# FINAL REPORT

# VERIFICATION OF MICNOISE COMPUTER PROGRAM FOR THE PREDICTION OF HIGHWAY NOISE

# Part II - Additional Verification of MICNOISE Version 5

by

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### ABSTRACT

This is a continuation of an earlier report in which the MICNOISE computer program for the prediction of highway noise was evaluated. The outputs of the MICNOISE program are the L<sub>50</sub> and L<sub>10</sub> sound pressure levels, i.e., those levels experienced 50% and 10% of the time.

In the earlier report, it was noted that there were difficulties when truck volumes were low. To overcome these, a modified version was proposed, which is now referred to as MICNOISE 2X.

In this continuation of the earlier report, a new version of MICNOISE, Version 5, is evaluated. Also, an experimental variant, 5X, and a variant proposed by the Virginia Department of Highways and Transportation, 5V, are evaluated. In MICNOISE 5X, the elevation corrections due to trucks are modified as though the truck frequency spectrum were shifted to half the corresponding frequencies for autos. In MICNOISE 5V, truck noise is assumed to originate 13.5 ft. (4.1 m) above the highway, as compared with 8 ft. (2.4 m) for Version 5.

It had been found earlier that for 68% confidence 2 dB should be added to the predicted values of MICNOISE 2X. This is shown to increase to 3 dB for MICNOISE, Version 5, but falls again to 2 dB for MICNOISE 5V. However, results for 5V show greater standard deviations, the 68% confidence band being restored only because it is more conservative than MICNOISE 2X. The reduced accuracy of Version 5 and its variants is attributed to the methods used for handling vertical corrections.

It is concluded that MICNOISE 5V is acceptable, but that the earlier methods of elevation correction are preferable

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#### INTRODUCTION

The Virginia Department of Highways and Transportation has received several versions of the Michigan/117 and Michigan/144 time-sharing computer programs from the Michigan Department of State Highways and Transportation. Most of these have been converted to batch processing format and have been made available to IBM 360 users. During 1973, the Virginia Highway and Transportation Research Council initiated a study to verify these computer programs.

The original report, <sup>(1)</sup> of which this is Part II, presents the results of a verification of the MICNOISE Version 2 computer program, which is based on the recommendations of <u>NCHRP Reports</u> <u>No. 117 and 144</u><sup>(2,3)</sup>Because there were some obvious areas for improvement to the original program a so-called "modified MICNOISE" computer program, in which these improvements were included, was also evaluated.

At the time of writing the original report, it was believed that the forthcoming MICNOISE Version 5 would be virtually identical to the modified MICNOISE program. Therefore, premature conclusions about the accuracy of Version 5 were drawn in the original report. However, when Version 5 became available, it was found that changes suggested in NCHRP Report No. 144 had been made in the treatment of vertical (i.e., elevated or depressed roads) and barrier corrections, which have resulted in some lack of conservatism, so that predictions of noise levels tend to be somewhat lower than those made by the modified MICNOISE program. In this report, Part II, the effects of the vertical corrections have been evaluated in some detail. For brevity, Version 2 is referred to as MICNOISE 2, the modified MICNOISE program is referred to as MICNOISE 2X, Version 5 is referred to as MICNOISE 5, and an experimental modification of 5, which is described later, is referred to as MICNOISE 5X. A version proposed by the Virginia Department of Highways and Transportation is referred to as MICNOISE 5V. In this version, truck noise is assumed to originate 13.5 feet(4.1 m) above the ground, whereas in Version 5 it is assumed to originate 8 feet (2.4 m) above the ground.

For 68% confidence, it was found necessary to add 2 dB to predictions made with MICNOISE 2X. This increased to 3 dB for MICNOISE 5, but becomes 2 dB again for MICNOISE 5V. However, the standard deviation of the error is greater for MICNOISE 5V than for MICNOISE 2X. Therefore, it is concluded that, although MIC-NOISE 5V is perfectly acceptable, the earlier method of computing vertical corrections used in MICNOISE 2 and 2X is preferable.

#### OBJECTIVES

The primary objective of this study was to evaluate MICNOISE 5, and the slightly modified version, MICNOISE 5V.

Because it was found that neither version gave such good predictions as did the earlier MICNOISE 2X, considerable emphasis was placed on an evaluation of the vertical corrections used, since these represented the major difference between Versions 2 and 5.

During this study, the experimental MICNOISE 5X was investigated, in the belief that it might give better results than MIC-NOISE 5. However, the improvement of the vertical correction method was never made an objective of this study.

#### DESCRIPTION OF MICNOISE 5 COMPUTER PROGRAM

In the original report, a listing of MICNOISE 2 was given, and the algorithm used was compared in some detail with that of <u>NCHRP Report No. 117</u>. Features of MICNOISE 2X (or modified MIC-NOISE) were discussed, and possible changes to be incorporated into MICNOISE 5 were indicated.

MICNOISE 5 is listed in Appendix A of this Part II of the report. It is based on NCHRP Report No. 144 and is similar to

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the MICNOISE 5V program proposed by the Virginia Department of Highways and Transportation, with the sole exception that truck noise in version 5V originates at 13.5 feet (4.1 m) above the road surface, as compared with 8 feet (2.4 m) for version 5.

Altogether, six programs are involved in this study. Some are only minor variations of others, but MICNOISE 5 is a major revision of MICNOISE 2, even though the computer results are not greatly different. To avoid lengthy and unnecessary discussions, only the essential differences between MICNOISE 2X, 5, 5X and 5V are covered below.

# Input Format

The input format for MICNOISE 5 is different from that for MICNOISE 2, as is indicated by the comparison given in Table 1. For the purpose of this evaluation, in which a card input for MICNOISE 2 had already been prepared, a preprocessor was programmed to convert the Version 2 input to Version 5 format.

	(Note: All da	ita input in English units,	the progra	am is not compat	ible for SI units)
	MICNO	DISE 2		MICN	OISE 5
No.	Symbol	Description	No.	Symbol Symbol	Description
1	REN	No. of Road Els.	1	REN*	
2	NLG	No. of Lane Grps.	2	NLG*	
3	ADT	Avg. Daily Tr.	3	Q	Vehicles Per Hour
4	PCADT	% ADT per hr.			
5	TMIX	% Trucks	4	TMIX*	
6	ST	Truck Sp. (mph)	5	ST*	
7	SA	Auto Sp. (mph)	6	SA*	
8	HD	Road Elev. Type	7	HE	Roadway Elev. (ft.)
9	DN	Obs. to Road (ft.)	8	DN*	
10	RL.	Road Length Type	9	RL*	(= 0, 1  or  2)
11	BL	Barr. Length Type	10	BL*	(= 0, 1  or  2)
12	FLO	Traffic Flow	1		
13	P	No. of Lanes	11	P#	
14	DEL3	Grade Corr.	12	DEL3*	
15	DEL5	Road Surf. Corr.	13	DEL5*	
16	DEL7	Struc. Corr.	14	DEL7*	
17	MED	Median Width (ft.)	15	MED*	
18	THETA	Road Incl. Angle	16	THETA*	
19	H1	Road Elev. (ft.)	17	но	Obs. Ht. (ft.)
20	DS	Obs. Shoulder (ft.)	18	DS*	
21	H2	Road Depress. (ft.)			
22	DC	Obs. to Cut (ft.)	19	DC*	
23	Н	Barrier Ht. (ft.)	20	H*	
24	DB	Obs. to Barr. (ft.)	21	DB*	
25	ALPHA	Barr. Incl. Angle	22	ALPHA*	
26	но	Obs. Ht. (ft.)	23	BETA	Barrier End Angle

Comparison of Input Data. MICNOISE 2 & 5.

Table 1

\*No change from corresponding MICNOISE 2 item which is on same line.

# Correction for L<sub>10</sub>

The values of  $L_{10}$  -  $L_{50}$  used in MICNOISE 2 and 5 are shown in Figure 1 as curves plotted against the parameter VD/S, which has units of vehicle ft/mile (0.1894 vehicle m/km). There is a small difference between the two curves, however a careful examination of the results of the evaluation reported here showed that the effects of this difference were of little consequence.

### Vertical Corrections

The corrections for elevated or depressed highways and barriers are shown in Figures 2, 3, and 4. Figure 2 shows the corrections for MICNOISE 2X, which are identical to those given in the original report. Figure 3 shows the corrections for MIC-NOISE 5, which are based on the recommendations of NCHRP Report No. 144. In this application, one curve is used for all cases, but, in place of the 5 dB reduction for trucks, each truck is analyzed as though its principal noise source were eight feet (2.4 m) above the road in MICNOISE 5 and 13.5 feet (4.5 m) in MICNOISE 5V. Figure 4 shows the trial correction used for MIC-NOISE 5X, in which the curve for trucks was shifted to the right as though the frequency of noise from a truck were half that from an automobile. This correction was made on a trial basis, because it was felt that a more realistic prediction of the effects of acoustical barriers on trucks would result if the relatively lower frequency of sound from trucks were taken into account. In MICNOISE 5, overall corrections for finite roads and barriers stay almost the same as in MICNOISE 2, however, these corrections were not evaluated.

## Miscellaneous Changes

In programming MICNOISE 5 several minor changes and improvements were made over MICNOISE 2. Amongst these changes were:

- A test for line-of-sight conditions was introduced to eliminate incorrect application of vertical corrections in such cases.
- Handling of elevation coordinates in vertical corrections was simplified by referring all elevations to one reference plane, (the roadway elevation, HE, given in Table 1). (With small modifications, the program could take care of a combination of elevation and barrier corrections.)

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Figure 4. Vertical corrections in MICNOISE 5X.

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## EVALUATION OF COMPUTED NOISE LEVELS

The computed noise levels from MICNOISE 2X are given in Tables B-1 through B-5 of Appendix B. These are identical to the values given for "Modified MICNOISE" in Tables A-28 through A-32 of the original report. Using a preprocessor to convert the Version 2 input to Version 5 format, as detailed in Table 1, noise levels were computed from MICNOISE 5, 5X and 5V, and are given in Tables B-6 through B-20 of Appendix B. Statistical analyses of the com-puted results for MICNOISE 2X, 5, and 5V are given in Table 2 using the same format as in Table 9 of the original report. The 68% confidence limits, that is, the mean value plus and minus one standard deviation, are also shown in Figure 5 for each of the  $L_{10}$ and L50 values given in Table 9. Remembering that a negative error represents underprediction of the actual noise level, and is therefore unconservative, it will be noted that MICNOISE 5 is somewhat unconservative with respect to MICNOISE 2X, with MICNOISE 5V showing some improvement, and falling between the two. However, standard deviations for the Version 5 programs are somewhat larger than for Version 2, the improvement in MICNOISE 5V being due to greater conservatism in the mean value.

Present requirements are that  $L_{10}$  not exceed 70 dB, so consider here errors in L10 only. According to Table 2, the lower 68% confidence limits on MICNOISE 2X, 5 and 5V are -2.10, -3.06, and -2.68 respectively. If 2 dB were added to the MICNOISE 2X predictions, the lower 68% confidence limits on error would be 0 dB or above to the nearest decibel. However, it would be necessary to add 3 dB to the MICNOISE 5 predictions to achieve the same results. With MICNOISE 5V, the error for site 5 would be below 0 dB (actually -0.68 dB) if 2 dB were added, but would be 0 dB or better for the other sites. To find the 95 and 99% confidence limits two and three standard deviations are subtracted, from the mean, respectively. Examining the values given in Table 2 for MICNOISE 2X, one sees that these correspond to lower confidence limits of -3.85 and -5.6 dB, therefore, to the nearest decibel, 2, 4 and 6 dB must be added to predicted levels for 68, 95 and 99% confidence respectively. However, standard deviations for MICNOISE 5 and 5V are larger, in general, than for MICNOISE 2X, so that in some cases, larger increments must be added to the Version 5 results, for a given degree of confidence.

Because the changes have evidently resulted from changes in the method of computing vertical corrections, the accuracy of vertical corrections has been studied in more detail, as reported in the following sections.

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Site #		-1			2		ю			ŧ			ഹ	
No. of Recordings		13 <sup>a</sup>			12		q9			٢			0 8	
MICNOISE Variant	2X	5	5ν	2X	5 & 5V	2X <sup>.</sup>	ى	5V	2X	പ	ξV	2X	പ	ξV
L <sub>50</sub> Mean Error	0.20	-0.98	۰ 89 8	0	0	0.25	-1.52	.22	3.46	3.73	4.57	0.70	0.80	1.06
RMS Error	1.33	1.72	1.40	1.15	1.15	1.74	2.76	1.86	4.01	4.45	5.03	1.50	2.26	2.22
Standard Deviation	1.36	1.47	1.27	1.20	1.20	1.87	2.52	2.02	2.19	2.62	2.27	1.42	2.26	2.08
68% Confidence Range	-1.16	-2.45	-1.95	-1.20	-1.20	-1.62	-4.04	-1.8	1.27	1.11	2.3	-0.72	-1.46	-1.02
	1.56	0.49	.59	1.20	1.20	2.12	1.00	2.24	5.65	6.35	6.84	2.12	3.06	3.14
L <sub>10</sub> Mean Error	0.32	-0.90	-0.39	0.49	0.57	0.77	-0.05	1.90	4.10	н <b>8</b> . Н	5.97	-0.35	0.24	0,40
RMS Error	1.60	1.73	1.45	1.00	1.06	2.56	2.75	3.36	4.91	5.81	7.26	1.68	2.92	2.91
Standard Deviation	1.62	1.54	1.45	0.91	0.93	2.67	3.01	2.99	2.90	3.47	4.46	1.75	3.11	3.08
68% Confidence Range	-1.30	-2.44	-1.84	-0.42	-0.36	-1.90	-3.06	-1.09	1.2	1.37	1.51	-2.10	-2.87	-2.68
	1.94	0.64	1.06	1.40	1.50	3.44	2.96	4.89	7.0	8.31 ]	0.43	1.40	3.35	3.48
L10 <sup>-L50</sup>														
Mean Error	0.12	0.08	.29	0.50	0.57	0.52	1.47	1.68	0.64	1.11	1.40	-1.05	-0.56	-0.66
RMS Error	0.78	0.79	. 84	0.92	1.01	1.25	1.75	2.12	3.54	3.68	4.06	1.91	1.86	1.85
Standard Deviation	0.80	0.82	.82	0.82	.87	1.25	1.04	1.42	3.76	3.79	4.12	1.71	1.90	1.85
68% Confidence Range	-0.68	-0.74	53	-0.32	-0.30	-0.73	0.43	0.26	-3.12 -	-2.68 -	-2.72	-2.76	-2.46	-2.51
	0.92	0.90	1.11	1.32	1.44	1.77	2.51	3.10	4.40	4.90	5.52	0.66	1.34	1.19

Errors in Noise Levels Computed by MICNOISE 2X, 5, and 5V

Table 2

(a) The three records taken on a slope at 106 feet (32 m) were not included.

Trial number 1 was excluded. Therefore, results are not the same as those given in Ref. 1. The predicted noise of trucks on the side road was deleted for trial number 1. (e)

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Figure 5. 68% confidence levels with three versions of MICNOISE.

## ANALYSIS OF VERTICAL CORRECTION ERRORS

In planning the original program of roadside measurements, it was decided that all recordings should be made in pairs, with one microphone at a fixed location.

Out of a total of 26 trials, there was one microphone failure, and three trials included measurements on the side of a large embankment, where the MICNOISE program underpredicted by 5 dB. The remaining 22 trials, covering five sites, provided 22 pairs of data for the evaluation of vertical correction errors.

Because all of the measurements were made on divided highways, and therefore involved the combination of highway noises subjected to different vertical corrections, the following procedure was adopted.

- 1. Only L50 errors were studied. There is, of course, no difference between the respective vertical corrections used for  $L_{50}$  and  $L_{10}$ .
- 2. The dependent variable studied was the correction error, which may be defined as
  - E = [Calculated L<sub>50</sub> at far microphone minus calculated L<sub>50</sub> at near microphone] minus [Measured L<sub>50</sub> at far microphone minus measured L<sub>50</sub> at near microphone].

or

$$E = (L_{50})_{CALC} - (L_{50})_{MEAS}$$
.

Thus, a positive error, E, represents an overpredicted  $L_{50}$  level at a distance, and is therefore a conservative correction for distance.

