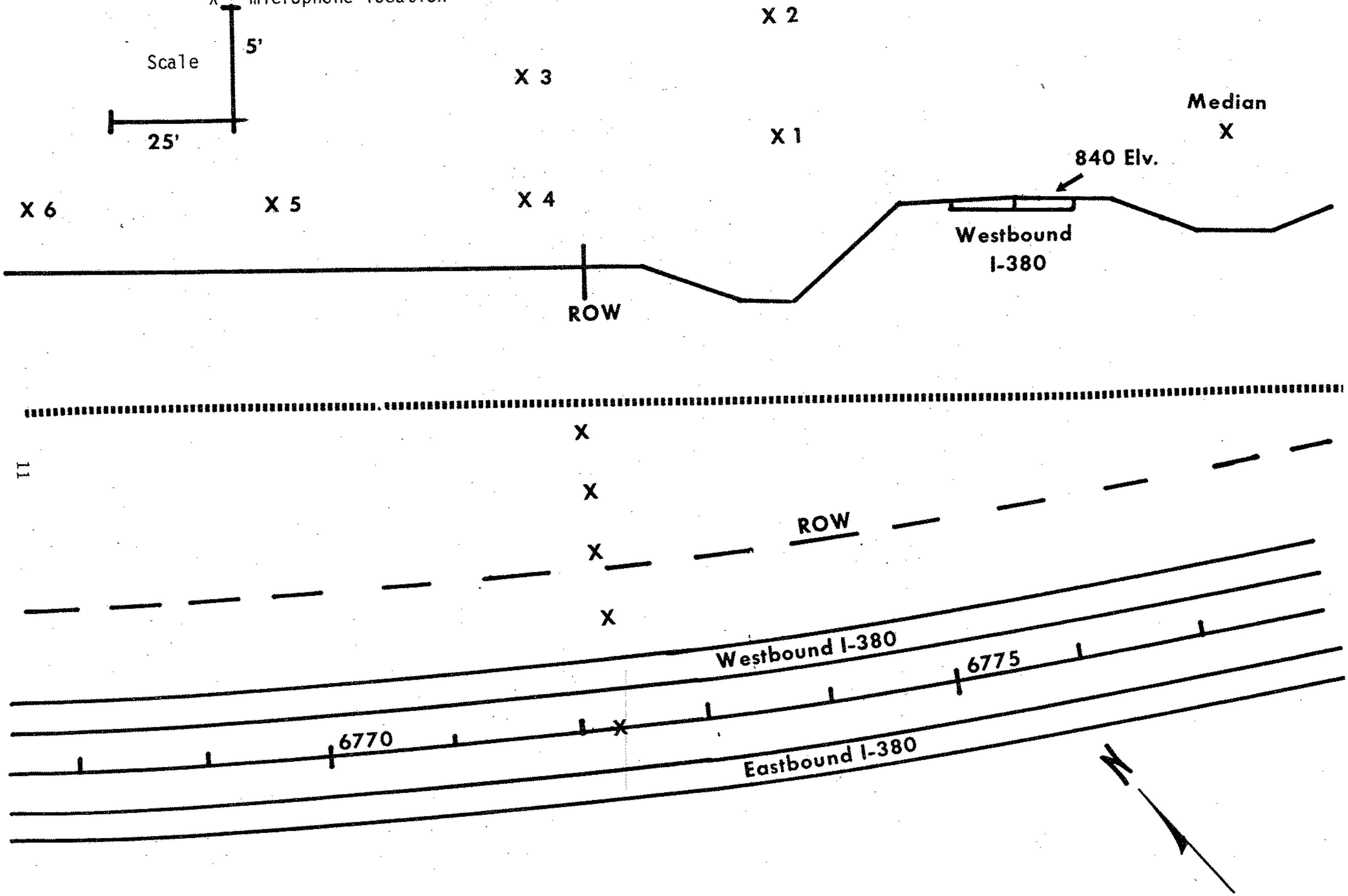
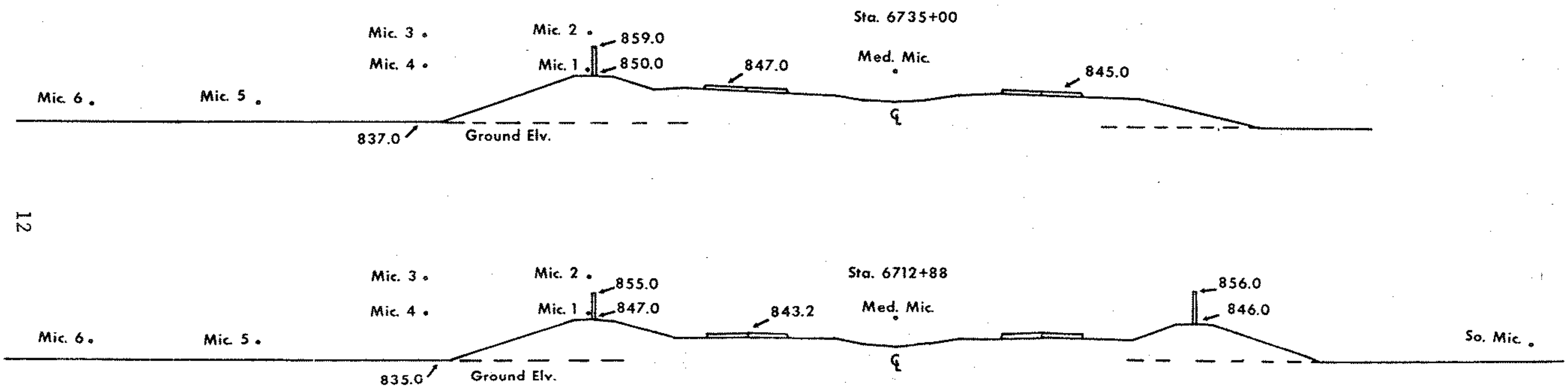


Figure 7. Cross sections of single wall and parallel walls sites



## IV. EQUIPMENT AND CONDITIONS

Five vehicle types were used as controlled noise sources:

1. 1971 International truck tractor, 6 cylinder diesel, 270 horsepower, 855 cubic inch, Fuller 13-speed transmission, pulling trailer carrying JD 450 dozer weighing 8 tons. Total Loaded Weight 48,000 lbs. (Figure 8)
2. 1981 Ford LT8000 tandem axle, 8 cylinder diesel, 210 horsepower, Caterpiller 3208 engine, Fuller R66-13 transmission (13-speed). Total Loaded Weight 52,000 lbs. (Figure 9)
3. 1975 Ford F700 two axle, 8 cylinder gas, 5-speed Clark transmission. Total Loaded Weight 28,000 lbs. (Figure 10)
4. 1980 Ford F150 ½ ton pickup, 6 cylinder gas, 300 cubic inch engine, automatic transmission. Carried No Load. (Figure 11)
5. 1981 Chevrolet Impala Station Wagon, 8 cylinder gas, 267 cubic inch engine, automatic transmission.

The tandem axle and two axle trucks were equipped with Firestone Super All Traction tires on the rear axles. These have a cross bar type of tread design. (Figure 12) The semi tractor had Goodyear Super High Miler tires on the rear which are also cross bar type. The remainder of the test vehicle tires were of a conventional rib design. (Figure 13) The vehicle drivers were instructed to cruise past the microphone site in normal open-road gear at a steady speed of 50-60 mph. Actual passby speeds were measured with a portable radar gun.