3. The first independent variable is the calculated distance correction.

(L<sub>50</sub>) DIST.

This is obtained by supressing the vertical corrections in the computer program, in which case all MICNOISE versions, (2X, 5, 5X, and 5V) give the same values. It is an overall distance correction, applicable to a particular case, because it depends on the relative traffic levels in the different roadways. Calculated values for (L50)DIST. obtained without vertical corrections are given in Tables B6-B10 of Appendix B. 4. The second independent variable is the calculated vertical correction.

$$(L_{50})_{VERT} = (L_{50})_{CALC} - (L_{50})_{DIST}$$

This is different for the different MICNOISE versions, and is again applicable only to a particular case.

Table 3 contains a listing of  $(L_{50})_{MEAS}$ ,  $(L_{50})_{CALC}$ ,  $(L_{50})_{DIST}$ ,  $(L_{50})_{VERT}$  and E for the three versions of MICNOISE studied. For brevity, these are referred to as "MEAS", "CALC", "DIST", "VERT", and "E" respectively.

For further clarification of these results for MICNOISE 2X and 5, they are presented as three-dimensional plots in Figures 6 and 7. These show the error, E, which is the dependent variable, as an arrow of the appropriate length, directed upwards if E is positive (corresponding to overprediction). The independent variables  $(L_{50})_{\text{DIST}}$  and  $(L_{50})_{\text{VERT}}$  are indicated by the oblique axes. Positive  $(L_{50})_{\text{VERT}}$  values correspond to cases where the highway is elevated, so that the attenuation due to the vertical correction becomes less as the observer moves away from the road.

For each of the four cases, a least squares fit or regression plane was determined, its edges are indicated by dotted lines in Figures 6 and 7. It is immediately evident that the least square fit plane is closest to the zero error plane for the MICNOISE 2X results.

Table 4 shows the parameters relevant to the least squares study. The plane may be represented by the equation

 $E_{FIT} = C_{o} + C_{DIST} \times (L_{50})_{DIST} + C_{VERT} \times (L_{50})_{VERT}$ 

where the coefficients  $C_0$ ,  $C_{DIST}$  and  $C_{VERT}$  are given in the table. Also shown are the RMS values of E relative to the  $E_{FIT}$  plane,

$$E_{\rm RMS} = \sqrt{\Sigma (E - E_{\rm FIT})^2}$$

and the original values of  $E_{RMS}$  and E (mean value) as calculated from the appropriate columns in Table 3.

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Errors
Correction
of
Analysis

	VERT	- 8.7	-10.8	- 9.1	- 8.6	-10.4	0	0	0	0	0	0	- 0.2	2.5	3.8	2.3	- 0.7	- 3.1	- 4.9	0.1	1.1	1.3	1.2
OISE 51	Е	-1.3	-1.1	-1.9	0.3	-2.7	-0.5	+.0-	0.3	2.4	0.3	0.5	-1.9	-0.6	-2.9	-5.6	0.1	2.5	-1.2	-3.9	0.4	0.4	0.1
MICN	CALC	-15.1	-19.5	-15.7	-14.9	-18.2	- 2.3	- 5.6	- 7.7	- 7.8	- 5.6	- 2.2	- 4.0	- 2.6	- 5.1	- 5.0	- 4.2	-10.1	- 8.5	- 2.8	- 0.4	- 2.5	- 4.2
	VERT	- 9.3	-11.4	- 9.7	- 9.2	-10.8	0	0	0	0	0	0	1.3	2.5	3.8	3.0	- 3.9	- 8.7	- 5.0	1.9	0.2	1.2	1.5
IOISE 5X	ш	-1.9	-1.7	-2.5	-0.3	-3.1	-0.5	-0.4	0.3	2.4	0.3	0.5	-0.4	-0.6	-2.9	6.4-	-3.1	-3.1	-1.3	-2.1	-0.5	0.3	4.0
MICN	CALC	-15.7	-20.1	-16.3	-15.5	-18.6	- 2.3	- 5.6	- 7.7	- 7.8	- 5.6	- 2.2	- 2.5	- 2.6	- 5.1	- 4.3	- 7.4	-15.7	- 8.6	- 1.0	- 1.3	- 2.6	- 0.0 0.0
	VERT	1.6 -	-11.8	- 9 <b>.</b> 8	- 9.3	-11.1	0	0	0	0	0	0	6.2	3.9	4.7	1.4	- 0.7	- 5.1	- 4.9	0	0	1.4	1.3
IOISE 5	ш	-2.0	-2.1	-2.6	+.0-	-3.4	-0.5	-0.4	0.3	2.4	0.3	0.5	4.5	0.8	-2.0	-6.5	0.1	0.5	-1.2	-4.0	-0.7	0.5	0.2
MICN	CALC	-15.8	-20.5	-16.4	-15.6	-18.9	- 2.3	- 5.6	- 7.7	- 7.8	- 5.6	- 2.2	2.4	- 1.2	- 4.2	- 5.9	- 4.2	-12.1	- 8.5	- 2.9	- 1.5	- 2.4	- 4.1
	VERT	-6.2	-8.9	-6.9	-5.9	-8.0	0	0	0	0	0	0	2.3	4.4	5.9	4.1	-2.8	-6.1	-4.9	3.3	0.7	1.4	1.5
IOISE 2	ដា	1.2	0.8	0.3	3.0	-0.3	-0.5	-0.4	0.3	2.4	0.3	0.5	0.6	1.3	-0.8	-3.8	-2.0	-0.5	-1.2	-0.7	0	0.5	1.0
MICN	CALC	-12.6	-17.6	-13.5	-12.2	-15.8	- 2.3	- 5.6	- 7.7	- 7.8	- 5.6	- 2.2	- 1.5	- 0.7	- 3.0	- 3.2	- 6.3	-13.1	- 8.5	+ 0.4	- 0.8	- 2.4	- 3.9
	DIST	-6.4	-8.7	-6.6	۱ 6.3	-7.8	-2.3	-5.6	-7.7	-7.8	-5.6	-2.2	-3.8	-5.1	-8.9	-7.3	-3.5	-7.0	-3.6	-2.9	-1.5	-3.8	-5.4
	MEAS	-13.8	-18.4	-13.8	-15.2	-15.5	- 1.8	- 5.2	- 8.0	-10.2	- 5.9	- 2.7	- 2.1	- 2.0	- 2.2	0.6	- 4.3	-12.6	- 7.3	+ 1.1	- 0.8	- 2.9	- 4.3
	SITE	-1	DEPR				2	LEV					m	EL			ŧ	DEPR		2	EL		
	TEST	1-2	1-3	2-1	3-2	3-3	4-1	4-2	4-3	5-1	5-2	5-3	7-1	7-2	7-3	7-4	8-1	8-2	8-3	9-1	9-2	9-3	4-6





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trucks at I, ഹ Correction errors in MICNOISE 8 ft. (2.4 m). Figure 7.

Tabl	e	4
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Program Version	с <sub>о</sub>	C <sub>DIST</sub>	C <sub>VERT</sub>	E <sub>RMS</sub> (Fit)	E <sub>RMS</sub> (Original)	Ē (Original)
2X	-0.205	-0.0338	-0.0715	1.33	1.37	0.0636
5	0.263	0.126	0.148	2.03	2.32	-0.7136
5X	-0.256	0.128	0.077	1.55	1.99	-1.1409
5 V	-0.208	0.102	-0.002	1.83	1.99	7591

Least Squares Fit Study

The errors indicated in Figures 6 and 7 may be attributed to a number of causes, among which are:

- 1. Errors in the readings of the paired microphones.
- Errors in the analysis of the results. (This includes failure to analyze identical lengths of magnetic tape.)
- 3. Inaccuracies in the prediction of distance corrections.
- 4. Inaccuracies in the prediction of vertical corrections.

Effects due to inaccuracies in the prediction of noise levels from the traffic should be expected to cancel out when the differences between the two microphone readings are taken; therefore these have not been included in the above list.

Of the four possible causes of error cited, the first two can be expected to lead to random errors, which could not be improved greatly when related to the least squares fit plane. However, the last two errors cited should cause systematic variations. Thus, if the least squares fit plane were to depart appreciably from the zero plane, it might indicate a need for the revision of the distance or vertical correction.

For example, suppose that the data have been taken without any reading or analysis errors. Suppose, also that the vertical correction is absolutely correct, but that the attenuation is in

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fact 10 dB for a tenfold increase in distance, whereas 15 dB is used in MICNOISE (see equation 12 of reference 1). Then the error would be -5 dB for  $(L_{50})_{\text{DIST}}$  equal to -15 dB, so that the least squares fit plane would tilt at an angle whose tangent would be 1/3 in the  $(L_{50})_{\text{DIST}}$  direction. It is quite evident from an inspection of Figures 6 and 7 that there is no such tilt, thus the 15 dB law appears to be justified by the results.

A further indication of the possible advantages to be gained from a modification of the distance and vertical corrections can be obtained from Table 4, which shows the RMS errors both relative to the least squares fit plane and as originally calculated. A comparison of the two RMS errors indicates the best improvement that could be obtained from a revision of the calculated distance and vertical corrections. The least improvement (from 1.37 to 1.33 dB) is obtained with MICNOISE 2X, which also has the lowest RMS errors, and is therefore, the best program of the four according to the results of this study. Of the others, MICNOISE 5X and 5V are somewhat better than MICNOISE 5, but both show some improvement when related to the least squares fit plane. However, both indicate a degree of unconservatism or underprediction in the prediction of corrections as evidenced by the fact that the mean errors,  $\overline{E}$ , are negative.

Possibly, an extension of this approach would lead to improved methods of calculating vertical corrections. However, the errors are not large in themselves; the worst RMS error in Table 4 is 2.32 dB, as compared with a maximum  $(L_{50})_{MEAS}$  of 18.4 dB in Table 3. The least RMS error in Table 4 is 1.33, which is comparable with the experimental RMS error reported in the original report. (Actually, 1.16, 0.70, 5.52, 11.10 and 1.39 respectively for the five sites, as given by Table 7 of reference 2).

Thus there is little margin for improvement so that, even though the programs could be made to fit the measured data better, there is little guarantee that such improvements would hold with other data.

It is concluded that the data bank available does not justify further efforts at refining the predictions of vertical errors in the computer programs, and that, before such an effort is made, it would be advisable to plan and execute a new and more extensive program of roadside measurement. The desirability of going to such lengths must be weighed against the future need for MICNOISE, taking into consideration other computer programs which are available or under development. It might be asked why MICNOISE 5, using a new method of calculating vertical corrections and based on the recommendations of <u>NCHRP Report No. 144</u>, should be less reliable than MICNOISE 2X, using earlier techniques. It would appear that MICNOISE 2X predicts noise levels of traffic at sites where tractor trailers predominate over other types of trucks with considerable accuracy. For example, examine the results for site 2 in Table 2, for which there were no vertical corrections. The vertical corrections used in MICNOISE 2X were based on early readings of the data used in the preparation of <u>NCHRP Report No. 144</u>. These are also shown to have led to accurate predictions. However, a degree of over-conservatism was introduced into the MICNOISE 5 program, which was based on the following recommendations in NCHRP Report No. 144.

- 1. A single correction should be used for elevated and depressed highways, and barriers, as suggested by Kurze and Anderson. (4,5) (This was done in MICNOISE 5.)
- 2. Not applicable.
- 3. The 5 dB reduction in the vertical correction for trucks should be cut to 3 dB or truck noise sources should be taken as eight feet (2.4 m) above the road with 0 dB reduction for trucks. (The latter was done.)
- 4. Possibly, the 10 dB law should be used over very flat terrain. (This was not done.)

The net effect of these recommendations appears to have been to overcompensate for acoustical barrier effects leading to a tendency to underpredict noise levels.

One further disadvantage of the MICNOISE 5 treatment of trucks is evident from a comparison of  $(L_{50})_{VERT}$  values from MICNOISE 2X and 5 for site 1 in Table 3. These values indicate up to 3 dB more attenuation predicted by MICNOISE 5 compared with MICNOISE 2X, leading to an average relative underprediction of  $L_{50}$  levels of around 1 dB, as indicated by Table 2. The reason for this is that the 8-foot (2.4 m) height assumed for trucks in MICNOISE 5 is small compared with the 35-foot (10.7 m) depression of the roadway at this site, whereas there is the same 5 dB across-the-board reduction for trucks in MICNOISE 2X, regardless of the depth of the cut.

## CONCLUSIONS AND RECOMMENDATIONS

In the following conclusions, due attention is paid to the fact that only MICNOISE Versions 2, 5, and 5V are available to Virginia Department of Highways and Transportation personnel at present. Actually, only Versions 2 and 5 are authorized for use by the Federal Highway Administration, however version 5V is demonstrably more conservative than 5. Because MICNOISE 2 has certain drawbacks, and is therefore not fully useable, only MICNOISE 5 and 5V can be considered.

In view of this, the following conclusions and recommendations are made.

- In applying predictions made by MICNOISE 5, 3 dB should be added to obtain the 68% confidence level, and with Version 5V, 2 dB should be added.
- 2. If better accuracy is desirable, consideration should be given to making appropriate changes to MICNOISE 5, so that MICNOISE 2 or 2X methods are used in calculating vertical corrections. By doing this, the 68% and 95% confidence levels can be brought to within 2 dB and 4 dB respectively of predicted values.
- 3. Further attempts to improve methods of calculation beyond the level of MICNOISE 2X should not be made unless a parallel program of roadside measurements can be justified.

#### REFERENCES

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- 2. Gordon, C. G., W. J. Galloway, B. A. Kugler, and D. L. Nelson, "Highway Noise — A Design Guide for Highway Engineers", <u>National Cooperative Highway Research Program — Report No. 117,</u> Highway Research Board, Washington, D. C., 1971.
- Kugler, B. A., and A. G. Piersol, "Highway Noise A Field Evaluation of Traffic Noise Reduction Measures", <u>National Cooperative Highway Research Program — Report No. 144</u>, Highway Research Board, Washington, D. C., 1973.
- 4. Kurze, U., and G. S. Anderson, "Sound Attenuation by Barriers", J. Applied Acoustics, Vol. 4, No. 1, (1971), pp. 35-53.
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#### APPENDIX A

## LISTING OF VERSION 5 COMPUTER PROGRAM

## Input Stack

A typical input stack for the IBM 360 Job Control Language (HASP System) is shown in Figure A-1. Note that the conversion program reads input cards as File #1, writes both input (MIC-NOISE 2) output (MICNOISE 5) formats as File #2 (output listing), and also writes MICNOISE 5output as File #3. File #3 is set up as the temporary library MICDAT.

MICNOISE 5 then reads MICDAT as File #1, and writes final output as File #2 (output listing).

//G0.FT02F001 DD\_SYSOUT=A.DCB=(RECFM=FA.LRECL=133.BLKSIZE=133) // //G0.FT02F001 DD SYSOUT=A,DCB=(RECFM=FA,LRECL=133,BLKSIZE=133)
//G0.FT03F001 DD UNIT=SYSDA,DSN=@@MICDAT,DISP=(NEW,PASS), //G0.FT01F001 DD UNIT=SYSDA,DSN=@@MICDAT,DISP=(OLD,DELETE), // SPACE=(800.(25.5)).DCB=(RECFM=F8.BLKSIZE=800.LRECL=80) // SPACE=(800,(25,5)),DCB=(RECFM=FB,BLKSIZE=800,LRECL=80) MICNOISE VERSION 5 PROGRAM N INPUT DATA FOR MICNOISE CONVERSION PROGRAM JOB CARD \$ // EXEC FORTGCLG //FORT.SYSIN DD \* //FORT.SYSIN DD \* //G0.FT01F001 DD // EXEC FORIGCLG \* \* \*

Input stack for MICNOISE 5 run using MICNOISE 2 data. Figure A-1.

# Conversion Program

The conversion program is shown in Figure A-2. The following calculations are made.