Figure 8. Tractor-trailer

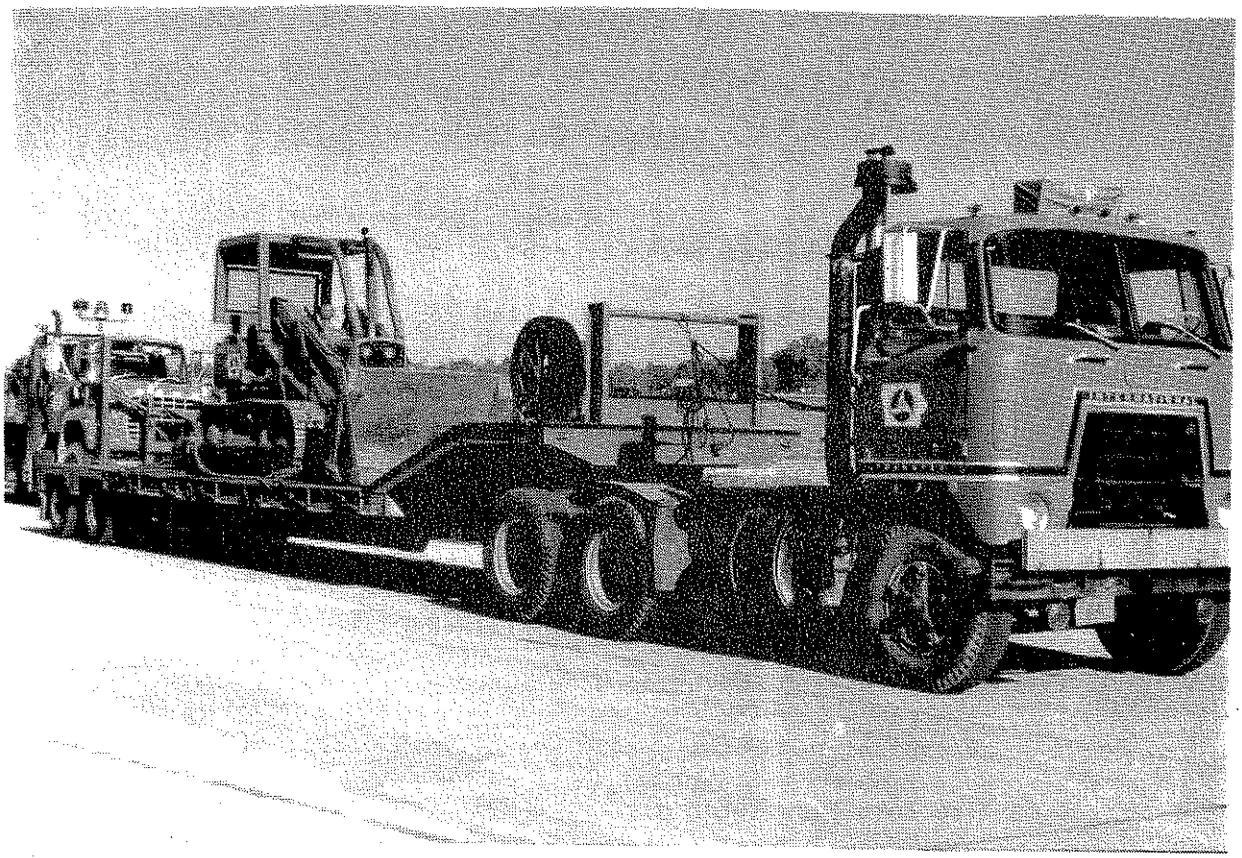


Figure 9. Tandem axle truck

Figure 10. Two axle truck

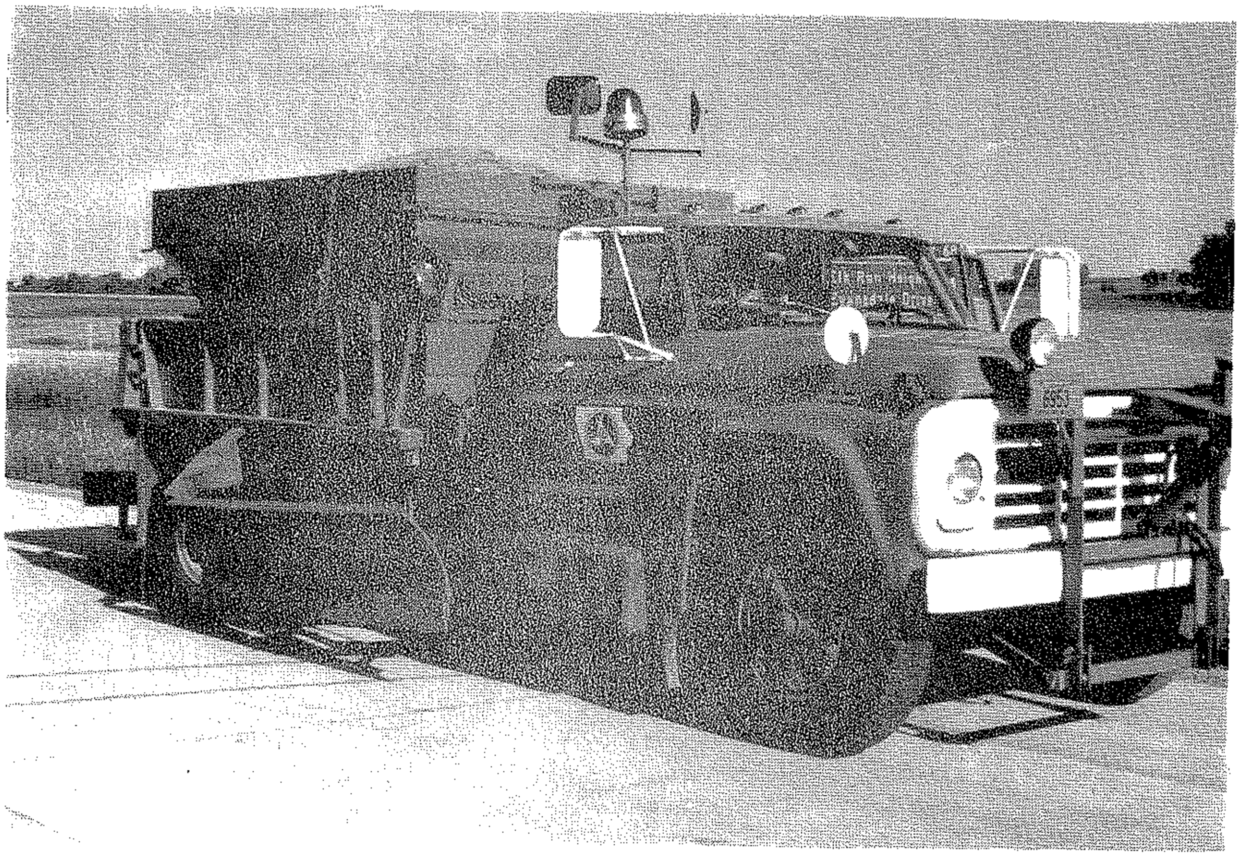


Figure 11. Pickup truck

Figure 12. Cross bar type tread

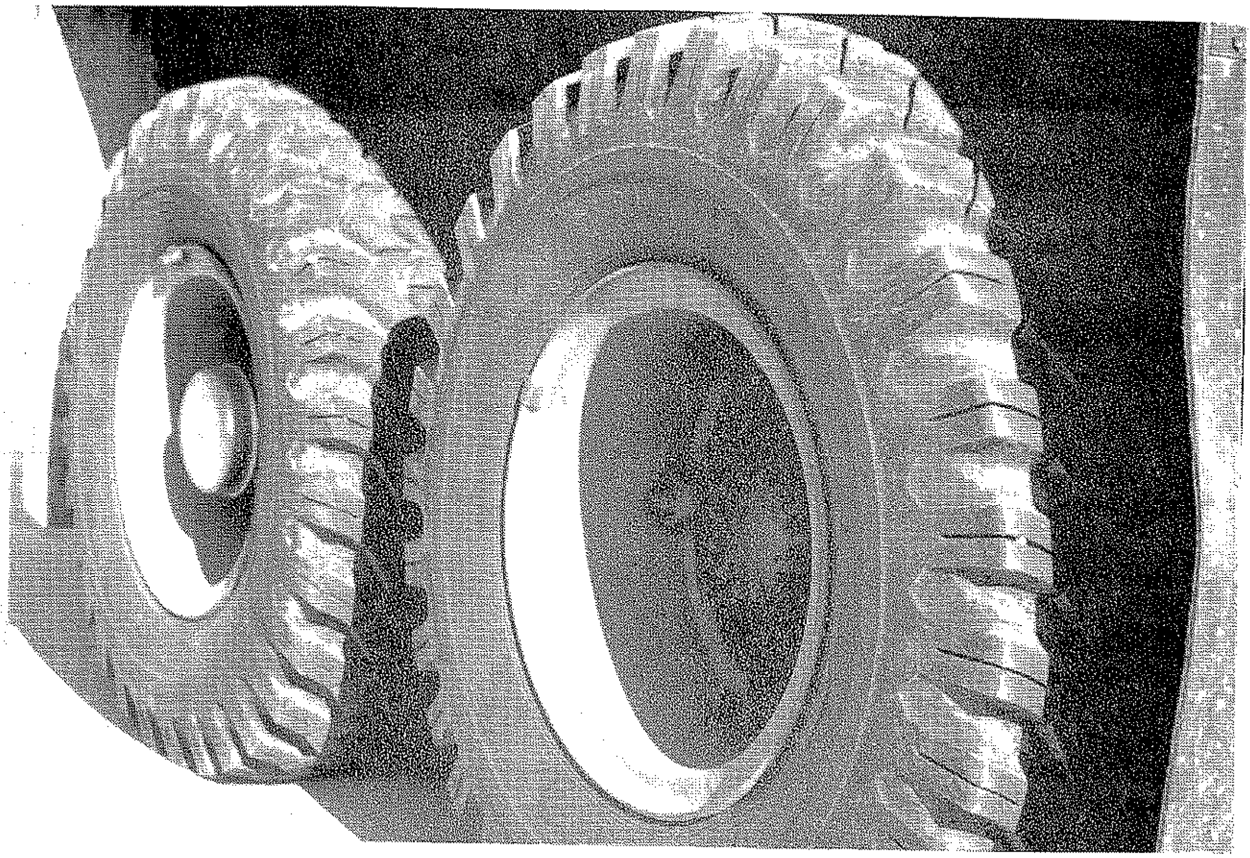
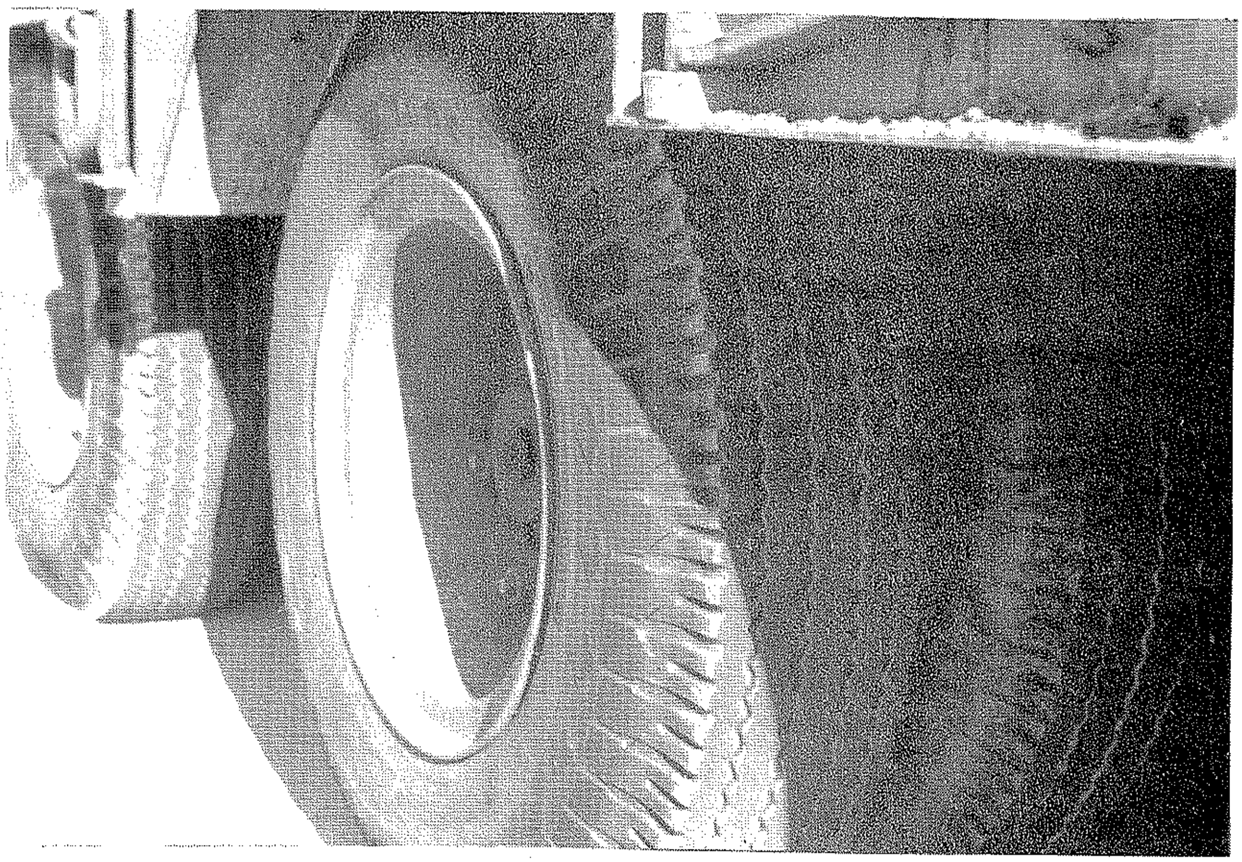


Figure 13. Rib design tread



Noise measurement equipment was provided by the FHWA Demonstration Projects Division's Noise trailer. General Radio ½ inch microphones were connected to the Hewlitt-Packard data analysis system. A BBN Model 614 noise analyzer was located in the median and set on the threshold mode to record peak noise levels for each passby. A sample of 70 seconds duration was collected at each of the remote microphones during each passby.

Favorable meteorological conditions were noted for each test period:

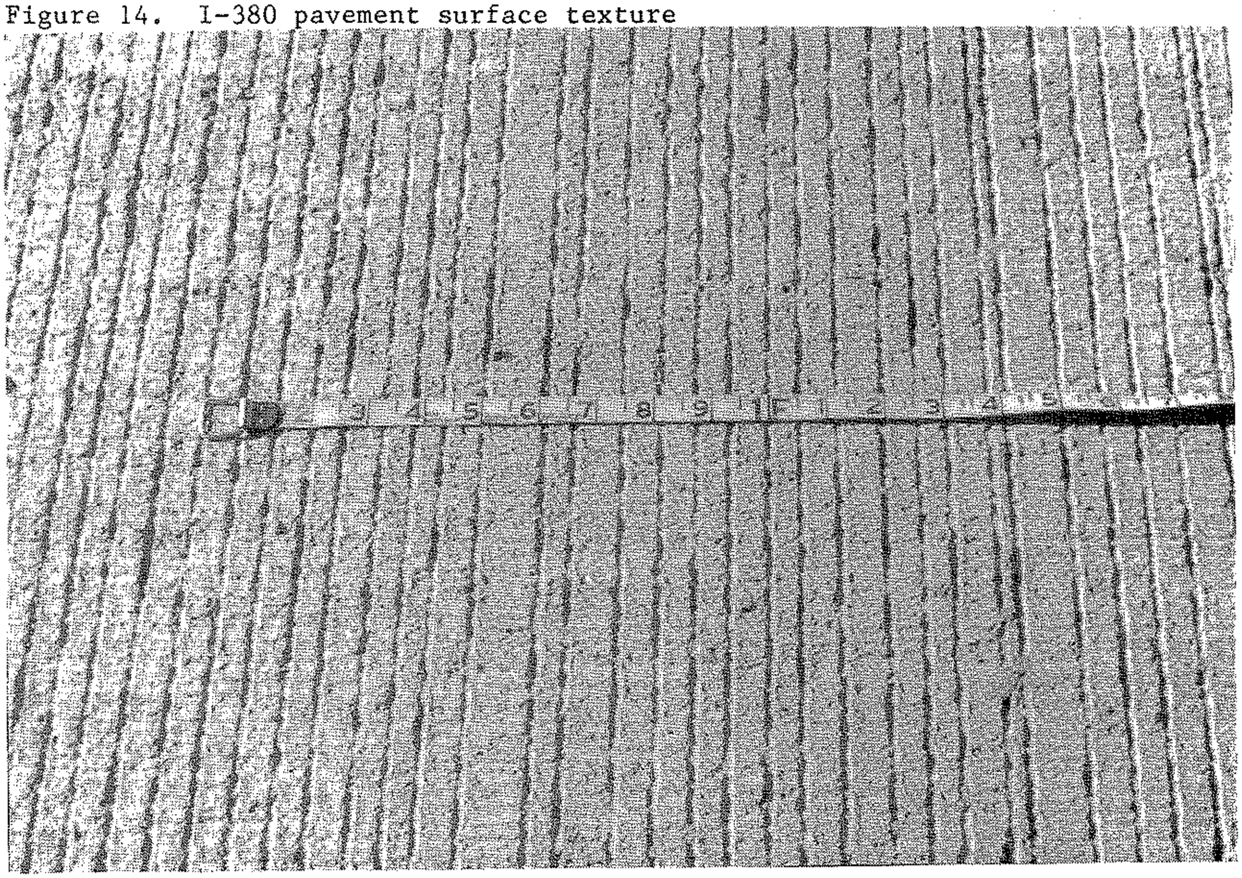
free field - 0% cloud cover, wind 0-5 mph from the south humidity 50-60%, temperature 64-68 F.

single wall - 0% cloud cover, wind 3-8 mph from the southeast, humidity 40-45%, temperature 60-65 F.

parallel walls - 100% cloud cover, wind 0-5 mph from the south, humidity 45-50%, temperature 55-60 F.