MICNOISE 5 data		MICNOISE 2 data
Q	=	ADT * PCADT * N/100
Q = Hourly Traffic		ADT = Average Daily Traffic
		PCADT = Percentage of ADT during peak hours
		N = No. of lane groups per roadway element
НЕ	=	H1 - H2
HE = Roadway Elevation		H1 = Height of elevated road
		H2 = Depth of depressed road

BETA = 0

No equivalent

BETA = Barrier and angle (was not used)

C         C         Comparing to converting inclusions:         Libration of the inclusion o	ſ					
0         0			PROGRAM TO CONVERT MICNOISE 2 INPUT DATA TO	O MICNOISE 5 FOR	IMAT	
0.0         0.00 <th0< td=""><td></td><td>ы</td><td>OUTPUT IS ONTO UNITS 2 AND 3</td><td></td><td></td><td></td></th0<>		ы	OUTPUT IS ONTO UNITS 2 AND 3			
2       Contrue       Contrue         3       WETE (2-+++)       UBB-1D/MC/MEE         4       FTE (2-+++)       UBB-1D/MC/MEE         4       FTE (2-+++)       UBB-1D/MC/MEE         4       FTE (2-+++)       UBB-1D/MC/MEE         4       FTE (2-++++)       UBB-1D/MC/MEE         4       FTE (2-+++)       UBB-1D/MC/MEE	100	007	WRIELCOMMATIONS (MICHOICE 2 INDUT DATA CONVE	FRTED TO MICNOIS	ر بر	
2         Contract         Contract           1         FRANT(1.444)         UG8.10.MC.MRE           1         FRANT(1.444)         UG8.10.MC.MRE           1         FRANT(1.01-55.4.23.11.18)         HTE (2.444)           1         FRANT(2.51.11.8)         HTE (2.444)           1         FRANT(2.51.11.8)         HTE (2.444)           1         FRANT(2.51.11.8)         HTE (2.444)           1         FRANT(2.51.11.8)         HTE (2.444)           1         FRANT(2.441)         HTE (2.444)           1         FRANT(2.444)         HTE (2.444)           1         FRANT(2.444)         HTE (2.4	200		IFORMAT (INDICATED BY **)*)		, ,	
Bit Mathematical Structure         Statution         Statution         Statution           0.0         0.0         0.0         0.0         0.0         0.0           0.0         0.0         0.0         0.0         0.0         0.0         0.0           0.0	003	29	CONTINUE			
33       08717 (23-11) (10)         11       100 TOU INEE-11481         11       100 TOU INEE-11482         11       100 TOU INEE-11482         11       100 TOU INEE-11482         11       101 20 TOU INEE-11482         11       101 20 ALS-DEL         11	104		READ(1,444) JOB, ID, NC, NRE			
************************************	005	9 S	WRITE(2,445) JOB, ID, NC, NRE			
07       445       FORMATIC 16, 05, C23, C23, 11, 110         11       1	006	444	FORMAT(2A3+11+18)			
08       FITE (3.444) JOB: DO GO TO BOO BITE (3.444) JOB: DO.KC.ME         11       17: Control MEE : ME         12       FRUIL: 1.440 JOB: DO.KC.ME         13       FITE (3.444) JOB: DO.KC.ME         14       FITE (3.444) JOB: DO.KC.ME         15       FITE (3.444) JOB: DO.KC.ME         16       FRUIL: 1.440 JOB: DO.KC.ME         17       FITE (3.444) JOB: DO.KC.ME         18       FITE (3.444) JOB: DO.KC.ME         19       FITE (3.444) JOB: DO.KC.ME         11       FITE (3.444) JOB: DO.KC.ME         12       FITE (3.444) JOB: DO.KC.ME         13       FITE (3.444) JOB: DO.KC.ME         14       FITE (3.444) JOB: DO.KC.ME         15       FORMATICAL (3.411) FITE (3.41	07	445	FORMAT(*0*,5X,2A3,I1,I8)			
00       WHITE (2:+++) JOB-1D-MC-MRE         11       WHITE (2:++++) JOB-1D-MC-MRE         11       READ(1:+++) JOB-1D-MC-MRE         11       READ(1:+++) JOB-1D-MC-MR         11       READ(1:+++) JOB-1D-MC-MC         11       READ(1:+555) JOB-1D-MC-MC         12       READ(1:+555) JOB-1D-MC-MC         13       READ(1:+555) JOB-1D-MC-MC         14       READ(1:+555) JOB-1D-MC-MC         15       READ(1:+555) JOB-1D-MC-MC         16       READ(1:+555) JOB-1D-MC-MC         17       REL3-MCL-SOL         18       READ(1:+555) JOB-1D-MC-MC         19       READ(1:+555) JOB-1D-MC-MC         10       READ(1:+555) JOB-1D-MC-MC         11       READ(1:+555) JOB-1D-MC-MC         12       SE READ(1:+555) JOB-1D-MC-MC         12       SE READ(1:+10-D5-MC-MC         12       SE READ(1:+10-D5-MC-MC         12       SE READ(1:+10-HC         12       <	008		IF(NC.NE.0) G0 T0 800			
10       W1TE (3,4,44) JOB:1D.MC.MRE         11       W1TE (3,4,44) JOB:1D.MC.ME         12       W1TE (2,4,44) JOB:1D.MC.M         13       W1TE (2,4,4) JOB:1D.MC.M         14       Tr(C,4'E.1) JOB:1D.MC.M         15       W1TE (2,4,4) JOB:1D.MC.M         16       W1TE (2,4,4) JOB:1D.MC.M         17       W1TE (2,4,4) JOB:1D.MC.MC.MC         18       TC(2,1') SES         19       W1TE (2,4,4) JOB:1D.MC.ADT.PCADT.PLIAT.         19       W1TE (2,4,4) JOB:1D.MC.ADT.PCADT.PLIAT.         11       W1TE (2,5,5) JOB:1D.MC.ADT.PCADT.PLIAT.         12       SES FOBMIT (2A):11.F6.0.13F5.0)         13       SES FORMAT (2A):11.F6.0.13F5.0)         14       SES FORMAT (2A):11.F6.0.13F5.0)         15       FORMAT (2A):11.F6.0.13F5.0)         16       SES FORMAT (2A):11.F6.0.13F5.0)         16       SES FORMAT (2A):11.F6.0.13F5.0)         17       SES FORMAT (2A):11.F6.0.13F5.0)         18       FERIT (2,555) JOB:10.M3.MED.THETA.H1.D5.H2.MC.H1.PM.H0         18       FERIT (2,555) JOB:10.M3.MED.THETA.H1.D5.H2.MC.H1.PM.H0         19       W1TE (2,555) JOB:10.M3.MED.THETA.H0.D5.MC.H1.PM.H0         10       FERIT (2,555) JOB:10.M3.MED.THETA.H0.D5.M2.H2.M4.H0         10       FERIT (2,555) JOB:10.M3.ME	60		WRITE (2,446) JOB,ID,NC,NRE			
11       Exo(1,+++) J0:NE         12       FC00(1,+++) J0:NE         13       FFFE(2,++5) J06:10.MC         14       FFE(2,++5) J06:10.MC         15       FFFE(2,++5) J06:10.MC         16       FFE(2,++5) J06:10.MC         17       FFC(2,++5) J06:10.MC         16       FFE(2,++5) J06:10.MC         17       FFC(2,++5) J06:10.MC         18       FFA(1,++5) J06:10.MC         19       FFC(2,+5) J06:10.MC         111       FFC(2,+5) J06:10.MC         112       FFC(2,+5) J06:10.MC         113       FFC(2,+5) J06:10.MC         114       FFC(2,+5) J06:10.MC         115       FFC(2,+5) J06:10.MC         116       FFC(2,+5) J06:10.MC         117       FFC(2,+5) J06:10.MC         118       FFC(2,+5) J06:10.MC         119       FFC(2,+5) J06:10.MC         111       FFC(2,+5) J06:10.MC         1111       FFC(2,+5) J06:10.MC     <	10		WRITE(3,444) JOB, ID, NC, NRE	· · · · · · · · · · · · · · · · · · ·	1	
12       WEITE (2-444) JOB: 10:40.0         13       FUTE (2-444) JOB: 10:40.0         14       FUTE (2-444) JOB: 10:40.0         15       445 FORMAT (1+5)         16       FUTE (2-450) JOB: 10:40.0         11       FUTE (2-450) JOB: 10:40.0         11       FUTE (2-450) JOB: 10:40.0         12       FUTE (2-450) JOB: 10:40.0         13       FUTE (2-450) JOB: 10:40.0         14       FUTE (2-450) JOB: 10:40.0         15       FUTE (2-450) JOB: 10:40.0         16       JOEL JOEL JOEL JOEL JOEL JOEL JOEL JOEL	11		D0 700 INRE=1.NRE			
113       WRITE(2+445) JOB-ID.NC.N         115       FUE (C.R.1) JOB TO NOC.N         116       FUE (C.R.1) JOB TO NOC.N         117       FUE (C.R.1) JOB TO NOC.N         118       FUE (C.R.1) JOB TO NOC.N         119       FUE (C.R.1) JOB TO NOC.N         119       FUE (C.R.1) JOB TO NOC.NOT.PCCDT.THIX.ST.SA.HD.ON.RL.BL.FLO.P.         119       FUE JOELS-DUEL 7         119       PUE TO C.R.2.25 JOB TO NOC.NOT.PCCDT.THIX.ST.SA.HD.ON.RL.BL.FLO.P.         119       PUE TO C.R.2.25 JOB TO NOT.PCCDT.THIX.ST.SA.HD.ON.RL.BL.FLO.P.         119       PUE TO C.R.2.75 JOB TO NOT.PCCDT.THIX.ST.SA.HD.ON.RL.BL.FLO.P.         119       PUE TO C.R.2.75 JOB TO NOT.PCCDT.THIX.ST.SA.HD.ON.RL.BL.FLO.P.         1115       PUE TO C.R.2.75 JOB TO NOT.PCC.PLDE.THIX.ST.SA.HE.ON.RL.BL.P.         1116       FUE TO C.R.2.75 JOB TO NOT.PCC.PLDE.THIX.ST.SA.HE.DN.RL.BL.P.         1117       PUE TO C.R.2.75 JOB TO NOT.PCC.PLDE.THIX.ST.SA.HE.DN.RL.BL.P.         1118       PUE TO C.R.2.75 JOB TO NOT.PCC.PLDE.TO THIX.ST.SA.HE.DN.RL.BL	12		READ(1,444) JOB,ID,NC,N			
1:       FT(K1,K1,K1,K1,K1,K1,K1,K1,K1,K1,K1,K1,K1,K	13		WRITE(2,445) JOB,ID,NC,N			
15       446 FORMAT(2:+445) JOB-1D.NK.4N         11       RATT(1:355) JOB-1D.NK.4NT+FCADT:THIX.5T:SA.HD.DN.RL.BL.FLO.P.         11       RATT(1:355) JOB-1D.NK.4NT+FCADT:THIX.ST:SA.HD.DN.RL.BL.FLO.P.         12       UREL3+0EL5+0EL7         13       JDEL3+0EL5+0EL7         14       RATT(1:35):JDB-1D.NK.4NT+FCADT:THIX.ST:SA.HD.DN.RL.BL.FLO.P.         15       FORMAT(1:2):SX:23:JDB-1D.NK.4NT+FCADT:THIX.ST:SA.HD.DN.RL.BL.FLO.P.         25       FORMAT(1:2):SX:23:JDB-1D.NK.4NT+SE.SDC.H+DBB.ALPHA.HD         26       SSE FORMAT(1:2):SX:23:JDB-1D.NK.6D.THETA.H1.DS:HZ:DC.H+DBB.ALPHA.HD         27       FORMAT(1:0):SX:23:JDB-1D.NK.6D.THETA.H1.DS:HZ:DC.H+DBB.ALPHA.HD         28       DIREL3/0EL5         29       SSE FORMAT(1:0):SSE JOB.1D.NK.6D.THETA.H1.DS:HZ:DC.H+DBB.ALPHA.HD         28       MERTEL72         29       VERTEL72         20       DIREL3/0EL5/0EL7         21       VERTEL72         22       SSE FORMAT(1:0):SSE JOB.1D.NK.6D.THETA.H1.DS:HZ.BL.P.P.         28       UREL3/0EL5/0EL7         29       VERTEL72         20       DIREL3/0EL5/0EL7         21       VERTEL72         22       SSE FORMAT(1:0):SSE JOB.1D.NK.6D.THETA.H1.DS:HZ.BL.P.P.         23       WERTEL72         24       VERD	14		IF(NC.NE.I) G0 T0 800			
446         FORMATT:         ****         ****           11         REATE(1955)         JOBNED.MCK         MORED.MCK			WRITE(2.446) JOB.ID.NC.N			
17       RETRIDATION OB: DOWCANT: FORDERMIX: 51:5300.00%.RL.BL.FLO.P.         19       WRITE (55:56)       UOB: DOWCANT: FORDERMIX: 51:5300.00%.RL.BL.FLO.P.         20       555 FOMMAT (20:55.56)       UOB: DOWCANT: FEGATI (FFG.0:13F5.0)         22       555 FOMMAT (20:55.56)       UOB: DOWCANT: FEGATI (FFG.0:13F5.0)         23       555 FOMMAT (20:55.56)       UOB: DOWCANT: FEGATI (FFG.0:13F5.0)         24       156.100       00         25       160.100.00%.RL:01       00         26       170.00%.RL:01       00         27       170.00%.DOMCANT: 5550       UOB: DOMCANT: 515.00%         28       170.00%.DOMCANT       00         29       170.00%.DOMCANT       00         29       171.00%.DOMCANT       00         20       170.00%.DOMCANT       00         21       170.00%.DOMCANT       00         22       170.00%.DOMCANT       00         23       WRITE (2550)       UOB: DOMCANT         24       WRITE (2550)       UOB: DOMCANT         257       FORMAT (7)       700.00%.DOMCANT         26       171.00%.DOMCANT       100         27       WRITE (2550)       UOB: DOMCANT         28       100       100 <td></td> <td>446</td> <td>FORMAT(*** ** ** 243.11.18)</td> <td></td> <td></td> <td></td>		446	FORMAT(*** ** ** 243.11.18)			
10         READ(11-555) JOB:ID:NC:ADT.FCADT.THIX.ST:SA:HD.DN.RL.BL.FLO.P.           19         JDEL3.0EL5.0EL7           20         555 FORMAT(05.52.23.11)F8.0:13F5.0)           21         555 FORMAT(05.52.23.11)F8.0:13F5.0)           22         555 FORMAT(05.52.23.11)F8.0:13F5.0)           23         FORMAT(05.52.23.11)F8.0:13F5.0)           24         FTRA.C.555 JOB.1D.N.C.ADT.FFCADT.THIX.ST.53.HD.DN.RL.BL.FLO.P.           25         FORMAT(05.52.23.31)F8.0:13F5.0)           26         FTRA.C.555 JOB.1D.N.J.MED.THETA.H1.05.H2.DC.H.DB.ALPHA.HO           25         FTRA.C.555 JOB.1D.N.C.0.THIX.ST.53.HE.DN.RL.BL.P.           26         FTRA.C.555 JOB.1D.N.C.0.THIX.ST.53.HE.DN.RL.BL.P.           27         FERTHLE           28         WHITE(2.557 JOB.1D.N.G.0.THETA.H1.05.H2.DC.H.DB.ALPHA.HO           29         FTRA.C.           20         DB.1D.N.S.FESTHE.DN.RL.BL.P.           21         FERTHLE           23         WHITE(2.555 JOB.1D.N.G.0.THETA.H0.05.DC.H.DB.ALPHA.HETA           24         FERTHLE           25         FRAMAT           26         DB.1D.N.S.FESTHE.DN.RL.BL.P.           27         FORMAT(1. ERGO.THETA.H0.05.DC.H.DB.ALPHA.BETA           28         FRITE(2.555) JOB.1D.N.S.FESTA.HE.DN.RL.BL.P.           28 <t< td=""><td>17</td><td></td><td>WRITE (3.444) JOB.ID.NC.N</td><td></td><td></td><td></td></t<>	17		WRITE (3.444) JOB.ID.NC.N			
100         1000000000000000000000000000000000000	18		READ(1.555) JOB.ID.NC.ADT.PCADT.TMIX.ST.SA	.HD.DN.RL.BL.FLC	, P,	
19       Intrictsessi Jose ID.NC.ADT.PCADT.TMIX.ST.SA.H0.0N.RL.BL.FL0.P.         20       555 FOHMAT (20.13F5.0)         21       555 FOHMAT (20.13F5.0)         22       001762.001.001         23       7500.001.001.001         24       555 FOHMAT (20.13F5.0)         25       60170.001         26       7017.001.555         27       7017.001         28       7101.000         29       757 FOHMAT (00.1555)         20       1011.000         21       1021.001.000         22       1011.000         23       77 FOHMAT (00.1555)         24       1011.000         25       1011.000         26       1011.000         27       1011.000         28       1011.000         29       1011.000         20       1011.000.000.000         21       BEL3.001         22       1011.000.000.000         23       0011.000         24       1011.000.000.000         25       1011.000.000         26       1011.000.000         27       1011.000         28       1011.0000         29			IDEL 3.DEL 5.DEL 7			
20       555 FORMAT (2A3-11)F6.0.13F5.0)         21       555 FORMAT (2A3-11)F6.0.13F5.0)         22       555 FORMAT (2A3-11)F6.0.13F5.0)         23       FCMAT (2A3-11)F6.0.13F5.0)         25       FORMAT (2A3-11)F6.0.13F5.0)         25       FORMAT (2A3-11)F6.0.13F5.0)         25       FORMAT (2A3-11)F6.0.13F5.0)         25       FCMAT (2A3-11)F6.0.13F5.0)         26       FEAD(1.555) JOB.ID.NO.40FHETA.H1.05.H2.0C.H.0B.ALPHA.H0         27       FEAD(1.555) JOB.ID.NO.40FHETA.H1.05.H2.0C.H.0B.ALPHA.H0         27       FEAD(1.555) JOB.ID.NO.40FHETA.H1.05.H2.0C.H.0B.ALPHA.H0         27       FEAD(1.555) JOB.ID.NO.40FHETA.H1.05.H2.0C.H.0B.ALPHA.H0         28       IDEL3.0EL5.0EL7         30       FORMATO	0		UDITE (2, EE6) (OB, ID, NC, ADI, PCADI, IMIX, ST, S)	A.HD.DN.RI .BI .FI	0.P.	
20         555         FORMAT(CA3+11;FB.0+13F5.0)           22         55         FORMAT(CA3+11;FB.0+13F5.0)           23         67001         600           24         READ(1;FS5)         008+10:N3;MED;THETA,H1,D5:H2:0C;H+DB.ALPHA,H0           25         FTCC.KC.KC.55         008+10:N3;MED;THETA,H1,D5:H2:0C;H+DB.ALPHA,H0           26         READ(1;FS5)         008+10:N3;MED;THETA,H1,D5:H2:0C;H+DB.ALPHA,H0           27         WRITE(2:557)         J08+10:N3;MED;THETA,H1,D5:H2:0C;H+DB.ALPHA,H0           28         WRITE(2:557)         J08+10:N3;MED;THETA,H1,D5:H2:0C;H+DB.ALPHA,H0           28         WRITE(2:557)         J08+10:N3;MED;THETA,H0:D5:NC,H0B.ALPHA,H0           29         557         FORMAT(******;23:11;FB.0;13F5.0)           20         DECL30EL5/0EL7         J08+10:N1:MED;THETA,H0:D5:NC,H1BB,ALPHA,H0           28         WRITE(2:4557)         J08+10:N1:N:K51;53A+KE:0N:RL,PL,P;           30         DECL30EL5/0EL7         J08+10:N1:N:K51;53A+KE:0N:RL,PL,P;           31         BEFAG         MRITE(2:4555)           32         WRITE(2:3:555)         J08+10:N3:MED;THETA,H0:D5:DC,H1BB,ALPHA,BETA           33         B00         RTTE(2:3:555)         J08+10:N1:NE           34         T0         C0110         J05         J08-10:N1:NE	41.		WILL (CODD) UNDER UP INCERDISTICATION STRATES			
20       555       FORMATI (70,5X:433):115:0.0)         21       555       FORMATI (70,5X:433):115:0.0)         23       FE (NC.NE.2)       005         24       READ1555       V08:10.N3,MED.THETA,H1.05.H2.0C.H.0B.ALPHA.H0         25       FF (NC.NE.2)       008:10.N3,MED.THETA,H1.05.H2.0C.H.0B.ALPHA.H0         26       HEH1-H2       009:10.N3,MED.THETA,H1.05.H2.0C.H.0B.ALPHA.H0         27       FORMATI (71,5555)       J08:10.N3,MED.THETA,H1.05.H2.0.N.R.P.H4.P1.         28       WRITE (2.5557)       J08:10.N0.0.011X.ST.SA.HE.0N.RL.9L.P.         29       S57       FORMATI (71,1.1.4.8.1.5.57.SA.HE.0N.RL.9L.P.         21       WRITE (2.5557)       J08:10.N0.0.0.13F.50.0)         23       VRITE (2.5557)       J08:10.N0.0.0.13F.50.0)         24       NRITE (2.5557)       J08:10.N0.0.0.11X.ST.5.SA.HE.0N.RL.9L.P.         25       FORMATI (71, 1.4.8.1.2.7.5.5.SA.HE.0N.RL.9L.P.         26       VRITE (2.5557)       J08:10.N0.0.0.13F.50.00.13F.50.0)         27       FORMATI (71, 1.4.8.1.1.5.7.5.SA.HE.0N.RL.9L.P.         28       VRITE (2.5557)       J08:10.N0.3.MED.THETA,H0.05.0C.0.14.9B.ALPHA.9ETA         29       VRITE (2.4.50.0)       VRITE (2.4.50.0)         21       VRITE (2.4.60.1)       J08.10.N0.3.MED.THETA,H0.05.0C.0.14.9B.ALPHA.9ETA			IUEL3+UEL5+UEL/			
21       555 FORMATT(*0:5X,231.11F6.0.13F5.0)         22       20070.000         23       FF(NC.ME.2)       500 T0 800         24       FFN01.5X,231.11F6.0.13F5.0)         25       FFN1.100         26       FFN1.100         27       FFF1.14         28       FFT1.14         29       FFN1.14         29       FFN1.14         21       FFN1.14         23       FFN1.14         24       FFT1.14         27       FFF1.14         28       FFN1.14         29       557         257       FORMATT         29       557         257       FORMATT         257       FORMATT         26       FFN1.14         27       BET.25         28       FORMATT         29       557         200.108.10.10.33.4ED.14ETA.410.05.0C.41.408.4LPHA.4ETA         21       BET.25         22       WHTE.12.5557         23       UNT.14.5T.554.46.0N.RL.8L.PL         24       WHTE.12.557         255       JOB.1D.43.4ED.140.05.0C.41.408.4LPHA.4ETA         23       WHTE.13.5555	20	222	FORMAT(2A3,11,F8.0,13F5.0)			
ZZ         IF (NC, ME, Z)         G0 10         B00           ZZ         READTFFCGT*N/100         READTFFCGT*N/100         READTFFCGT*N/100           ZZ         READTFFCGT*N/100         SOD 10000         READTFFCGT*N/100           ZZ         READTFFCGT*N/100         SOD 1000         READTFFCGT*N/100           ZZ         READTFFCGT         SOD 10000         READTFFCGT           ZZ         READTFFCGT         SOD 10000         READTFFCGT           ZZ         READTFFCGT         SOD 10000         READTFFCGT           ZZ         READTFFCGT         READTFFCGT         READTFFCGT           ZZ         READ	21	556	<pre>FORMAT(*0*,5X,2A3,I1,F8.0,13F5.0)</pre>			
23       ReadT**CADT**/100         24       RED0(1,555) J08.10.N3.MED.THETA.H1.05.H2.0C.H.0B.ALPHA.H0         25       IF(N3.NE.3) 60 T0 800         26       HETLAL2         27       HETLAL2         28       J05.10.N3.MED.THETA.H1.05.H2.0C.H.0B.ALPHA.H0         28       IECL3.0E.5051 J08.10.NG.0.THIX.51.5A.HE.0N.RL.BL.P         29       557 F0HATC         20       VRTTE(2.557) J08.10.NG.0.THIX.51.5SA.HE.0N.RL.BL.P         20       VRTTE(2.555) J08.10.NG.0.THIX.51.5SA.HE.0N.RL.BL.P         21       VRTTE(3.555) J08.10.NG.0.THIX.51.5SA.HE.0N.RL.BL.P         23       VRTTE(3.555) J08.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         23       VRTTE(3.555) J08.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         23       VRTTE(3.555) J08.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         24       D01.30.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         25       F08.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         23       WRTTE(2.557) J08.10.N3.MED.THETA.H0.055.0C.H.0B.ALPHA.BETA         24       T00 CONTINUE         35       G0 T0 901         36       B01 F00.AC.00         37       G0 T0 901         38       B01 F00.AC.00         39       B01 F00.AC.100         41       901 F00.10	22		IF(NC.NE.Z) G0 T0 800			
24         READ(1;555)         JOB:ID:N3.MED.THETA.H1.05.H2:0C:H:0B.ALPHA.H0           25         IF (N3.NE.3)         60 TO 800           27         WRITE(2:556)         JOB:ID:N0.AMED.THETA.H1.05.H2:0C:H:0B.ALPHA.H0           28         WRITE(2:555)         JOB:ID:N0.AMED.THETA.H1.05.H2:0C:H:0B.ALPHA.H0           29         S57 FORMATI'         VAL           29         S57 FORMATI'         VAL           20         WRITE(3:555)         JOB.ID:NC.Q0.TMIX.5T.5SA.HE.0N.RL.BL.P.           21         BETAJ         VAL           23         VARITE(3:555)         JOB.ID:NC.Q0.TMIX.5T.5SA.HE.0N.RL.BL.P.           31         BETAJ         VARITE(3:555)         JOB.ID:NC.Q0.TMIX.5T.5SA.HE.0N.RL.BL.P.           32         DEL3.0EL5.0EL7         JOB.ID:NC.Q0.TMIX.5T.5SA.HE.0N.RL.BL.P.           33         DEL3.0EL7         JOB.ID:NC.Q0.TMIX.5T.5SA.HE.0N.RL.BL.P.           33         DEL3.0EL7         JOB.ID:NC.Q0.THETA.H0.05.DC.H.0B.ALPHA.BETA           34         NRITE(3:555)         JOB.ID:NO.3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA           35         VARITE(3:555)         JOB.ID:N3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA           36         DO TO 900         OO TO 900           37         BO TO YOU         STOR           38         NARTE(2:4555)	23		Q=ADT*PCADT*N/100			
25       IF(12:556) JOB:JDN3.MED.THETA.H1.DS.H2.DC.H.DB.ALPHA.HO         26       IF(10:10.16:3)         27       WRITE(2:557) JOB.ID.NC.0.TMIX.5T:SA.HE.ON.RL.BL.P.         28       IDEL3.DEL5.POEL7         29       S57 FORMAT(*) *1 ** *.         21       URITE(2:557) JOB.ID.NC.0.TMIX.5T:SA.HE.ON.RL.BL.P.         29       VRITE(2:555) JOB.ID.NC.0.TMIX.5T:SA.HE.ON.RL.BL.P.         21       URITE(3:555) JOB.ID.N3.MED.THETA.H0.05.0C.H.DB.ALPHA.BETA         23       WRITE(2:557) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         33       WRITE(2:5557) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         33       WRITE(2:5557) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         34       TOD CONTINUE         35       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         36       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         39       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         39       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         39       B01 FORMATI FRAGM IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         30       FOR CARDIJ.4441 JOB.ID.NC.ICON         41       900 FOR BOD.NC.ICON         42       FOR CARDIJ.4441 JOB.ID.NC.ICO	24		READ(1.555) JOB.ID.N3.MED.THETA.H1.DS.H2.	DC,H,DB,ALPHA,HC		
26         IF (N3.NE.3)         60         00           27         HE=H1-HZ         HE=H1-HZ         HE=H1-HZ           28         WRITE (2.557)         JOB.ID.NC.0.TMIX.5T.5A.HE.ON.RL.BL.P.           29         557 FORMATT ***         *.2A3.11,FB.0.13F5.0)           30         JDEL3.0EL5.0EL7         **.2A3.11,FB.0.13F5.0)           31         WRITE (2.555)         JOB.ID.NC.00.TMIX.5T.5A.HE.ON.RL.BL.P.           32         WRITE (2.555)         JOB.ID.N3.MED.THETA.H0.D5.0C.H.DB.ALPHA.BETA           32         WRITE (2.555)         JOB.ID.N3.MED.THETA.H0.D5.0C.H.DB.ALPHA.BETA           32         WRITE (2.555)         JOB.ID.N3.MED.THETA.H0.D5.0C.H.DB.ALPHA.BETA           33         WRITE (2.555)         JOB.ID.N3.MED.THETA.H0.D5.0C.H.DB.ALPHA.BETA           34         TO         CONTINUE         MRITE (2.555)           35         BOI         MRITE (2.601)         MRITE (2.601)           36         BOI         MRITE (2.801)         MRITE (2.801)           37         BOI         MRITE (2.801)         MRITE (2.801)           38         BOI         MRITE (2.801)         MRITE (2.801)           39         BOI         MRITE (2.801)         MRITE (2.801)           30         FRO         MRITE (2.801)         <	2		WRITE (2.556) JOB.ID.N3.MFD.THETA.H1.DS.H2.(	DC . H. DB . AL PHA. HC		