Pavement conditions were dry for all passbys. Pavement texture was 1/8 inch transverse grooves at 5/8 - 1¼ inch spacing. (Figure 14)

Figure 14. I-380 pavement surface texture



## V. PROCEDURE

Test vehicle passby sequencing was maintained through hand-held radio contact with one of the vehicle drivers who then would instruct the other vehicle drivers to begin their runs. The radios also permitted contact between the roadside test area and the noise analysis trailer. Personnel in the trailer were alerted at the beginning of each passby so that the passby noise curve would be included within the 70-second monitoring period required by the computer. The roadside "coordinator" also measured passby speed with the battery powered radar gun and made a notation of the specific passby description on the BBN printout tape. In the trailer hard copies of the Leq and Ln values measured at each microphone were printed. Additionally a frequency analysis printout was prepared for microphone number 6 located 190 feet from near lane (150 feet from wall) at each test site. The four truck types were used at all three sites. The automobile was used at the free field site and the single wall site but was eliminated from the test during the parallel wall portion of the study. It was observed that the automobile passby data were nearly identical to that of the pickup and it was decided that the time spent at the parallel site could be better used obtaining data from the other vehicle types.

## VI. DATA OBSERVATIONS

A total of 102 vehicle passbys were recorded and were broken down as follows: 28 free field passbys, 35 single barrier passbys, and 39 parallel barrier passbys. The Leq and L1 values measured at each microphone are shown on Tables 1, 2, and 3. After a preliminary review of the passby data, the initial single barrier passby was eliminated. As can be seen on Table 2, although values were recorded for the initial passby, they were much lower than would have normally occurred with a tandem axle truck passby. In addition the underlined values shown on Table 3 were also considered invalid. The occasional traffic on a nearby street influenced the noise levels at these microphones to a greater degree than was originally expected. The remaining data is summarized by the mean values shown on Table 4, 5 and 6. These data represent noise levels at the microphones located 100 feet and 150 feet from the wall and also at the reference microphone and the median microphones respectively.

Upon reduction and review of the noise data definite trends could be identified; however the limited number of passbys and the variance in individual passby speeds and noise levels make the value of a larger data base clear. From the data collected the following observations were made:

1. Noise data from all microphones show a tendency towards increased noise levels under the parallel wall condition as compared to the single wall.

2. This tendency for higher noise levels with parallel walls is generally more apparent in the far lane passbys than the near lane passbys with this tendency very obvious at the reference microphone (Mic. 2) location.

Table 1. Vehicle passby data-free field

Free Field Site

T-T Tractor Trailer, T-A Tandem Axle, 2-A Two Axle 6-Tire
P - Pickup, A - Auto, West=Near Lane, East=Far Lane

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED MPH | Mic.1 | | Mic.2 | | Mic.3 | | Mic.4 | | Mic.5 | | Mic.6 | | Mic.7 | | Mic.8 | | Median | | So. Wall | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | Lmax | Mic. | Lmax |
| 0-1 | T-T | West | 10:07 | 53 | 68 | 84 | 68 | 83 | 65 | 80 | 64 | 78 | 59 | 74 | 55 | 68 | | | | | 77 | 83 | | |
| 0-2 | T-T | East | 11:20 | 60 | 68 | 78 | 68 | 79 | 66 | 76 | 61 | 70 | 59 | 70 | 56 | 66 | | | | | 80 | 87 | | |
| 0-2 | T-A | East | 11:25 | 45 | 62 | 71 | 63 | 72 | 61 | 69 | 57 | 65 | 55 | 63 | 53 | 60 | | | | | 74 | 78 | | |
| 0-2 | 2-A | East | 11:29 | 45 | 63 | 73 | 64 | 72 | 62 | 71 | 57 | 65 | 55 | 63 | 53 | 60 | | | | | 74 | 79 | | |
| 0-2 | P | East | 11:33 | 58 | 54 | 67 | 56 | 67 | 54 | 65 | 50 | 59 | 48 | 57 | 47 | 54 | | | | | 71 | 74 | | |
| 0-3 | T-A | West | 11:53 | 51 | 71 | 86 | 71 | 86 | 67 | 82 | 65 | 79 | 62 | 75 | 60 | 72 | | | | | 74 | 83 | | |
| 0-3 | 2-A | West | 11:59 | 53 | 73 | 87 | 74 | 88 | 70 | 81 | 67 | 79 | 64 | 76 | 62 | 73 | | | | | 76 | 85 | | |
| 0-4 | T-A | East | 12:22 | 55 | 71 | 84 | 72 | 84 | 69 | 79 | 66 | 77 | 63 | 73 | 61 | 72 | | | | | 77 | 85 | | |
| 0-4 | 2-A | East | 12:27 | 54 | 67 | 79 | 69 | 80 | 67 | 77 | 62 | 72 | 59 | 69 | 57 | 67 | | | | | 79 | 86 | | |
| 0-4 | P | East | 12:32 | 56 | 54 | 65 | 56 | 66 | 54 | 64 | 49 | 59 | 48 | 57 | 47 | 54 | | | | | 71 | 73 | | |
| 0-4 | A | East | 12:37 | 55 | 53 | 65 | 54 | 65 | 53 | 64 | 50 | 59 | 48 | 57 | 46 | 53 | | | | | 70 | 73 | | |
| 0-5 | T-T | West | 12:43 | 56 | 73 | 87 | 73 | 87 | 69 | 82 | 68 | 80 | 64 | 76 | 61 | 73 | | | | | 77 | 85 | | |
| 0-5 | T-A | West | 12:50 | 55 | 71 | 86 | 72 | 86 | 67 | 80 | 66 | 78 | 63 | 74 | 60 | 71 | | | | | 76 | 86 | | |
| 0-5 | 2-A | West | 12:54 | 53 | 72 | 86 | 73 | 87 | 69 | 81 | 67 | 80 | 63 | 76 | 58 | 70 | | | | | 76 | 84 | | |
| 0-6 | T-A | East | 14:47 | 53 | 64 | 77 | 66 | 79 | 64 | 77 | 60 | 71 | 59 | 71 | 57 | 68 | | | | | 78 | 84 | | |
| 0-6 | 2-A | East | 14:52 | 55 | 68 | 79 | 68 | 78 | 67 | 77 | 63 | 73 | 61 | 71 | 59 | 68 | | | | | 78 | 86 | | |

Table 1 (cont.)

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED | Mic.1 Leq | Mic.1 L1 | Mic.2 Leq | Mic.2 L1 | Mic.3 Leq | Mic.3 L1 | Mic.4 Leq | Mic.4 L1 | Mic.5 Leq | Mic.5 L1 | Mic.6 Leq | Mic.6 L1 | Mic.7 Leq | Mic.7 L1 | Mic.8 Leq | Mic.8 L1 | Median Leq | Median Lmax | So. Wall Mic. | So. Wall Lmax |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0-6 | P | East | 14:56 | 55 | 53 | 64 | 55 | 65 | 53 | 63 | 50 | 59 | 48 | 57 | 47 | 54 | | | | | 70 | 73 | | |
| 0-6 | A | East | 15:01 | 55 | 54 | 65 | 55 | 64 | 54 | 63 | 52 | 61 | 50 | 59 | 49 | 56 | | | | | 70 | 73 | | |
| 0-7 | T-T | West | 15:11 | 54 | 70 | 85 | 71 | 85 | 67 | 79 | 66 | 78 | 63 | 75 | 60 | 71 | | | | | 77 | 83 | | |
| 0-7 | T-A | West | 15:16 | 52 | 70 | 85 | 70 | 85 | 66 | 80 | 65 | 78 | 62 | 74 | 59 | 71 | | | | | 74 | 83 | | |
| 0-7 | 2-A | West | 15:21 | 51 | 71 | 85 | 72 | 86 | 68 | 80 | 67 | 78 | 63 | 74 | 61 | 72 | | | | | 75 | 83 | | |
| 0-7 | P | West | 15:25 | 55 | 60 | 75 | 61 | 75 | 58 | 69 | 55 | 67 | 53 | 64 | 50 | 61 | | | | | 70 | 73 | | |
| 0-7 | A | West | 15:30 | 53 | 59 | 73 | 60 | 73 | 56 | 68 | 54 | 66 | 51 | 63 | 49 | 59 | | | | | 68 | 70 | | |
| 0-8 | T-T | West | 15:37 | 55 | 70 | 85 | 71 | 85 | 67 | 79 | 66 | 78 | 63 | 75 | 61 | 72 | | | | | 77 | 83 | | |
| 0-8 | T-A | West | 15:41 | 52 | 71 | 85 | 71 | 85 | 68 | 83 | 66 | 79 | 63 | 76 | 60 | 73 | | | | | 76 | 83 | | |
| 0-8 | 2-A | West | 15:46 | 52 | 72 | 86 | 73 | 87 | 68 | 80 | 66 | 78 | 63 | 74 | 60 | 71 | | | | | 76 | 84 | | |
| 0-8 | P | West | 15:50 | 53 | 59 | 73 | 60 | 73 | 56 | 67 | 54 | 66 | 52 | 63 | 50 | 59 | | | | | 69 | 71 | | |
| 0-8 | A | West | 15:55 | 55 | 59 | 74 | 60 | 73 | 56 | 68 | 54 | 66 | 52 | 64 | 49 | 59 | | | | | 69 | 71 | | |