27       HE=HI-HZ         28       WRITE(2:557) JOB.ID.NC.Q.TMIX.ST.SA.HE.DN.RL.BL.P.         29       557 FORMAT(1 *1 ** *: 2.33.11)+F8.0).13F5.0)         30       JDEL3.DEL5.DEL7         31       BETA=0         32       WRITE(2:557) JOB.ID.NC.Q.TMIX.ST.SA.HE.DN.RL.BL.P.         33       WRITE(3:555) JOB.ID.NC.Q.TMIX.ST.SA.HE.DN.RL.BL.P.         33       WRITE(3:555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         34       TO CONTINUE         35       60 TO 900         36       00 WRITE(2:557) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         33       WRITE(2:555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         34       TO CONTINUE         35       60 TO 900         36       B01 PRATI         37       00 WRITE(2:455) JOB.ID.NC.NC.         38       B10 READ(1.4441) JOB.ID.NC.NC.         39       B10 READ(1.4441) JOB.ID.NC.ICON         39       B10 READ(1.4441) JOB.ID.NC.ICON         39       F(NC.EG.0) GO TO 30         39       F(NC.EG.0) GO TO 30         40       PON READ(1.4441) JOB.ID.NC.ICON         41       PON READ(1.4441) JOB.ID.NC.ICON         42       WRITE(3.4445) JOB.ID.NC.ICON         44       WRITE(2.4445) JOB.ID.NC.ICON </td <td>26</td> <td></td> <td>TF (N3. NF. 3) GO TO 800</td> <td></td> <td></td> <td></td>	26		TF (N3. NF. 3) GO TO 800			
28         WRITE(2:557) JOB.ID.NC.0.TMIX.5T.53.HE.DN.RL.9L.P.           29         557 FOEMAT(r.1.*.*					the second	
Construction         Construction<			HE-HI-HE HDITE/2 EE7/  AB.IN NC.0.IMIV.EI.EA.HE.AN.E	0, 10, 10,		
29         557         FORMAT(*)         **         *.233.11,F8.0.13F5.01           30         WRITE(3.555) JOB.ID.NC.0.TMIX.ST.5S4.HE.DN.RL.BL.P.           31         BETA           32         WRITE(2.557) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           33         WRITE(2.557) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           34         TOD CONTINUE           35         WRITE(2.555) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           34         TOD CONTINUE           35         B00 MRITE(3.555) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           36         MOTOTINUE           37         B00 MRITE(2.555) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           36         B00 MRITE(3.555) JOB.ID.N3.MED.THETA.H0.D5.DC.H.DB.ALPHA.BETA           37         B00 FORMAT(* <error been="" card="" has="" in="" order.="" run="" skipped*)<="" td="" this="">           38         B01 FORMAT(* ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED*)           38         B10 READ(1.444) JOB.ID.NC.NCME           39         B10 READ(1.444) JOB.ID.NC.ICON           40         90 READ(1.444) JOB.ID.NC.ICON           41         900 READ(1.444) JOB.ID.NC.ICON           42         WRITE(2.445) JOB.ID.NC.ICON           44         WRITE(2.445) JOB.ID.NC.ICON           45         WRITE(2.4445) JOB.ID.NC.ICON</error>	07		MALIE (2900// 000/LU910/04/14/20/90/1904/12/00/11			
30       URTE(3.555) JOB.ID.NC.0.TMIX.ST.53.HE.DN.RL.BL.P.         31       BETA=0         32       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.DB.ALPHA.BETA         33       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0B.ALPHA.BETA         34       VO         35       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0B.ALPHA.BETA         36       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0B.ALPHA.BETA         37       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0B.ALPHA.BETA         36       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0B.ALPHA.BETA         36       WRITE(3.555) JOB.ID.N3.MED.THETA.H0.DS.DC.H0B.ALPHA.BETA         35       B00       WRITE(2.901)         36       B01       FORMATU         37       B01       FORMATU         381       FORMATU       ERROR         391       READ(1.444) JOB.ID.NC.NRE         392       B01       FORMATU         393       B10       READ(1.444) JOB.ID.NC.ICON         40       G0       TO       B10         41       900       READ(1.444) JOB.ID.NC.ICON         42       WRITE(2.445) JOB.ID.NC.ICON       MRITE(2.445) JOB.ID.NC.ICON         44       WRITE(2.445) JOB.ID.NC.ICON       MRITE(2.445) JOB.ID.NC.ICON         45			luctsouctsouch requiring the static state of			
30       IDEL3:0EL5:0EL7         31       IDEL3:0EL5:0EL7         32       WRITE(3:557) JOB:ID.N3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA         33       WRITE(2:557) JOB:ID.N3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA         34       700 CONTINUE         35       B01 MRITE(2:557) JOB:ID.N3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA         36       WRITE(2:555) JOB.ID.N3.MED.THETA.H0.05.DC.H.0B.ALPHA.BETA         37       WRITE(2:5601)         38       B01 MRITE(2:401)         39       FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         39       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         39       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         31       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         32       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         31       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         32       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         33       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         34       B01 FORMATI'ERROR IN CON         35       B01 FORMATI'ERROR IN CARD ORDER. THIS RUN HAS BEEN SKIPPED')         34       B01 FORMATI'ERROR INCCION         41       900 READ(1.4444) JOB.ID.NC.ICON	53	202	FURMAI (* * * * * * * 2 A3 * 1 F B * U * 1 S T > • U	c č		
IDEL3:0EL5:0EL           31         URETa=0           32         WRITE (2:557) JOB:ID.N3.MED.THETA.H0.05.0C.H.0B.ALPHA.BETA           33         WRITE (2:557) JOB:ID.N3.MED.THETA.H0.05.0C.H.0B.ALPHA.BETA           34         T00 CONTINUE           35         B01 MITE (2:555) JOB:ID.N3.MED.THETA.H0.05.0C.H.0B.ALPHA.BETA           34         T00 CONTINUE           35         B00 MITE (2:555) JOB.ID.N3.MED.THETA.H0.05.0C.H.0B.ALPHA.BETA           36         B01 FORMATI           37         B01 FORMATI           38         B01 FORMATI           39         FORMATI           31         B01 FORMATI           32         B01 FORMATI           33         B01 FORMATI           34         B01 FORMATI           35         B01 FORMATI           36         B01 FORMATI           37         B01 FORMATI           38         B10 READ(1.4444) JOB.ID.NC.NC.NE           39         FO           41         900 READ(1.4444) JOB.ID.NC.ICON           42         WRITE (2.4455) JOB.ID.NC.ICON           43         WRITE (2.4455) JOB.ID.NC.ICON           44         WRITE (2.4445) JOB.ID.NC.ICON           45         WRITE (2.4445) JOB.ID.NC.ICON	30		WKITE (3+555) JUB+ID+NC+U+IMIA+51+5A+HE+UN+P	KL,BL,F,		
31       BETA=0         32       WRITE(2,5557) JOB.ID.N3.MED.THETA.H0.DS.DC.H.0BA.LPHA.BETA         33       VOI CONTINUE         34       700 CONTINUE         35       60 T0 900         36       800 MRITE(2,601)         37       801 FORMATI< ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)			1DEL3+DEL5+DEL/			
32       WRITE (2+557) JOB: ID:N3.MED: THE TA.H0.05.DC.H109: ALPHA.BETA         33       700 (KTTE (2+555) JOB: ID.N3.MED: THETA.H0.05.DC.H0.0B.ALPHA.BETA         35       60 T0 900         36       801 WRITE (2+561)         37       801 FORMATI' ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED')         38       801 FORMATI' ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED')         39       801 FORMATI' ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED')         31       801 FORMATI' ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED')         39       900 WRITE (2+445) JOB: ID.NC.ICON         41       900 READ(1+444) JOB: ID.NC.ICON         42       WRITE (2+445) JOB: ID.NC.ICON         43       WRITE (2+445) JOB: ID.NC.ICON         44       WRITE (2+445) JOB: ID.NC.ICON         45       WRITE (2+445) JOB: ID.NC.ICON         46       16 (IC.Con) 999.29900         47       999 SOP         47       999 SOP	IE		BETA=0			
33       WRITE (3+555) JOB: ID.*N3.MED. THE TA.H0.405.DC.H1.40B.ALFHA.4BE.LA         34       700 CONTINUE         35       600 MRITE (2+601)         36       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         37       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 READ(1.444) JOB.1D.NC.NRE         39       17 (NC.640) 60 T0 30         41       900 READ(1.444) JOB.1D.NC.ICON         42       WRITE (2+445) JOB.1D.NC.ICON         43       WRITE (2+445) JOB.1D.NC.ICON         44       WRITE (2+445) JOB.1D.NC.ICON         45       WRITE (2+445) JOB.1D.NC.ICON         46       If (NC.NN) 999.29.900         47       999 23.00         48       FND	32		WKITE (2,5557) JUB+ID+N3+MED+IMEIA+HU+U5+UC+T	H, UB, ALFHA, BEIA		
34       700 CONTINUE         35       60 T0 900         36       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         39       17 (NC.64.0) G0 T0 30         40       900 READ(1.4444) JOB.ID.NC.ICON         41       900 READ(1.4444) JOB.ID.NC.ICON         42       WRITE(2.445) JOB.ID.NC.ICON         43       WRITE(2.445) JOB.ID.NC.ICON         44       WRITE(2.4445) JOB.ID.NC.ICON         45       WRITE(2.4444) JOB.ID.NC.ICON         46       FI (CON) 999.29.900         47       999 STOP         47       999 STOP			WRITE(3,555) JOB, ID, N3, MED, THETA, H0, DS, DC,	H.UB.ALPHA.BEIA		
35       60 T0 900         36       800 MRITE(2+801)         37       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 READ(1,444) JOB.ID.NC.NRE         39       15(NC.EQ.0) G0 T0 30         40       900 READ(1,444) JOB.ID.NC.ICON         41       900 READ(1,444) JOB.ID.NC.ICON         42       MRITE(2,445) JOB.ID.NC.ICON         43       MRITE(2,445) JOB.ID.NC.ICON         45       WRITE(2,4445) JOB.ID.NC.ICON         46       15(NC.NE.4) JOB.ID.NC.ICON         47       999 239.900         46       15(ICON) 999.29.900	34	700	CONTINUE			
36       800 WRITE(2.801)         37       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 READ(1,444) JOB.ID.NC.NRE         39       15 (NC.EQ.0) 60 T0 30         40       900 READ(1,444) JOB.ID.NC.ICON         41       900 READ(1,444) JOB.ID.NC.ICON         42       WRITE(2.445) JOB.ID.NC.ICON         43       15 (NC.EQ.0) 60 T0 800         44       WRITE(2.445) JOB.ID.NC.ICON         45       WRITE(2.444) JOB.ID.NC.ICON         46       17 (NC.NC.)         47       999 29.9900         46       17 (ICON) 999.29.900	35		GO TO 900			
37       801 FORMAT(* ERROR IN CARD ORDER, THIS RUN HAS BEEN SKIPPED*)         38       810 READ(1,444) J08,1D.NC.NRE         39       15 (NC.EQ.0) 60 T0 30         41       900 READ(1,444) J08,1D.NC.ICON         42       WRITE(2,445) J08,1D.NC.ICON         43       WITE(2,445) J08,1D.NC.ICON         44       WRITE(2,445) J08,1D.NC.ICON         45       WRITE(2,445) J08,1D.NC.ICON         46       WRITE(2,444) J08,1D.NC.ICON         47       999 29,29,900         46       FND         47       999 29,29,900	36	800	MRITE(2+801)			
38     810     READ(1,444)     JOB.ID.NC.NRE       39     1F (NC.EQ.0)     G TO 30       41     900     READ(1,444)     JOB.ID.NC.ICON       42     WRITE(2,445)     JOB.ID.NC.ICON       43     NFITE(2,445)     JOB.ID.NC.ICON       44     WRITE(2,444)     JOB.ID.NC.ICON       45     WRITE(2,444)     JOB.ID.NC.ICON       46     WRITE(2,444)     JOB.ID.NC.ICON       47     99     29.9900       46     FNI     JOB.ID.NC.ICON       47     99     29.9900	37	801	FORMAT( • ERROR IN CARD ORDER • THIS RUN HAS	BEEN SKIPPED.)		
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AI         VILTE(2:+45) JOB.10.NC.1CON           43         IF (NC.NE.4) G0 T0 800           44         WRITE(2:+46) JOB.10.NC.1CON           45         WRITE(2:+44) JOB.10.NC.1CON           45         WRITE(2:+44) JOB.10.NC.1CON           46         IF (ICON) 999,29,900           47         999 29,29,900           47         999 29,900		000	DEAD/1.444) IND.TD.MC.TCON			
No.         No. <td></td> <td>224</td> <td>WERDITYTT COULDING TOW</td> <td></td> <td></td> <td></td>		224	WERDITYTT COULDING TOW			
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145 WRITE(3:444) JUB:ID:NC.ICON 146 IF(ICON) 999,29,900 147 999 STOP 148 END			NOT 601 01 01 000 01 10 10 10 10 10 10 10 10			
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147 999 STOP	)46		IF(ICON) 999,29,900			
AR END	5 240	666	STOP			
	440		UN J			

MICNOISE 2 format to MICNOISE

Conversion program. 5 format.

Figure A-2.

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**A-4** 

# MICNOISE 5

Figure A-3 shows the MICNOISE version 5 program, as supplied by the Data Processing Division of the Virginia Department of Highways and Transportation. Some minor changes have been made for this evaluation.

- (1) The program has been fixed so that it will accept a zero percentage of truck traffic.
- (2) Output has been increased.

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CC       N       0000       III       SSS       EFEEFE         CC       N       N       0       0       I       SS       E         CC       N       N       0       0       I       SS       E         CC       N       N       0       0       I       S       E       E         C       N       N       0       0       I       S       E<	CC       NN       0000       III       SSS       EEEEEE         CC       NN       0       0       I       SSS       EEEEE         CC       NN       0       0       I       SS       EEEEE         C       NN       0       0       I       SS       EEEEE         C       NN       0       0       I       SS       EEEEE         C       NN       0       0       I       SS       EEEEEE         DS       JOB       SIMUREE       FLUR       INFRRUCHS       INFRRUF       INFRRUF	H       H       HI       CCCC       N       0000       III       SSS       EFEFEE         H       H       I       C       N       0       0       I       SS       EFEFEE         C       H       H       I       C       N       N       0       0       I       SS       EFEFEE         C       N       N       0       0       I       S       E       E         C       N       N       0       0       I       SS       E       E       E       E       E       E       E       N	I IV G LEV	/EL 21		MAI	z	Ğ	ATE = $7$	505 <b>8</b>	15/5
INPUT VARIABLES         UOB = JOB NUMBER         U0 = IDENTIFICATION NO.         U0 = JOB NUMBER         U0 = IDENTIFICATION NO.         UC = CARD IENTIFICATION NO.         UC = CARD IENTIFICATION NO.         UN = SIGNUT FLOW RATE (DESIGN HOUR TRAFFIC VOLUME)         N = HOURLY FLOW RATE (DESIGN HOUR TRAFFIC VOLUME)         N = HOURLY FLOW RATE (DESIGN HOUR TRAFFIC VOLUME)         N = SIGNER TRUCK MIX         ST = RUUK SPEED (MPH)         HX = ROADWAY LEVATION (FERI)         HX = ROADWAY LENDIN         HX = ROADWAY LENDIN         HX = ROADWAY LENDIN         HX = ROADWAY LENDIN         HX = RARER NALL         HX = ROADWAY LENDIN         HX = RARER LENDIN	INPUT VARIABLES JOB = JOB NUMBER JOB = DENTIFICATION NUMBER NC = CARD IDENTIFICATION NUMBER NC = NUMBER OF LANG FOUST FERENS N = NUMBER OF LANG FOUST FERENS THIX = PERCENT THOCK MIX = INTERNUFFED THIX = PERCENT THOCK MIX = INTERNUFFED THIX = PERCENT THOCK MIX = INTERNUFFED N = NUMER FEE (DES) NO HOUR TRAFFIC VOLUME) SA = AUTO SPEED (MPH) HE = ROADWAY ELEVANIA SA = AUTO SPEED (MPH) HE = ROADWAY ELEVANIA E = ROADWAY ELEVANIA E = ROADWAY ELEVANIA HIX = PERCENT FOCK FEE O N = DEFRESTED 0 = AIT GADE + = ELEVATED N = DEFRESTED 0 = AIT GADE + = ELEVATED N = DEFRESTED 0 = AIT GADE + = ELEVATED N = DEFRESTED 0 = AIT GADE + = ELEVATED N = DEFRESTED 0 = NUMER FOR NUMER (FEET) N = DEFRESTED 0 = NUMER OF OLD N = NOW NOT DECLORECTION D = NOW NOT DECLORECTION D = NOW NOT NOT DATA D = NOW NOT NOT DATA D = STRUCTURE SHIELD CORRECTION D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = RAMARER NOT UNCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER INCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER INCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER INCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER INCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER INCLUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER RULUDED ANOLE (DEGRESS) WHEN RL = GF 0 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER RULUDED ANOLE (DEGRESS) MEEN RL = GF 2 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, THE = BARRIER RULUDED ANOLE (DEGRESS) MEEN RL = GF 2 D = DESERVER TO CONTERCTION (-4.5 IST ROW HOUSES, D = DESERVER TO SUTTER (-1 SO ROADER (-1 SO ROADER)	INPUT VARIABLES JOB = JOB NUMBER JOB = JOB NUMBER TO = LOB NUMBER OF ROMANY ELEMEN'S ME = NUMBER OF ROMANY ELEMEN'S ME = NUMBER OF ROMANY ELEMEN'S ME = NUMBER OF ROMANY = INTERNIPTED THIX = PERCENT TRUCK MIX = HOURY FLOW ATE (DESIGN HOUR TRAFFIC VOLUME) THIX = PERCENT TRUCK MIX = AUTO SPEED (HPH) E = ROMANY ELEVTION (FET) HE = ROMANY ELEVTION (FET) = DEPRESED, 0 = AI GABE, + = ELEVATED SA = AUTO SPEED (HPH) E = ROMANY ELEVTION (FET) HE = ROMANY ELEVTION (FET) E = ROMANY ELEVTION (FET) = 1 = INFINITE, 2 = SEMI-INFINITE, 3 = FINITE B = BARTIER LENGH TYTE, 2 = FINITE B = BARTIER LENGH THYTE, 2 = FINITE E = BARTIER LENGH THYTE, 2 = FINITE B = ROMANY SELECTION THEN = ROMANY NCLUDER FER AND NORMAL, ROUGH DEL3 = GABEC CORRECTION DEL3 = GABEC CORRECTION DEL3 = ROMANY NCLUDER FEED AND DEL3 = ROMANY NCLUDER FEET) WHEN HE .1, 0 DEL3 = ROMANY NCLUDER AND AND (14.5) IST ROW HOUSES, DEL3 = SABEC FORMERS, -1 = ANT DEL3 = ROMANY NCLUDER FEET) WHEN HE .1, 0 DEL3 = SABEC FORMERS - 10 AX.3 DEL3 = SABEC FORMERS - 10 AX.3 DEC3 = DEC3 = SABEC FORMER - 10 AX.3 DEC3 =	້ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບໍ່ບ		**************************************					** ~ ~ ~ ** ** ~ ~ ~ ~ ~ ** * ~ ~ ~ ~ ~	י א ע ע ע א ע ע ע א ע ע ע ע א ע ע ע ע א ע ע ע ע
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a HORLY FLOWERTE CLOSTEN HOUR TRAFFIC VOLUME         NO SIGN = FREE FLOW = INTERRUPTED         THIS CRECENT TRUCK MIX         ST = RECENT TRUCK MIX         ST = RECENT TRUCK MIX         ST = RECENT TRUCK MIX         ST = RUCK SPEED (MPH)         H = ROADWAY ELEVATION (FET)         - = DEPRESSID. 0 = AT GABE, + = ELEVATED         - = BORENET TO CENTER OF NEAR LANE (FEET)         - = DEPRESSID. 0 = AT GABE, + = ELEVATED         C DN = OBSERVER TO CENTER OF NEAR LANE (FEET)         R = RARIER LENGTH         T = INFINITE, 2 = SEMI-INTIE, 3 = FINITE         B = BARRIER LENGTH         R = BARRIER LENGTH         C DN = OBSERVER TAKE GROUP         DEL3 = GRADE CORRECTION         C DEL3 = GRADAY SUBFACE CORRECTION         C DEL3 = GRADAY SUBFACE CORRECTION         DEL3 = GRADAY SUBFACE CORRECTION         DEL3 = GRADE CORRECTION         C DEL3 = GRADAY SUBFACE CORRECTION         DEL3 = GRADAY SUBFACE CORRECTION         DEL3 = GRADE CORRECTION         DEL3 = GRADE CORRECTION         DEL3 = GRADAY SUBFACE CORRECTION         DEL3 = GRADAY NICLUDED ANGLE DEGREES) WHEN	0       = HOURLY FLOW ATE OCESIGN HOUR TRAFTC VOLUME)         0       0       SIGN = FREE FLOW.       = INTERUPTED         0       10       SIGN = FREE FLOW.       = INTERUPTED         0       57       = RUCK SFEED (MPH)         0       FERVENT TRUCK MIX       = ERVATED         0       FERVENT TRUCK MIX       = ELEVATED         0       = SADDWAY ELEVATION (FEET)       = ELEVATED         0       = SADDWAY ELEVATION (FEET)       = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = AT FILTE.       2         0       = DEPRESSED.0       = AT GRADE. + = ELEVATED         0       = DEPRESSED.0       = INFINITE. 2       = FINITE         0       = DEPRESSED.0       = INFINITE. 2       = FINITE         0       =	G       = HURLY FLOW RATE (DESIGN HOUR TRAFFIC VOLUME)         THIX = PERCENT TRUCM MATE (DESIGN HOUR TRAFFIC VOLUME)         S1 = TRUCK SPEED (MPH)         C DN = DBSERVER TO CENTER OF NEER LANE (FEET)         B1 = INFINITE, 2 = SFMI-INFINITE, 3 = FINITE         B1 = INFINITE, 2 = SFMI-INFINITE, 3 = FINITE         B1 = INFINITE, 2 = SFMINE         C D = NOUMBER OF LANES FER LANE GROUP         D = SABALE CORRECTION         D = SABALE CUUBER SURFERTON (-4-5 15 ROW HOUSES)         D = SABALE CUUBER SURFERTON (-4-5 15 ROW HOUSES)         D = SABALE TO CUT (FEET) WHEN RL = 1 OR 2         D = DBSERVER TO CUT (FEET) WHEN RL = 1 OR 2         D = DBSERVER TO CUT (FEET) WHEN RL = 1 OR 2         D = DBSERVER TO CUT (FEET) WHEN RL = 1 OR 2         D = DBSERVER TO CUT (FEET) WHEN RL = 1 OR 2 <t< td=""><td></td><td>NRE = NUM N - NUMBE</td><td>BER OF</td><td>ROADWAY</td><td>ELEMEN</td><td>TS POADMAY FI</td><td>EMENT</td><td></td><td></td></t<>		NRE = NUM N - NUMBE	BER OF	ROADWAY	ELEMEN	TS POADMAY FI	EMENT		
Mo SIGN = FREE FLOW = INTERRUPTED (C) SA = AUTO SPEED (MPH) (E) SA = SPEAD (MPH) (E) SA = SPEAD (MPH) (E) SA = AUTO SPEED (MPH) (E) SA = ARAIER HEIGHT (FEET) WHEN HE = 1 OR 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA = ABARIER NCLOOR ON OLT (FEET) WHEN BL = 1 OR 2 (D) SA = ABARIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA AUTO ANGLE (D) ANGLE (DEGREES) WHEN RL = 2 & BL = 2 (D) SA AUTO ANGLE (D)	<pre>C IMIS SEGN = FREE FLOW, - = INTERRUPTED C FILL SEGN (MPH) E = ROADMAY ELEVATION (FET) H = ROADMAY ELEVATION (FET) H = ROADMAY ELEVATION (FET) H = ROADMAY LENGTH C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CENTER OF NEAR LANE (FEET) C DN = 005ERVER TO CORRECTION C DL3 = GRADE CORRECTION C DEL3 = GRADE CORRECTION C DEL3 = GRADE CORRECTION C DEL5 = ROADMAY SUFFACE CORRECTION C DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 75) DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 75) DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 2 C DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 2 C DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 2 C DEL5 = FORDIAN UNTHE OF NEAR HE AL 66. 2 C DEL5 = SOBSERVER TO CUT (FEET) WHEN HE 61. 0 C DE = MEDIAN UNTHE OF NEAR HE AL 66. 2 C DE = 005ERVER TO CUT (FEET) WHEN HE 61. 0 C DE = 005ERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DE = 005ERVER TO CUT (FEET) WHEN BL</pre>	<pre>     Monumer Construction (FEET)     Fere FLOW, - = INTERRUPTED     FERE FLOW, FEET (WH)     FERE FLEWTIND (FEET)     FE RONDWAT ELEVATION (FEET)     FE RONDWAT ELEVATION (FEET)     FE RONDWAT ELEVATION (FEET)     FERE FLENGTH     FENEL FLONGTH     FENEL     FENEL FLONGTH     FENEL FLONGTH     FENEL     FENEL FLONGTH     FENEL     FENE</pre>	<b>ט נ</b>	Q = HOURL	Y FLOW	RATE (C	ESIGN H	DUR TRAFF	IC VOLU	Ť	
C SI = TRUCK SPEED (MPH) C SI = AUTO SPEED (MPH) FE ROADWAY ELEVATION (FEF) - = DEPRESSED, 0 = AT GRADE, + = ELEVATED C DN = OBSERVER TO CENTER OF NEAR LANE (FEET) C DN = OBSERVER TO CENTER OF NEAR LANE (FEET) C DL = DADWAY UNITE, 2 = SEMI-INFINITE, 3 = FINITE BL = BARNIER LENGTH 0 = NUMBER OF LANE SPER LANE GROUP C DEL3 = GRADE CORRECTION C DEL3 = GRADA Y SUFFACE CORRECTION C DE = 0055RVER TO SUULDER AFEET) WHEN BL = 1 OR 2 D C DE = 0055RVER TO SUULDER AFEET) WHEN BL = 1 OR 2 D C DE = 0055RVER TO SUULDER AFEET) WHEN BL = 1 OR 2 D C DE = 0055RVER TO SUULDER AFEET) WHEN BL = 1 OR 2 D C DE = 0055RVER TO SUULDER AFEET) WHEN BL = 2 & BL = 2 D C DE = 0055RVER FEIGHT REL. TO REFE VERTICAL FOR THIS VALUE C D D E SUBSERVER TO SUPCLE FOR UNCLE OSS OFFACES) WHEN RL = 2 & BL = 2 D C D E SUBSERVER TO SUPCLE FOR LOW 1 STANCE FOR LID 1 CHANGE OSSERVER'S POSITION) C D E SUBJERVER FEIGHT REL TO REFE FOR PROGRAM, O NEW DATA, C D D E SUBJERVER FEIGHT REL TO REFE FOR WHEN RL = 2 & BL = 2 C D D E SUBJERVER FEIGHT REL TO REFE FOR WHEN RL = 2 & BL = 2 C D D E SUBJERVER FEIGHT REL TO REFE FOR PROGRAM, O NEW DATA, C D E SUBJERVER FEIGHT	C SI = TRUCK SPEED (MPH) C SI = AUTO SPEED (MPH) C BE ADWAY ELEVATION (FEET) - = DEPRESSED: 0 = AT GRADE. + = ELEVATED C DN = OBSERVER TO CENTER OF NEAR LANE (FEET) C DN = OBSERVER TO CENTER OF NEAR LANE (FEET) C BL = BARNIER LENGTH C BL = BARNIER LENGTH C BL = BARNIER LENGTH D = NONE. 1 = INFINIE. 2 = FINITE B = BARNIER LENGTH C BL = BARNIER LENGTH C BL = BARNIER LENGTH D = NONE. 1 = INFINIE. 2 = FINITE B = ARADE CORRECTION C DEL3 = GRADE CORRECTION C DEL3 = GRADA Y SUFACE OR CORPUSE OFFENS MED = MEDIAN WIDTH FOR DIVIDED ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER INCLUDED ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER INCLUDED ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = BARRIER ROLONOMAL ANGLE (DEGREES) WHEN RL = 2 C DE = C D OF DATA NOUTH ROLONO OF COMUTE OBSERVERYS POSITION C D C D C DEGRER	C SI = TRUCK SPEED (MPH) C SI = AUTO SPEED (MPH) C HE = ROADWAY ELEVATED OF NEAR LANE (FEET) C HE = ROADWAY ELEVATHON (FEET) C HE = ROADWAY ELEVATHON (FEET) C HE = ROADWAY ELEVATHON (FEET) C HL = ROADWAY ELEVATHONE C RL = BARRIER LENGTH TYPE C RL = BARRIER LENGTH C RL = STOUTHE SIRTEC CORRECTION C DEL3 = GRADE CORRECTION C DEL3 = GRADA C DE 2 DE C DEGREES WHEN RL = Z & BL C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = Z & BL C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = 1 OR Z C DE 2 DESERVER REIGHT (FEET) WHEN RL = 2 & BL C DE 2 DESERVER REIGHT	υu	NO SI TMIX = PE	GN = F RCENT	REE FLOW TRUCK MI		NTERRUPTE	۵		
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GT. 1 THETA = RODAWY INCLUDED ANGLE (DEGRES) WHEN RL GE. 2 THETA = RODAWAY INCLUDED ANGLE (DEGRES) WHEN RL GE. 2 C D = DBSERVER TO CUT (FEET) WHEN RL = 1 OR 2 C D = DBSERVER TO SHOULDED ANGLE (DEGRES) WHEN RL GE. 2 D C D = DBSERVER TO SHOULDED ANGLE (DEGRES) WHEN RL = 2 & B C D C = DBSERVER TO SHOULDED ANGLE (DEGRES) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 1 OR 2 D C D A = BARRIER REJOHNEN BL = 1 OR 2 D C D B = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER TO BARRIER (FEET) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER RED-NORMAL ANGLE (DEGREES) WHEN RL = 2 & B C D C = DBSERVER R	C DN = DERREASED: 0 = AI GANDE: * = ELEVAIED C RL = ROADWAY LENGTH TYPE 1 = INFINITE. 2 = SEMI-INFINITE. 3 = FINITE B = BARRIER LENGTH C 0 = NONE. J = INFINITE. 2 = FINITE C 0 = NONE. J = INFINITE. 2 = FINITE C 0 = NOMER OF LANES PER LANE GROUP C 0 = NOMER OF LANES PER LANE GROUP C 0 = L3 = GRADMAY SURFACE CORRECTION C DEL3 = GRADMAY INCLUDED ANGLE (DEGREES) WHEN RL GGE. 2 ALPHA = BARRIER HEJGHT (FEET) WHEN HE1 OR C D C = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B = DBSERVER TO CUT (FEET) WHEN BL = 2 OR 2 C D B	C DN = DBSRYER TO CENTER OF NEAR LANE (FEET) RL = ROADWAY LENGTH TYPE C RL = ROADWAY LENGTH TYPE B = BARRIER LENGTH B = BARRIER LENGTH C 0 = NONE, 1 = INFINITE, 2 = FINITE C 0 = NONE, 1 = INFINITE, 2 = FINITE C 0 = NONE, 1 = INFINITE, 2 = FINITE C 0 = NONE, 1 = INFINITE, 2 = FINITE C 0 = NONE, 1 = INFINITE, 2 = FINITE C 0 = LAMBER OF LANES PER LANE GROUP C 0 EL3 = GRABE CORRECTION C 0 EL3 = GRABE CORRECTION C 0 EL5 = ROADWAY SURFACE CORRECTION C 0 EL7 = STRUCTURE SHIELD CORRECTION C 0 EL7 = STRUCTURE SHIELD CORRECTION C 0 EL7 = STRUCTURE REIGHT NON- MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL 6GE, 2 THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL 6GE, 0 C 0 E BARRIER HEIGHT (FEET) WHEN HE .LT 0 C 0 E 0BSERVER TO CUT (FEET) WHEN RL .1 0 C 0 C = 0BSERVER TO CUT (FEET) WHEN BL .1 0 C 0 C = 0BSERVER TO CUT (FEET) WHEN BL .1 0 C 0 C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 B = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 B = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 B = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 B = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C 0 D C = 0BSERVER TO CUT (FEET) WHEN BL .2 0 C	0	HE = ROAD	WAY EL	EVATION	(FEET)	ĩ			