Table 2. Vehicle passby data-single barrier

Single Barrier Site

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED | Mic.1 Leq | Mic.1 L1 | Mic.2 Leq | Mic.2 L1 | Mic.3 Leq | Mic.3 L1 | Mic.4 Leq | Mic.4 L1 | Mic.5 Leq | Mic.5 L1 | Mic.6 Leq | Mic.6 L1 | Mic.7 Leq | Mic.7 L1 | Mic.8 Leq | Mic.8 L1 | Median Leq | Median Lmax | So. Wall Mic. | So. Wall Lmax |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *1-1 | T-A | West | 10:22 | 55 | 60 | 70 | 61 | 71 | 54 | 61 | 53 | 60 | 55 | 61 | 54 | 62 | 51 | 61 | | | 78 | 84 | | |
| 1-1 | 2-A | West | 10:30 | 54 | 61 | 70 | 73 | 87 | 60 | 68 | 56 | 64 | 54 | 61 | 53 | 60 | 53 | 60 | | | 79 | 86 | | |
| 1-1 | P | West | 10:35 | 54 | 50 | 57 | 61 | 75 | 49 | 56 | 48 | 52 | 48 | 51 | 47 | 49 | 46 | 49 | | | 71 | 74 | | |
| 1-1 | A | West | 10:41 | 55 | 51 | 56 | 61 | 74 | 51 | 58 | 49 | 54 | 49 | 52 | 49 | 51 | 49 | 53 | | | 70 | 72 | | |
| 1-2 | T-T | East | 10:50 | 55 | 53 | 64 | 65 | 77 | 57 | 67 | 53 | 62 | 51 | 59 | 51 | 58 | 51 | 59 | | | 76 | 82 | | |
| 1-2 | T-A | East | 10:57 | 51 | 59 | 68 | 66 | 78 | 60 | 70 | 56 | 65 | 57 | 63 | 54 | 60 | 54 | 61 | | | 75 | 83 | | |
| 1-2 | 2-A | East | 11:04 | 50 | 57 | 64 | 68 | 78 | 61 | 70 | 56 | 63 | 55 | 59 | 53 | 59 | 53 | 58 | | | 77 | 85 | | |
| 1-2 | A | East | 11:17 | 53 | 49 | 51 | 56 | 59 | 51 | 56 | 49 | 53 | 49 | 52 | 49 | 51 | 47 | 50 | | | 68 | 69 | | |
| 1-3 | T-T | West | 11:24 | 57 | 59 | 68 | 72 | 87 | 59 | 69 | 56 | 65 | 55 | 63 | 54 | 62 | 53 | 61 | | | 78 | 84 | | |
| 1-3 | T-A | West | 11:32 | 53 | 63 | 74 | 72 | 85 | 60 | 72 | 57 | 67 | 56 | 64 | 55 | 62 | 53 | 60 | | | 78 | 86 | | |
| 1-3 | 2-A | West | 11:39 | 52 | 60 | 71 | 74 | 88 | 63 | 74 | 59 | 66 | 57 | 64 | 56 | 62 | 55 | 62 | | | 79 | 86 | | |
| 1-3 | P | West | 11:43 | 55 | 50 | 56 | 63 | 74 | 54 | 60 | 51 | 56 | 50 | 54 | 49 | 53 | 48 | 52 | | | 70 | 73 | | |
| 1-3 | A | West | 11:48 | 55 | 50 | 57 | 61 | 74 | 51 | 58 | 49 | 54 | 49 | 53 | 48 | 52 | 47 | 52 | | | 71 | 73 | | |
| 1-4 | T-T | East | 13:22 | 53 | 55 | 62 | 64 | 75 | 60 | 68 | 56 | 63 | 54 | 60 | 55 | 63 | 53 | 62 | | | 75 | 81 | | |
| 1-4 | T-A | East | 13:29 | 45 | 57 | 64 | 64 | 74 | 58 | 68 | 54 | 62 | 54 | 59 | 53 | 58 | 51 | 56 | | | 75 | 80 | | |
| 1-4 | 2-A | East | 13:35 | 50 | 57 | 66 | 67 | 77 | 61 | 70 | 56 | 63 | 54 | 58 | 55 | 62 | 54 | 62 | | | 77 | 84 | | |
| 1-5 | T-A | West | 13:54 | 55 | 63 | 74 | 71 | 86 | 61 | 74 | 58 | 70 | 56 | 63 | 55 | 65 | 53 | 64 | | | 79 | 85 | | |
| 1-5 | 2-A | West | 13:59 | 52 | 60 | 70 | 73 | 86 | 62 | 71 | 57 | 66 | 55 | 62 | 55 | 63 | 54 | 63 | | | 79 | 86 | | |
| 1-5 | P | West | 14:03 | 60 | 49 | 58 | 62 | 75 | 52 | 62 | 49 | 56 | 49 | 58 | 49 | 55 | 46 | 54 | | | 71 | 75 | | |

*Underlined Values Eliminated Due to Data Collection Errors

Table 2. (cont.)