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BL = BARRIER LENGT 0 = NONE, 1 = INFINITE, 2 = FINITE P = NUMBER OF LANE SPER LANE GROUF DEL3 = GRADE CORRECTION 0.1.2.1.3.4.DB FOR .LE. 2, 3-4. 5-6. GE. 7%) DEL5 = ROADWAY SURFACE CORRECTION DEL5 = ROADWAY SURFACE CORRECTION DEL7 = STRUCTURE SHEELD CORRECTION (-4.5 1ST ROW HOUSES. -1.5 014FGS, -10 MAX.) MOMML, ROUGH DEL7 = STRUCTURE SHEELD CORRECTION (-4.5 1ST ROW HOUSES. -1.5 014FGS, -10 MAX.) MOHMAL, ROUGH DEL7 = STRUCTURE SHEELD CORRECTION (-4.5 1ST ROW HOUSES. -1.5 014FGS, -10 MAX.) MIGHWAYS (FEET) WHEN RL .GE. 2 MED = MEDIA WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .GE. 2 DE = 0055RVER TO SHOLDER (FEET) WHEN RL .GE. 2 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0	BL = BARRIER LENGT 0 = NONE, 1 = INFINITE, 2 = FINITE C D = NONE, 1 = INFINITE, 2 = FINITE C D = NUMBER OF LANGS PER LANG GROUP C D = STAUCTURE STREELON D = STRUCTURE STREELON C D = STRUCTURE STREELON C D = STRUCTURE STREELO CORRECTION C D = STRUCTURE STREELO CORRECTION C D = STRUCTURE STREELO CORRECTION C D = MEDIA WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. GT. 1 -1.5 OTHERS, -10 MAX.) MED = MEDIAM WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .6E. 2 D = MEDIAM WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .6E. 2 C D = MEDIAM WIDTH FOR DIVIDED ANGLE (DEGREES) WHEN RL .6E. 2 D = 085ERVER TO CUT (FEET) WHEN HE .1.0 C D C = 085ERVER TO CUT (FEET) WHEN BL = 1 OR 2 D = 085ERVER TO CUT (FEET) WHEN BL = 1 OR 2 C D = 085ERVER TO CUT (FEET) WHEN BL = 1 OR 2 D = 085ERVER HEIGHT (FEET) WHEN BL = 1 OR 2 D = 085ERVER HEIGHT REL. TO REF. PLANE (FEET): + ABOVE BELOW C D = 085ERVER HEIGHT REL. TO REF. PLANE (FEET): 4BOVE BELOW C D = 085ERVER HEIGHT REL. TO REF. PLANE (FEET): 4BOVE BELOW C C D = 005 TO COMPUTE OBS. 015T.FOR THIS VALUE C C D = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. C C D = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA.	BL = BARRIER LENGTH 0 = NONE, 1 = INFINITE, 2 = FINITE C DELS = RADE CORRECTION C DELS = RADE CORRECTION DEL7 = STRUCTURE SHELD CORRECTION C DEL7 = STRUCTURE SHELD CORRECTION DEL7 = STRUCTURE SHELD CORRECTION MED = MEDIAW WITTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .6G. 2 HETA = RDADWAY INCLUDED ANGLE (DEGREES) WHEN RL .6G. 2 D C D C = 0BSERVER TO SHOLLDER (FEET) WHEN HE .6T. 0 D C = 0BSERVER TO SHOLLDER (FEET) WHEN BL = 1 OR 2 D C D C = 0BSERVER TO CULT (FEET) WHEN BL = 1 OR 2 D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C = 0BSERVER TO CULDED ANGLE (DEGREES) WHEN BL = 2 O D C D C D C D C D C D C D C D C D C D C	<b></b> .	RL = ROAD	WAY LE	NGTH TYF TF. 2 =	E SFMT-IN	FINITE. 3	.INIJ =	E.	
<pre>0 = NUMBER PFLANE FINITE, 2 = FINITE 0 = NUMBER PFLANE GROUP DEL3 = GRADE CORRECTION DEL5 = ROADWAY SURFACE CORRECTION DEL5 = ROADWAY SURFACE CORRECTION DEL5 = ROADWAY SURFACE CORRECTION DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 01+55 -10 MAX.) DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 07HERS, -10 MAX.) DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 07HERS, -10 MAX.) DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 07HERS, -10 MAX.) DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 07HERS, -10 MAX.) DEL7 = STRUCTURE SHELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 07HERS, -10 MAX.) DEC 05 = 005ERVER TO SHOUDER (FEET) WHEN HE .6T. 0 DS = 005ERVER TO SHOUDER (FEET) WHEN HE .1 OR 2 DB = 005ERVER TO BARRER (FEET) WHEN HE .1 OR 2 DB = 005ERVER TO BARRER (FEET) WHEN BL = 1 OR 2 DB = 005ERVER TO BARRER (FEET) WHEN BL = 1 OR 2 DB = 005ERVER TO BARRER (FEET) WHEN BL = 1 OR 2 DB = 005ERVER TO BARRER (FEET) WHEN BL = 2 &amp; BL = 2 DB = 005ERVER HEIGHT REL. TO REF. PLANE (FEET); FOR THIS VALUE CL10 = L10 VALUE (DD), USCO TO COMPUTE OBS. DIST. FOR THIS VALUE CL10 = L10 VALUE (OB), USCO TO COMPUTE OBS. DIST. FOR THIS VALUE CL10 = L10 VALUE (OB), USCO TO COMPUTE OBS. DIST. FOR THIS VALUE CL10 = L10 VALUE (FOR L10, 1 CHANGE OBSERVER'S POSITION) Z FIND DISTANCE FOR L10, 1 CHANGE OBSERVER'S POSITION)</pre>	C 0 = NONE. 1 = INFINITE. 2 = FINITE C 0 = NUMBER OF LANE GROUP C DEL3 = GRADE CORRECTION DEL5 = POADWAY SURFACE CORRECTION C DEL5 = ROADWAY SURFACE CORRECTION C DEL7 = STRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES. -1.5 OTHERS10 MAX.) MED = MEDIAW WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 6GT. 1 -1.5 OTHERS10 MAX.) MED = MEDIAW WIDTH FOR DIVIDED ANGLE (DEGREES) WHEN RL .6GE. 2 DS = OBSERVER TO SHOULDER (FEET) WHEN HE .6T. 0 C DC = OBSERVER TO SHOULDER (FEET) WHEN HE .6T. 0 C DC = OBSERVER TO SHOULDER (FEET) WHEN BL = 1 OR 2 ALPHA = BARRIER INCLUDED ANGLE (DEGREES) WHEN BL .6G. 2 ALPHA = BARRIER INCLUDED ANGLE (DEGREES) WHEN BL .6G. 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DC = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 2 C DB =	C 0 = NUMBER OF LANES PER LANE GROUP C DEL3 = GRADE CORRECTION DEL5 = RADAWAY SURFACE CORRECTION C DEL5 = RADAWAY SURFACE CORRECTION C DEL7 = STRUCTURE SHIELO CORRECTION (-4.5 157 ROW HOUSES, -5.0 0.5 DB FOR SMOOTH NORMAL, ROUGH C DEL7 = STRUCTURE SHIELO CORRECTION (-4.5 157 ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIAW WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. GT. 1 C THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .6E. 2 D5 = OBSERVER TO CUT (FEET) WHEN HE .4T. 0 C DC = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 D C = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 D C = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 D C DB = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DB = DBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 D B = OBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 C DB = DBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 D B = DBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 D C DC = DBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 C DB = DBSERVER TO CUDED ANGLE (DEGREES) WHEN BL = 2 OR 2 D C DC = DBSERVER HEIGHT REL. TO REF. PLANE (FEET): +ABOVE BELOW C C D C = DBSERVER HEIGHT REL. TO REF. PLANE (FEET): 4BOVE BELOW C C D C = DBSERVER FORD-NOMMAL ANGLE (DEGREES) WHEN BL = 2 OR 2 D C D C D C DATA INDICATOR (-1 STOP PROGRAM. 0 NEW DATA. C C D C D C DATA INDICATOR (-1 STOP PROGRAM. 0 NEW DATA.	υ υ	BL = BARR	IER LE	NGTH				ļ	
DEL3 = GRADE CORRECTION 0+52+3+3+0 B FOR .LE 2; 3-4+ 5-6+ .GE. 7%) DEL5 = ROADWAY SUFACE CORRECTION -5, 0+ +5 DB FOR SMOOTH, NORMAL, ROUGH DEL7 = STRUCTURE SHIELD CORRECTION (-4+5 1ST ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIA WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N .GT. 1 THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .GE. 2 DS = OBSERVER TO SHOULDER ANGLE (DEGREES) WHEN RL .GE. 2 DS = OBSERVER TO SHOULDER ANGLE (DEGREES) WHEN RL .GE. 2 DS = OBSERVER TO SHOULDER ANGLE (DEGREES) WHEN RL .GE. 2 DS = OBSERVER TO BARRIER (FEET) WHEN RL .GT. 0 H = BARRIER HEIGHT (FEET) WHEN RL = 1 OR 2 DD = OBSERVER TO BARRIER ANGLE (DEGREES) WHEN RL .EQ. 2 ALPHA = BARRIER INCLUDED ANGLE (DEGREES) WHEN RL .EQ. 2 ALPHA = BARRIER INCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 ALPHA = BARRIER INCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 CLID = LIQ VALUE (OB). USCO TO COMPUTE OBS. DIST. FOR THIS VALUE CON = END OF DATA INICIATOR (-1 STOP PROGRAM, O NEW DATA, 2 FIND DISTANCE FOR LLD., I CHANGE OBSERVER'S POSITION)	<pre>C DEL3 = GRADE CORRECTION D+25+33+3+0 BF FOR .LE 2; 3-44, 5-64. GE. 7%) DELS = ROADWAY SUFAGE CORRECTION = 5, 0, +5 DB FOR SHOOTH. NORMAL, ROUGH DELS = ROADWAY SUFAGE CORRECTION (-4.5 1ST ROW HOUSES, = 1.5 OTHERS, -10 MAX.) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. GT. 1 THET = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .GE. 2 DE = 095ERVER TO SHOULDER (FEET) WHEN HE .GT. 0 DC = 095ERVER TO SHOULDER ANGLE (DEGREES) WHEN RL .GE. 2 DB = 095ERVER TO SHOULDER NEET) WHEN BL = 1 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 1 OR 2 DE = 095ERVER TO BARDIER ANGLE (DEGREES) WHEN BL .EO. 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 1 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 1 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER TO BARDIER (FEET) WHEN BL = 2 OR 2 DE = 095ERVER REL TO PROF. TO REF. PLANE (FEET); FOR THIS VALUE CLID = 10 VALUE (DB). USED TO COMPUTE 095. DIST; FOR THIS VALUE CLID = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, 2 FIND DISTANCE FOR LIO, 1 CHANGE 085ERVER'S POSITION)</pre>	DEL3 = GRADE CORRECTION 0 +52 +33+3 +0 BF FOR .LE 2; 3 -4, 5 -6, .GE. 7%) DEL5 = ROADWAY SUFACE CORRECTION C DEL5 = ROADWAY SUFACE CORRECTION C DEL7 = SRUCTURE SHIELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIA WIDTH FOR UNIVIED HIGHWAYS (FEET) WHEN N .GT. 1 THET = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .GE. 2 THET = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .GE. 2 C DS = OBSERVER TO SHOULDER (FEET) WHEN HE .GT. 0 C DC = OBSERVER TO SHOULDER NGLE (DEGREES) WHEN BL .GT. 0 C DC = OBSERVER TO BARRIER (FEET) WHEN BL .GT. 0 C DC = OBSERVER TO BARRIER (FEET) WHEN BL .GT. 0 C DA = BARRIER NCLUDED ANGLE (DEGREES) WHEN BL .EQ. 2 DB = OBSERVER HEIGHT REL1 ON RL .EL OR 2 C DB = OBSERVER HEIGHT REL1 OR RL .GT. 0 C DO C DO C DO C DO C DO COMPULE OBSERVER'S POSITION) C CLI 0 = LIO VALUE (DB). USE OT C COMPUTE OBSERVER'S POSITION) C CLI 0 = END OF DISTANCE FOR LIO, I CHANGE OBSERVER'S POSITION)	00	0 = P = NUMBE	NONE.	1 = INFI ANES PER	NITE. 2	= FINITE ROUP			
0.1011 0.1011	C DELS = ROADWAY SURFACE CORRECTION DELS = ROADWAY SURFACE CORRECTION C DELT = STRUCTURE SHIELD CORRECTION (-4.5 1ST ROW HOUSES, -1.5 OTHERS, -10 MAX,) MED = WEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 6GT. 1 THETA = REDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 6GT. 1 THETA = ROADWAY TOCLUDED ANGLE (DEGREES) WHEN RL .6GE. 2 DS = OBSERVER TO SHOULDER (FEET) WHEN HE .6T. 0 DC = DBSERVER TO CUT (FEET) WHEN HE .6T. 0 DC = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DB = DBRETER INCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DB = DBRETER INCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) WHEN BL = 1 OR 2 C DD = DBSERVER TO CUT (FEET) TO REC	C DELS = ROADWAY SURFACE CORRECTION DELS = ROADWAY SURFACE CORRECTION C DELS = ROADWAY SURFACE CORRECTION C DELT = STRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES, DELT = STRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES, THETA = ROADWAY INCLUDED INVIGE HIGHWAYS (FEET) WHEN RL .66. 2 THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .66. 2 THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .66. 2 DE = DBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 C D = DBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 C D = DBSERVER TO BARRIER (FEET) WHEN BL .60. 2 D = DBSERVER TO BARRIER (FEET) WHEN BL . 1 OR 2 D = DBSERVER TO BARRIER (FEET) WHEN BL . 1 OR 2 D = DBSERVER TO BARRIER (FEET) WHEN BL . 20. 2 D = DBSERVER HEIGHT REL. TO REF. PLANE (FEET): - ABOVE BELOW C LI 0 = LI 0 VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE C C LI 0 = LI 0 VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE C C LI 0 = LI 0 VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE C C LI 0 = LI 0 VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE C C C 0 = C D OF DISTANCE FOR LIO. 1 CHANGE OBSERVER'S POSITION)	<b>ں</b> ,	DEL3 = GR	ADE CO	RECTION	_				
<pre>-5, 0; +5 DB FOR SMOOTH, NORMAL, ROUGH -5, 0; +5 DB FOR SMOOTH, NORMAL, ROUGH AED = SRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 61. 1 THETA = ROADWAY INCLUDED ANGLE (DEGREES) WHEN RL .66. 2 DB = OBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 DC = 085ERVER TO SHOULDER (FEET) WHEN HE .1.0 DC = 085ERVER TO SHOULDER (FEET) WHEN BL = 1 OR 2 DB = 085ERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DB = 085ERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DB = 085ERVER TO BARRIER (FEET) WHEN BL = 2 OR 2 DB = 085ERVER TO LANGLE (DEGREES) WHEN BL = 2 &amp; BL = 2 DB = 085ERVER HEIGHT REL. TO REL. PLANE (FEET); 4080VE BELOW CLID = LIO VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE CLID = LIO VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE CLID = LIO VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE CLID = LIO VALUE (DB). USED TO COMPUTE OBS. DIST. FOR THIS VALUE CLID = LIO VALUE FOR LIO. 1 CHANGE OBSERVER'S POSITION)</pre>	<pre>-5, 0, +5 DB FOR SMOOTH, NORMAL, ROUGH -5, 0, +5 DB FOR SMOOTH, NORMAL, ROUGH AED = STRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIAN WITH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .66. 2 THETA = RODAWAY INCLUDED ANGLE (DEGREES) WHEN RL .66. 2 DS = OBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 C = 0085RVER TO SHOULDER (FEET) WHEN HE .61. 0 DC = 0085RVER TO SHOULDER (FEET) WHEN BL .60. 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 1 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 1 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 1 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 1 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO BARAIER (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO CUT (FEET) WHEN BL = 2 OR 2 DB = 0085RVER TO COMPLE OBS.015T, FOR THIS VALUE CLID = LID VALUE (DB). USED TO COMPUTE OBS.015T, FOR THIS VALUE CCON = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. 2 FIND DISTANCE FOR LID.1 (CHANGE OBSERVER'S POSITION)</pre>	<pre>-5, 0; +5 DB FOR SMOOTH, NORMAL, ROUGH -5, 0; +5 DB FOR SMOOTH, NORMAL, ROUGH AED = SRUCTURE SHIELD CORRECTION (-4.5 IST ROW HOUSES, -1.5 OTHERS, -10 MAX.) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN RL .66. 2 THETA = RODWAY INCLUDED ANGLE (DEGREES) WHEN RL .66. 2 DB = OBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 C DC = OBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 DC = OBSERVER TO SHOULDER (FEET) WHEN HE .61. 0 C DB = OBSERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DB = OBSERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DB = OBSERVER HEIGHT (FEET) WHEN BL = 1 OR 2 DB = OBSERVER HEIGHT REL. OR COMPULE OBSERVER HEIGHT C C LIO = 005120 ANGLE (DEGREES) WHEN RL = 2 &amp; BL = 2 C C DB = OBSERVER HEIGHT REL. TO REF. PLANE (FEET); FOR THIS VALUE C CLIO = LIO VALUE (DB) OSC TO COMPUTE OBSERVER'S POSITION) C C DB = OBSERVER HEIGHT REL. TO REF. PLANE (FEET); FOR THIS VALUE C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C CLIO = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, C C CLIO =</pre>	00	0. DEIS = RO	+2,+3, Adway	++ DB FC SURFACE	CORRECT	2, 3-4, 5 ION	-6, .6E.	. 7%)	
UELY = SINCLURE SILEU CUMARCIJON (***3 ISI NUM MODSES) -1.5 OTHERS, -10 MAX.) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 6GT. 1 THETA = RODWAY INCLUBED ANGLE (DEGREES) WHEN RL .6GE. 2 DS = OBSERVER TO SHOULDER (FEET) WHEN HE .1T. 0 C = 0BSERVER TO SHOULDER (FEET) WHEN HE .1T. 0 C = 0BSERVER TO SHOULDER (FEET) WHEN BL = 1 OR 2 DS = OBSERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 DS = 0BSERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 C = 0B = OBSERVER TO BARRIER (FEET) WHEN BL = 2 OR 2 BETA = BARRIER NCLUDED ANGLE (DEGREES) WHEN BL .EG. 2 BETA = BARRIER NCLUDED ANGLE (DEGREES) WHEN RL = 2 & BL = 2 C = 0B = 0BSERVER HEIGHT REL. TO REF. PLANE (FEET); FOR THIS VALUE C = 10 VALUE (DB). USED TO COMPUTE OBS. DIST, FOR THIS VALUE ICON = END OF DATA INDICATOR ( -1 STOP PROGRAM, 0 NEW DATA, Z FIND DISTANCE FOR LIO, 1 CHANGE OBSERVER'S POSITION)	C C DEL/ = SINCLURE SILEU CUMARCIJUN (1443) ISI NUM MODSES -1.5 OTHERS, -10 WAX,) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 6GT. 1 THETA = RODMAY INCLUBED ANGLE (DEGREES) WHEN RL .6GE. 2 THETA = RODMAY INCLUBER AFEET) WHEN HE .6T. 0 C DS = 085ERVER TO CUT (FEET) WHEN HE .4T. 0 C D = 085ERVER TO CUT (FEET) WHEN BL .1 OR 2 DB = 085ERVER TO BARRIER (FEET) WHEN BL . 1 OR 2 C DA = BARRIER MEJOHT (FEET) WHEN BL .1 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 2 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 2 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 2 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO BARRIER (FEET) WHEN BL . 3 OR 2 C DA = 085ERVER TO COMPULE OBS.0 HIEN RL . 5 OR 3 DA 2 C DA = 085ERVER HIGHT REL. TO REF. TANK (FEET) . 480VE, - BELOW C CLIO = LIO VALUE (DB). USED TO COMPUTE OBS.0 IST FOR THIS VALUE C CON = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. C T CON = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. C T CON = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. C T CON = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA.	ULL (1 = 5) OTHERS, -10 WAX.) MED = MEDIAN WIDTH FOR DIVIDED HIGHWAYS (FEET) WHEN N. 61. 1 THETA = RODWAY INCLUBED ANGLE (DEGREES) WHEN RL .66. 2 THETA = RODWAY INCLUBED ANGLE (DEGREES) WHEN RL .66. 2 C THETA = RODWAY INCLUBER (FEET) WHEN HE .17. 0 C DS = 085ERVER TO SHOULDER (FEET) WHEN HE .17. 0 H = BARRIER HEIGHT (FEET) WHEN BL = 1 OR 2 C DB = 085ERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 C DB = 085ERVER TO BARRIER (FEET) WHEN BL = 1 OR 2 C DB = 085ERVER TO BARRIER (FEET) WHEN BL = 2 OR 2 C DB = 085ERVER TO BARRIER (FEET) WHEN BL = 2 OR 2 C DB = 085ERVER HEIGHT (FEET) WHEN BL = 1 OR 2 C DB = 085ERVER HEIGHT (1 DECOMPLE OBS.) WHEN RL = 2 & BL = 2 C DB = 085ERVER HEIGHT REL. 70 REF. PLANE (FEET): 400VE BELOW C CLID = 110 VALUE (DB). USED TO COMPUTE OBS.) WHEN RL = 2 & BL = 2 C CLID = 110 VALUE (DB). USED TO COMPUTE OBS.) DIST. FOR THIS VALUE C CLID = END OF DATA INDICATOR ( -1 STOP PROGRAM. 0 NEW DATA. 2 FIND DISTANCE FOR LID. 1 CHANGE OBSERVER'S POSITION)			+ •0 •	5 DB F0F	SMOOTH	NORMAL .	ROUGH	Johon He	ı
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Figure A-3. MICNOISE 5 listing.