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED | Mic.1 Leq | Mic.1 L1 | Mic.2 Leq | Mic.2 L1 | Mic.3 Leq | Mic.3 L1 | Mic.4 Leq | Mic.4 L1 | Mic.5 Leq | Mic.5 L1 | Mic.6 Leq | Mic.6 L1 | Mic.7 Leq | Mic.7 L1 | Mic.8 Leq | Mic.8 L1 | Median Leq | Median Lmax | So. Wall Mic. | So. Wall Lmax |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1-6 | T-T | East | 14:09 | 53 | 52 | 60 | 63 | 74 | 58 | 68 | 53 | 61 | 52 | 57 | 53 | 60 | 51 | 60 | | | 76 | 81 | | |
| 1-6 | T-A | East | 14:15 | 49 | 58 | 66 | 64 | 75 | 59 | 70 | 54 | 64 | 53 | 58 | 53 | 59 | 52 | 60 | | | 74 | 81 | | |
| 1-6 | 2-A | East | 14:23 | 51 | 55 | 64 | 66 | 77 | 61 | 69 | 56 | 64 | 54 | 59 | 55 | 63 | 53 | 62 | | | 76 | 84 | | |
| 1-6 | P | East | 14:27 | 55 | 49 | 52 | 54 | 64 | 51 | 57 | 49 | 51 | 47 | 50 | 49 | 51 | 46 | 50 | | | 69 | 71 | | |
| 1-7 | T-T | West | 14:35 | 58 | 61 | 70 | 72 | 86 | 62 | 73 | 58 | 68 | 56 | 64 | 57 | 65 | 55 | 63 | | | 80 | 86 | | |
| 1-7 | T-A | West | 14:40 | 55 | 63 | 75 | 71 | 86 | 62 | 74 | 58 | 68 | 55 | 64 | 55 | 62 | 52 | 60 | | | 79 | 86 | | |
| 1-7 | 2-A | West | 14:47 | 51 | 61 | 71 | 73 | 86 | 63 | 72 | 61 | 71 | 56 | 63 | 57 | 66 | 54 | 63 | | | 79 | 86 | | |
| 1-7 | P | West | 14:50 | 65 | 50 | 59 | 63 | 77 | 54 | 65 | 50 | 57 | 49 | 55 | 51 | 57 | 48 | 54 | | | 72 | 76 | | |
| 1-8 | T-T | East | 14:57 | 53 | 53 | 59 | 64 | 75 | 60 | 70 | 54 | 61 | 53 | 57 | 55 | 60 | 53 | 59 | | | 75 | 81 | | |
| 1-8 | T-A | East | 15:04 | 49 | 59 | 69 | 65 | 75 | 59 | 69 | 55 | 65 | 55 | 62 | 54 | 60 | 52 | 60 | | | 76 | 82 | | |
| 1-9 | T-T | West | 15:27 | 60 | 62 | 71 | 73 | 86 | 62 | 71 | 58 | 67 | 57 | 63 | 58 | 65 | 55 | 63 | | | 78 | 86 | | |
| 1-9 | T-A | West | 15:34 | 55 | 64 | 72 | 71 | 85 | 62 | 75 | 58 | 70 | 55 | 62 | 55 | 63 | 53 | 62 | | | 79 | 85 | | |
| 1-9 | 2-A | West | 15:39 | 52 | 61 | 71 | 73 | 86 | 62 | 71 | 60 | 69 | 56 | 63 | 56 | 64 | 55 | 62 | | | 80 | 87 | | |
| 1-9 | P | West | 15:49 | 65 | 51 | 59 | 63 | 77 | 55 | 65 | 53 | 61 | 50 | 56 | 52 | 57 | 49 | 57 | | | 72 | 76 | | |
| 1-10 | A | West | 15:54 | 65 | 49 | 57 | 62 | 75 | 56 | 67 | 54 | 68 | 50 | 56 | 50 | 54 | 48 | 55 | | | 72 | 74 | | |
| 1-10 | A | East | 15:58 | 60 | 48 | 51 | 57 | 67 | 55 | 68 | 54 | 67 | 48 | 53 | 50 | 55 | 47 | 51 | | | 69 | 72 | | |

Table 3. Vehicle passby data-parallel barriers

Parallel Barrier Site

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED | Mic.1 Leq | Mic.1 L1 | Mic.2 Leq | Mic.2 L1 | Mic.3 Leq | Mic.3 L1 | Mic.4 Leq | Mic.4 L1 | Mic.5 Leq | Mic.5 L1 | Mic.6 Leq | Mic.6 L1 | Mic.7 Leq | Mic.7 L1 | Mic.8 Leq | Mic.8 L1 | Median Leq | Median Lmax | So. Wall Mic. Lmax |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| *2-1 | T-A | West | 10:11 | 55 | 66 | 73 | 72 | 85 | 62 | 72 | 58 | 68 | 55 | 63 | 54 | 63 | 54 | 65 | 57 | 66 | 77 | 85 | 63 |
| 2-1 | 2-A | West | 10:16 | 53 | 65 | 72 | 74 | 88 | 63 | 71 | 60 | 68 | 59 | 68 | 65 | 75 | 69 | 81 | 73 | 86 | 77 | 85 | 62 |
| 2-1 | P | West | 10:22 | 53 | 49 | 58 | 61 | 74 | 50 | 56 | 47 | 53 | 47 | 49 | 48 | 50 | 49 | 51 | 55 | 56 | 69 | 72 | -- |
| 2-2 | T-T | East | 10:35 | 55 | 57 | 65 | 69 | 80 | 61 | 70 | 56 | 66 | 54 | 60 | 54 | 61 | 55 | 61 | 58 | 66 | 77 | 84 | 63 |
| 2-2 | T-A | East | 10:38 | 50 | 58 | 66 | 68 | 81 | 61 | 71 | 56 | 66 | 55 | 60 | 55 | 61 | 57 | 66 | 65 | 77 | 76 | 84 | 64 |
| 2-2 | 2-A | East | 10:45 | 52 | 60 | 67 | 70 | 80 | 63 | 71 | 58 | 66 | 56 | 62 | 55 | 60 | 56 | 64 | 62 | 73 | 77 | 86 | 65 |
| 2-2 | P | East | 10:54 | 55 | 48 | 52 | 57 | 68 | 49 | 57 | 46 | 51 | 46 | 52 | 50 | 59 | 50 | 54 | 55 | 57 | 71 | 73 | -- |
| 2-3 | T-T | West | 11:01 | 59 | 61 | 73 | 73 | 87 | 60 | 70 | 56 | 66 | 53 | 62 | 54 | 62 | 54 | 61 | 57 | 63 | 79 | 86 | 65 |
| 2-3 | T-A | West | 11:08 | 55 | 68 | 75 | 73 | 86 | 62 | 73 | 58 | 67 | 56 | 66 | 54 | 62 | 55 | 63 | 59 | 71 | 77 | 86 | 64 |
| 2-3 | 2-A | West | 11:15 | 53 | 62 | 72 | 74 | 88 | 61 | 70 | 57 | 65 | 54 | 61 | 53 | 60 | 53 | 59 | 56 | 60 | 78 | 86 | 64 |
| 2-4 | T-T | East | 11:25 | 57 | 57 | 68 | 68 | 80 | 60 | 69 | 55 | 65 | 54 | 60 | 55 | 63 | 59 | 69 | 66 | 79 | 78 | 85 | 65 |
| 2-4 | T-A | East | 11:31 | 51 | 59 | 69 | 69 | 82 | 61 | 72 | 56 | 67 | 54 | 59 | 53 | 60 | 53 | 61 | 58 | 64 | 77 | 85 | 65 |
| 2-4 | 2-A | East | 11:37 | 52 | 59 | 68 | 70 | 81 | 63 | 72 | 58 | 66 | 55 | 63 | 55 | 61 | 56 | 63 | 62 | 72 | 78 | 86 | 65 |
| 2-4 | P | East | 11:42 | 55 | 49 | 52 | 58 | 68 | 51 | 58 | 48 | 52 | 47 | 53 | 49 | 57 | 53 | 63 | 60 | 74 | 71 | 73 | -- |
| 2-5 | T-T | West | 11:49 | 57 | 59 | 69 | 73 | 87 | 59 | 69 | 55 | 64 | 54 | 61 | 53 | 60 | 53 | 60 | 56 | 61 | 77 | 83 | 63 |
| 2-5 | T-A | West | 12:09 | 54 | 64 | 72 | 72 | 85 | 62 | 72 | 58 | 67 | 57 | 65 | 57 | 67 | 59 | 68 | 66 | 77 | 77 | 85 | 65 |
| 2-5 | 2-A | West | 12:16 | 53 | 62 | 72 | 74 | 88 | 61 | 70 | 58 | 66 | 55 | 61 | 54 | 60 | 54 | 60 | 56 | 60 | 79 | 86 | 64 |
| 2-5 | P | West | 12:20 | 60 | 51 | 59 | 62 | 76 | 52 | 58 | 51 | 56 | 49 | 56 | 51 | 58 | 54 | 63 | 61 | 73 | 71 | 74 | -- |
| 2-6 | T-T | East | 13:20 | 55 | 57 | 62 | 69 | 78 | 61 | 68 | 57 | 63 | 56 | 62 | 56 | 61 | 57 | 66 | 62 | 75 | 76 | 83 | 63 |

*Underlined Values Affected By Extraneous Noise Source

Table 3. (cont.)

| Passby No. | Vehicle Type | Direction Passby | TIME | SPEED | Mic.1 | | Mic.2 | | Mic.3 | | Mic.4 | | Mic.5 | | Mic.6 | | Mic.7 | | Mic.8 | | Median | | So. Wall | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | L1 | Leq | Lmax | Mic. | Lmax |
| 2-6 | T-A | East | 13:25 | 50 | 56 | 62 | 66 | 78 | 59 | 70 | 55 | 64 | 53 | 60 | 54 | 60 | 57 | 64 | 63 | 74 | 75 | 82 | 62 | |
| 2-6 | 2-A | East | 13:31 | 53 | 59 | 67 | 71 | 81 | 63 | 71 | 59 | 66 | 56 | 63 | 55 | 61 | 56 | 63 | 60 | 72 | 78 | 86 | 65 | |
| 2-6 | P | East | 13:35 | 60 | 53 | 59 | 59 | 69 | 53 | 60 | 51 | 57 | 50 | 57 | 51 | 57 | 52 | 59 | 56 | 59 | 71 | 74 | -- | |
| 2-7 | T-A | West | 13:50 | 55 | 69 | 78 | 73 | 85 | 62 | 73 | 58 | 68 | 55 | 64 | 54 | 63 | 55 | 65 | 59 | 69 | 77 | 86 | 64 | |
| 2-7 | P | West | 14:00 | 60 | 53 | 62 | 63 | 76 | 54 | 62 | 52 | 61 | 52 | 64 | 55 | 56 | 60 | 72 | 67 | 79 | 71 | 74 | -- | |
| 2-8 | T-T | East | 14:05 | 56 | 56 | 63 | 68 | 78 | 60 | 68 | 56 | 63 | 55 | 64 | 57 | 67 | 61 | 72 | 67 | 81 | 77 | 83 | 63 | |
| 2-8 | T-A | East | 14:10 | 51 | 56 | 67 | 68 | 81 | 60 | 71 | 56 | 66 | 53 | 59 | 53 | 59 | 53 | 61 | 58 | 67 | 76 | 83 | 62 | |
| 2-8 | 2-A | East | 14:22 | 53 | 60 | 68 | 71 | 81 | 63 | 71 | 60 | 68 | 58 | 68 | 60 | 73 | 64 | 77 | 72 | 84 | 77 | 86 | 65 | |
| 2-8 | P | East | 14:26 | 60 | 50 | 55 | 58 | 69 | 51 | 59 | 49 | 54 | 48 | 53 | 50 | 55 | 53 | 58 | 60 | 67 | 72 | 75 | -- | |
| 2-9 | T-T | West | 14:36 | 57 | 60 | 71 | 72 | 87 | 60 | 71 | 58 | 69 | 56 | 67 | 60 | 73 | 63 | 76 | 68 | 80 | 77 | 84 | 62 | |
| 2-9 | T-A | West | 14:42 | 52 | 68 | 77 | 73 | 87 | 63 | 75 | 59 | 68 | 55 | 64 | 55 | 63 | 55 | 64 | 58 | 68 | 77 | 87 | 65 | |
| 2-9 | 2-A | West | 14:52 | 52 | 62 | 72 | 72 | 89 | 59 | 70 | 56 | 65 | 53 | 61 | 52 | 59 | 53 | 59 | 56 | 61 | 77 | 86 | 64 | |
| 2-9 | P | West | 14:58 | 60 | 56 | 64 | 69 | 78 | 60 | 68 | 55 | 63 | 53 | 59 | 54 | 59 | 56 | 63 | 62 | 72 | 71 | 74 | -- | |
| 2-10 | T-T | East | 15:05 | 58 | 58 | 68 | 70 | 81 | 62 | 71 | 57 | 67 | 55 | 62 | 58 | 68 | 60 | 68 | 66 | 76 | 78 | 85 | 65 | |
| 2-11 | T-T | West | 15:17 | 60 | 62 | 72 | 74 | 87 | 62 | 71 | 59 | 66 | 57 | 65 | 60 | 71 | 65 | 77 | 70 | 83 | 79 | 86 | -- | |
| 2-11 | 2-A | West | 15:28 | 52 | 62 | 72 | 74 | 88 | 61 | 70 | 57 | 65 | 54 | 62 | 54 | 60 | 54 | 60 | 56 | 60 | 78 | 86 | -- | |
| 2-12 | T-T | East | 15:39 | 56 | 56 | 63 | 68 | 79 | 60 | 69 | 55 | 62 | 53 | 59 | 53 | 59 | 53 | 59 | 56 | 60 | 77 | 83 | 63 | |
| 2-13 | T-T | West | 15:51 | 61 | 59 | 69 | 73 | 88 | 60 | 69 | 56 | 64 | 54 | 61 | 54 | 61 | 55 | 63 | 58 | 65 | 77 | 84 | 64 | |
| 2-13 | 2-A | West | 16:02 | 55 | 63 | 73 | 75 | 89 | 62 | 71 | 58 | 67 | 56 | 64 | 55 | 61 | 57 | 63 | 62 | 73 | 78 | 86 | 64 | |
| 2-13 | P | West | 16:07 | 61 | 53 | 65 | 63 | 77 | 55 | 68 | 53 | 66 | 53 | 66 | 53 | 63 | 53 | 60 | 55 | 58 | 71 | 74 | -- | |

Table 4. Mean passby noise data

I-380 Evansdale Parallel Barrier Study

Typical House Set-Back Distance

Microphone No. 5   100 Feet From Wall

| | | Mean Passby vehicle speed and Leq | | | | | | Mean Passby L1 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Type | Mean Speed | Free Field | Mean Speed | Single Wall | Mean Speed | Parallel Walls | Free Field | Single Wall | Parallel Walls |
| I. Westbound (Near Lane) | TT | 55mph | 62dBA | 58mph | 56dBA | 59mph | 55dBA | 75dBA | 63dBA | 63dBA |
| | TA | 53mph | 63dBA | 55mph | 56dBA | 54mph | 56dBA | 75dBA | 63dBA | 64dBA |
| | 2A | 52mph | 63dBA | 52mph | 56dBA | 53mph | 54dBA | 75dBA | 63dBA | 62dBA |
| | P | 54mph | 53dBA | 59mph | 49dBA | 59mph | 52dBA | 64dBA | 55dBA | 59dBA |
| | A | 54mph | 52dBA | 58mph | 49dBA | -- | -- | 64dBA | 53dBA | -- |
| II. Eastbound (Far Lane) | TT | 60mph | 59dBA | 54mph | 53dBA | 56mph | 55dBA | 70dBA | 58dBA | 61dBA |
| | TA | 51mph | 59dBA | 49mph | 55dBA | 51mph | 54dBA | 69dBA | 61dBA | 60dBA |
| | 2A | 51mph | 58dBA | 50mph | 54dBA | 53mph | 56dBA | 68dBA | 59dBA | 64dBA |
| | P | 56mph | 48dBA | 55mph | 47dBA | 58mph | 48dBA | 57dBA | 52dBA | 54dBA |
| | A | 55mph | 49dBA | 57mph | 49dBA | -- | -- | 58dBA | 53dBA | -- |

Table 5. *Mean passby noise data*

I-380 Evansdale - Parallel Barrier Study

Noise Levels At Typical House Set-Back Distance

Microphone No. 6   150 Feet From Wall

| | Vehicle Type | Mean Passby vehicle speed and Leq | | | | | | Mean Passby L1 | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | Mean Speed | Free Field | Mean Speed | Single Wall | Mean Speed | Parallel Walls | Free Field | Single Wall | Parallel Wall |
| I. Westbound (Near Lane) | TT | 55mph | 59dBA | 58mph | 56dBA | 59mph | 54dBA | 71dBA | 63dBA | 61dBA |
| | TA | 53mph | 60dBA | 55mph | 55dBA | 54mph | 55dBA | 72dBA | 63dBA | 64dBA |
| | 2A | 52mph | 60dBA | 52mph | 55dBA | 53mph | 54dBA | 72dBA | 63dBA | 60dBA |
| | P | 54mph | 50dBA | 59mph | 50dBA | 59mph | 52dBA | 60dBA | 54dBA | 57dBA |
| | A | 54mph | 49dBA | 58mph | 49dBA | -- | -- | 59dBA | 52dBA | -- |
| II. Eastbound (Far Lane) | TT | 60mph | 56dBA | 54mph | 54dBA | 56mph | 54dBA | 66dBA | 60dBA | 61dBA |
| | TA | 51mph | 57dBA | 49mph | 54dBA | 51mph | 54dBA | 70dBA | 59dBA | 60dBA |
| | 2A | 51mph | 57dBA | 50mph | 54dBA | 53mph | 56dBA | 65dBA | 61dBA | 61dBA |
| | P | 56mph | 47dBA | 55mph | 49dBA | 58mph | 48dBA | 54dBA | 52dBA | 56dBA |
| | A | 55mph | 48dBA | 57mph | 50dBA | -- | -- | 55dBA | 53dBA | -- |

Table 6. Mean passby noise data

I-380 Evansdale Parallel Barrier Study

Noise Levels At Reference Microphone (Mic.2) And At The Median Microphone

| | | Mean Passby vehicle speed and L1 Reference Microphone | | | | | | Mean Passby $L_{Max}$ Median Microphone | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vehicle Type | Mean Speed | Free Field | Mean Speed | Single Wall | Mean Speed | Parallel Walls | Free Field | Single Wall | Parallel Walls |
| I. Westbound (Near Lane) | TT | 55mph | 85dBA | 58mph | 86dBA | 59mph | 87dBA | 84dBA | 85dBA | 85dBA |
| | TA | 53mph | 86dBA | 55mph | 86dBA | 54mph | 86dBA | 84dBA | 86dBA | 86dBA |
| | 2A | 52mph | 87dBA | 52mph | 87dBA | 53mph | 88dBA | 84dBA | 86dBA | 86dBA |
| | P | 54mph | 74dBA | 59mph | 76dBA | 59mph | 76dBA | 72dBA | 75dBA | 74dBA |
| | A | 60mph | 73dBA | 58mph | 74dBA | -- | -- | 71dBA | 73dBA | -- |
| II. Eastbound (Far Lane) | TT | 60mph | 79dBA | 54mph | 75dBA | 56mph | 79dBA | 87dBA | 81dBA | 84dBA |
| | TA | 51mph | 78dBA | 49mph | 76dBA | 51mph | 81dBA | 82dBA | 82dBA | 84dBA |
| | 2A | 51mph | 77dBA | 50mph | 77dBA | 53mph | 81dBA | 83dBA | 84dBA | 86dBA |
| | P | 56mph | 66dBA | 55mph | 64dBA | 58mph | 69dBA | 73dBA | 71dBA | 74dBA |
| | A | 55mph | 64dBA | 57mph | 63dBA | -- | -- | 73dBA | 71dBA | -- |

3. The parallel barrier effect is generally more identifiable in the higher frequency noise sources such as the pickup truck and in the higher frequency components of the other noise source vehicles.

4. Increases in passby noise levels from the single wall to the parallel wall condition are generally in the 1-3 dBA range but range up to 6dBA for the far lane pickup passby. This observation is based on mean $L_1$ values at microphone 6 which represents the typical house setback distance.

## VII. PHASE TWO RESEARCH

Measurements which will be taken at the same locations under normal traffic conditions should reveal the extent to which reflected noise actually reduces barrier effectiveness at the parallel walls. It will be interesting to observe whether or not far lane noise in combination with the near lane source causes comparable reductions in insertion loss. Additionally we may be able to identify varying degrees of multiple reflections depending on the percentage of automobile and other light duty vehicles in the "real world" conditions. It might be expected, for example, that 100% autos and other high frequency noise sources may result in a significant reduction in insertion loss. This phenomenon would have noteworthy implications in larger metropolitan areas where high automobile volumes constitute the major traffic noise source.

## VIII. Phase Two Methods

The microphone locations used in the controlled pass-by portion of the study were replicated at each field site to measure actual I-380 traffic noise in the fall of 1985. This monitoring work was accomplished with the assistance of staff members from FHWA's Office of Environmental Policy in Washington, D.C. It is felt that sufficient data were collected during this initial "real world" sampling effort to characterize the effectiveness of the single and parallel barrier systems under study. More extensive monitoring activity was prevented by computer system malfunction in the noise laboratory, difficulty in scheduling follow-up monitoring, and a reduction in Iowa DOT staffing. The data reduced and reported here will complete the contractual study.

## IX. Phase Two Results

The data collected from actual I-380 traffic can be analyzed from three perspectives:

1) The three field sites can be compared using noise data collected during periods of similar traffic conditions.

2) The single and parallel wall conditions can be analyzed using simultaneous and continuous monitoring of hourly noise levels at a given distance from each barrier system type.

3) The three field sites can be compared based on the frequency spectra obtained during sampling periods of similar traffic conditions and comparable overall traffic noise levels.

Table 7. Mean Leq at Each Microphone Position

| Site | Number of Samples | Mean Leq, dBA Microphone Position 40' high | 40' low | 90' High | 90' Low | 140' Low | 190' Low |
|---|---|---|---|---|---|---|---|
| Free Field | 6 | 72.7 | 72.4 | 68.2 | 65.3 | 62.4 | 58.6 |
| Single Wall | 20 | 73.2 | 58.7 | 63.1 | 56.9 | 57.1 | 55.7 |
| Parallel Walls | 17 | 73.2 | 58.9 | 62.2 | 58.9 | 56.4 | 55.1 |

At the free field site six 15-minute samples were taken, all during mid to late morning off-peak hours. A total of twenty 15-minute samples were taken at the single wall site and seventeen 15-minute samples were obtained at the parallel walls site. The mean Leq computed for each microphone location at each field site is shown in Table 7. These data show a fair consistency between the single wall site and the parallel walls site at distances near the wall and also at the more remote distances. However, at the 90' low microphone the noise level averages 2 dBA higher at the parallel walls site. This would suggest that multiple reflections might be influencing an intermediate zone on the residential side of the parallel walls. To further examine this multiple microphone data, individual sampling periods with similar traffic conditions and reference mike

(40' high) noise levels were selected. Table 8 presents this comparison for off-peak traffic conditions. Again residential side noise levels are lower at the parallel site except at the 90' low location which indicates a tendency toward reduced barrier effectiveness in this intermediate zone, possibly due to multiple reflections. A similar tendency can be identified during peak hour sampling, but unfortunately no corroborative traffic counts were obtained during the periods which best demonstrated this effect.

Additionally, continuous hourly samples were obtained simultaneously at both the single and parallel sites at a distance of 100 feet from the wall. Seventy-two such parallel samples were collected using a BBN 614 Community Noise Analyzer and a Digital Acoustics Community Noise Analyzer. For a typical hour the parallel walls site was 0.7 dBA higher than the Leq measured 100 feet from the single wall. Nine hours of data were collected at the distance of 50 feet from the wall (which corresponds to the 90' from near lane low microphone location discussed previously). The parallel site averaged 1.5 dBA higher than the single wall site at this distance. These data also support a finding of some reduction in barrier effectiveness under the parallel walls condition.

A frequency spectrum histogram for a selected microphone location was obtained during each 15-minute monitoring period. Most of the frequency information was from the microphones near the noise wall (24 of 42 periods) and no significant differences could be identified at these locations among the frequency spectra printouts from

Table 8. Comparison of Three Field Sites Under Similar Traffic Conditions

| | | | Traffic Autos - MT - HT | | Leq, dBA Microphone Distance, Position | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Site | Date | Time | WB | EB | 40' High | 40' Low | 90' High | 90' Low | 140' Low | 190' Low |
| Free Field | 11/8/85 | 11:05-11:20 | 40-2-11 | 57-1-10 | 73.9 | 73.1 | 69.2 | 66.4 | 63.4 | 59.4 |
| Single Wall | 11/5/85 | 1:50-2:05 | 50-2-8 | 61-0-6 | 72.0 | 58.1 | 64.4 | 55.6 | 57.7 | 56.7 |
| Parallel Walls | 11/6/85 | 1:20-1:35 | 61-1-3 | 64-2-7 | 72.1 | 58.2 | 61.6 | 58.4 | 55.4 | 54.2 |

the three field study sites. Frequency breakdown information from a limited number of other microphone locations also proved to be inconclusive in attempting to compare the single wall against the parallel wall situation. Lack of frequency component data from the intermediate receiver zone identified previously can be considered an oversight of this research effort. Further longer term research in this subject area might serve to smooth out traffic and meteorological variations and focus more directly on the frequency spectra aspects of the parallel walls condition.

## X. Summary and Conclusion

Both controlled pass-by and "real world" traffic noise was measured, characterized, and interpreted in an effort to assess the acoustical effectiveness differences between a single noise wall and parallel noise walls on I-380 in Evansdale, Iowa. Both phases of the study resulted in data which suggests minor reduction in noise wall effectiveness as a result of multiple reflections within the parallel barrier canyon. More extensive monitoring would serve to remove the influence of minor meteorological and traffic mix variations which have probable but limited influence on this short-term study. From a practical standpoint, the study suggests that the degree to which barrier effectiveness is compromised by the parallel situation in this particular noise abatement system is insignificant. The steel barrier material and configuration, the site geometrics including barrier height and interbarrier distance, the use of earthen berms and the transverse groove surface texturing all no doubt influence the resulting traffic noise levels within the study area. It would appear from this experience that a significant influence of a parallel wall situation would require very high walls of very reflective material, a relatively small interbarrier distance, and a higher proportion of peak noise of the high frequency type being generated at the tire/roadway interface.

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