Figure A-3 (cont.)

FORTRAN IV G	LEVEL	21 MAIN DATE = 75058 15/	5/55/47
	<b>ٿ</b> ٿ	PROGRAM VERSION NO. 5, 9/1/73.	ບ *
		ADDITIONAL REVISIONS HAVE BEEN MADED TO THIS PROGRAM BY RONALD HEISLER OF THE VIRGINIA DEPARTMENT OF HIGHWAYS TO OBTAIN RESULTS WITHOUT THE USE OF TELECOMMUNICATIONS	00000 * * * * * *
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00010002		COMMON /BLK1/H3,H4,H5,D3,D4,DE Common /blk3/bl.and.tect.	
0003		DIMENSION DIANTATIAN DIANTA	
0004		21.4	
0005	-	7EAL VAL(12)/13.1,12.8,12.,10.87,8.19,5.63,4.,3.,2.13,1.5,1.26	<b>.</b>
0006	• •		
2000	-	+0000100000800000./	
0008		×EAL AI(3//30.0100.0300.01000.03000./ XEAL A2(10)/.1.22.32.45.E5.€5.72.8.53.4	
6000		REAL A5(7)/-60*+-20*+20*+40*+60*+70*+80*+9+1*/	
0010	_ •	TEAL A6(7)/0.,10.,20.,40.,60.,100.,160./	
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0013	-	THE ALE VE(7)/780.09-10-09100400300/ VEAL V5(7)/782.034.06E.42 -7.02 0 FF 10 //	
0014		EAL V6(7)/-16.25,-12.349.686.564.682.342.66/	
0015	_	EAL VII(5)/8.,0.,-7.,-15.,-22./	
0016		EAL V12(5)/6.5,5,-7.,-15,,-22./	
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0020		EAL V18(5)/9-6.4-1-59-1/0,4-150,4-220./ EAL V18(5)/2-6.4-27 E1522 /	
0021		EAL V25(10)/03*=10*=2=32*=2/	
0022		EAL V210(10)/0.,2*-1.,-2.,2*-3,-4.,-6.,-7.,-10./	
0023	ш. I	EAL V215(10)/0.,-1.,2*-2.,-3.,-4.,-5.,-7.,-10.,-15./	
0025	<u> </u>	EAL*8 AUTOS/8H AUTOS / TRUCKS/8H TRUCKS /	
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9600	- ) ( - ) - )	# ] [12 - 6	
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	1.	COMPUTER JOB NO. 1,431 JUNE MICHIVAN NUISE PREUICION PRUGRAM.	, 30X

PAGE 0002

15/55/47 70 CONTINUE WRITE(20+50) INRE-NRE-N 450 FORMAT(--+44x)\*ROAD ELEMENT NO..+IZ//\*0TOTAL ROAD ELEMENTS ='+ 112.1469.1N0. Of LANE GROUPS ='+12) READ(1.555) JOB+ID+NC+Q(J)+TMIX(J)+ST(J)+SA(J)+HE+DN+RL+BL+P+DEL3+ 555 FORMAT(ZA3+11+F8+0+13F5+0) 15 (nc .ne. 2) G0 T0 800 READ(1,555) JOB+1D+NC+MED+THETA+H0+DS+DC+H+DB+ALPHA+BETA 15 (nc .ne. 3) G0 T0 800 DATE = 75058PRINT INPUT VARIABLES MAIN 10EL5+0EL7 FORTRAN IV G LEVEL 21 Figure A-3 (cont.) ပပ

0048 0049 0050

0051

0052 0053 0054 0055

0056

write(2,560) g(J),THIX(J):51(J).53(J).HE,DN.RL.BL.P.DEL3.DEL5.DEL7 write(2,560) g(J).THIX(J):51(J).53(J).HE,DN.RL.BL.P.DEL3.DEL5.DEL7 560 FORMAT(:00DE1GN HR. V(J).53(J).HE,DN.AL.BL.P.DEL3.DEL5.DET 1:F4.0.TB9:TRUCK SPEED =:F4.0. HPH'.OCAR SPEED =:F5.0. HPH'. 2:746.FR0D ELV. =:F5.0. FEET ::F199.0BS.TO ROAD =:F5.0.F5.0. FEET' 2:00AD ELV. =:F5.0. FEET ::F130.0FABRATER LENGTH =:F5.0.F99.F00 4 LANES PER LANG GROUP =:F3.0.1068ABE CORRECTION =:F3.0.FB9.T46 5:FR0AD SURFACE CORRECTION =:F4.0.\* DB'.T899.0570 UCTURE SHIELD CORR 4 LANES PER LAND.DB'.DB'.F4.0.\* DB'.T899.0570 UCTURE SHIELD CORR 5:FR0AD SURFACE CORRECTION =:F4.0.\* DB'.T869.\*00AD INCLUDED ANGLE =' 4 LANES FER LAND.DB'.DET =:F4.0.\* DB'.T899.\*0570 UCTURE SHIELD CORR 5:F10.\* DEGREES.T899.0BS.HT =:F4.0.\* FEET'.T460.\*80AD INCLUDED ANGLE =' 1F4.0.\* DEGREES.T899.0BS.HT =:F4.0.\* FEET'.T899.\*BARATER HT. = 2:F5.0.\* FEET'.F009S.TO GARTER ='F5.0.\* FEET'.T460.\*BARATER HT. = 2:F4.0.\* DEGREES.T899.0BS.TO BARRIER END-NORMAL ANGLE =', 4UDED ANGLE =:F4.0.\* DEGREES'.T899.\*BARRIER END-NORMAL ANGLE =', 4UDED ANGLE =:F4.0.\* DEGREES'.T899.\*BARRIER END-NORMAL ANGLE =', 5F4.0.\* DEGREES.T700 DEGREES'.T899.\*BARRIER END-NORMAL ANGLE =', 4UDED ANGLE =',F4.0.\* DEGREES'.T899.\*BARRIER END-NORMAL ANGLE =', 5F4.0.\* DEGREES.T700 DEGREES'.T809.\*BARRIER END-NORMAL ANGLE =', 7F4.0.\* DEGREES.T700 DEGREES'.T700 590 FORMAT ("OSUMMARIES FOR", A8, IN LANE GROUP NO.", I3/"OCORRECTIONS, D IEL TO DEL6:", 6F6.2,": L50=", F6.2," L10=", F6.2//) IF(J .60. 1) DN1 = DN 0060 0058

200 FORMAT(\* \*\* DEPRESSED ROAD - OBS. TO CUT VALUE INCORRECT\*) G0 T0 900 IF(DS .6T. 0.) G0 T0 103

101

WRITE(2,205) 205 FORMAT(\* \*\* ELEV. ROAD - OBS. TO SHOULDER VALUE INCORRECT\*)

60 TO 900 102 IF(DS .Eq. 0. .AND. DC .EQ. 0.) 60 TO 103

WRITE(2,210) 210 FORMAT(\* \*\* AT GRADE - OBS. TO SHOULDER OR CUT FIELD IS CODED\*)

G0 T0 900 103 IF (RL

IF(RL .6E. 2.) 60 T0 104 IF(THETA .EQ. 0.) 60 T0 105

0075

WRITE (2+215)

215 FORMAT(\* \*\* INFINITE ROAD TYPE HAS ROAD INCLUDED ANGLE\*) G0 T0 900

104 IF(THETA .NE. 0.) GO TO 105

008000081

0078 0079 0077

0082 0084 0085 0085

220 FORMAT(\* \*\* SEMI-INF. OR FINITE ROAD TYPE WITH ZERO ROAD ANGLE\*) 1.)106,108,107 WRITE (2,220) T0 900 g

IF(H .EQ. 0. .AND. DB .EQ. 0.) GO TO 109 WRITE(2,225) IF (8L -IF (H .EQ 105 106

PAGE 0003

FORTRAN IV G L	-EVEL	21	NIM	DATE = 75058	15/55/47	PAGE DODA
0087	225	FORMAT(* ** BARRIER	HT. AND/OR OBS. T	O BARRIER FIELD ARE	CODED WIT	
0088	-	60 TO 900	EKT			
0089	107	IF(ALPHA .NE. 0.) G	0 TO 108			
1600	230	FORMAT(* ** FINITE	BARRIER LENG. WITH	INCLUDED ANGLE ZEDC		
2600		G0 T0 900				
0094 0094	108	IF(H .6T. 0AND. WRITE(2.235)	DB .6T. 0.) 60 TO	109		
0095	235	FORMAT(* ** BARRIER	LENG. IS FINITE OF	R INFINITE AND BARRI	ER HT. OR	
9600	-	60 TO 900	EUVAL/LESS IMAN ZI	EK0•)		
0097 0098	109	IF (N .6T. 1) 60 TO	111			
6600		MRITE (2,245)	112			
0100	245	FORMAT(+ ** MEDIAN	WIDTH FOR ONE LANE	GROUP • )		
0102	111	GO TO 900 IF(MED _6F_ 0_) GO '	CU 112			
6010		WRITE (2,250)	311 0			
0104	220	FORMAT(* ** MEDIAN   GO TO DOO	WIDTH IS NEGATIVE			
0106	112	IF (DEL3 .GE. 0AN	)• DEL3 •LE• 4•) 60	T0 113		
0107		WRITE(2,255)				
0109	ĉ	FUKMAI(* ** GRADE C( 60 T0 900	DRRECTION NOT IN 0	- +4 RANGE +)		
0110	113	IF (DEL5 .GE5A)	40. DELS .LE. 5.) G	0 T0 114		
0112	260	WKIIE(2+260) FORMAT(+ ** ROAD SUF	RACE CORP. NOT -5.	0.08 4511		
0113		GO TO 900				
0114	11	IF(DEL7 .LE. 0ANC WRITF(2.265)	). DEL7 .GE10.)	G0 T0 98		
0116	265 1	FORMAT (* ** STRUCTUR	E CORRECTION NOT -	10 TO 0 DB•)		
	-	006 01 09				
	5	CALCULATE VEHICLE VO	LUMES			
0118	86	V = ABS(Q(J)) / N				
0120		() () = AMAX1 (V-VT ())	**01,1)  .)			
U (						
0121	82 1	JELZ - ELEMENT C (F(R) - 2.) 42.40.41	ORRECTION			
0122	40	(F (ICON . EQ. 0 . AND.	J .6T. 1 .0R. ICO	N .EQ. 1)		
0123	Ϋ́	CALL ANGLE (C2,C1,THE	TA, DNI, DNX)			
0124	9.0	0 TO 42	ITE ( A+ / + 1 )			
0125	4	F.(ICON .EQ. 0 .AND.	J .6T. 1 .0R. ICON	.EQ. 1)		
0126		EL2 = FIGB10(V6,A6,	IA+DN1+DNX) THETA+7+1)			
C.		E - EQUIVALENT	LAND DISTANCE CALCI	JLATION		
0128	20	E = SQRT (DN*DF)				
0120 C	<u>ہ</u>	ELI - DISTANCE CON	RECTION			
0130	190 D	ELI = FIGBIO(VII,AI)	92 •DN•5•0)			
0131	9	0 TO 61	:			
6133	5 U 1	ELI = FI6810(V12•A1; 0 T0 61	DN+5+0)			
0134	192 II	F(P - 4.) 193,194,19	55			

2047

Figure A-3 (	(cont.)							
FORTRAN IV (	S LEVEL	21 M	AIN	DATE =	- 75058	15/55/47	PAGE 000	ō
0136	193	DEL1 = FIGB10(V13,A1, G0 T0 61	DN+5+0)	i I				
0137	194	DELI = FIGBI0(V14,A1, G0 T0 61	DN+5+0)					
0139 0140	195	IF(P .6T. 6) G0 T0 19 DEL1 = FIGB10(V16.A1. G0 T0 61	16 DN,5,0)					
0142	196 C	DEL1 = FIGB10(V18,A1, DEL4 - VERTICAL C	DN+5+0)					
0143	- 19 19	IF (HE) 44,48,53						
0145	C n	H3 = 0.						
0146		H4 = HE = HO H5 = H4						
0148		D3 = DE - DS						
0150		04 = 05 60 T0 47						
0151	4	IF(J .EQ. ] .AND. ICO H3 = HE	N .EQ. ]) DC = DC	(NG +				
0153		H4 = -H0						
0155		03 = DE - DC						
0156		D4 = DC						
0158	47	CALL DELS(D2+DEL+DEL4 H3 = H3 + 8.	•1•)					
0159		H5 = H5 + 8.	and the second se		-			
0160		CALL DELS(D2,DEL,0L4,	1.) M					
0161	19 4 4 7	-0 - BARKIER CURRECTIO 15(BL -60- 0) 60 70 3	z m					
0162	2	IF (J . 61. 1 . 0R. ICON	NE. 0) GO TO 11	17				
0163		DBX = DB		-				
0165	111	IF (J .EQ. 1 .AND. ICO	N .EQ. 1) DB = DB	KNQ + 8				
0166		H- = EH						
0167		H4 = H + H0						
0169		D3 = DE-DB						
0170		D4 = D8				1		
0171		САLL DELS(D2•UEL•DEL6 Н3 = Н3 • А.	•1.)					
0173		H5 = H5 + 8						
0174		CALL DELS(D2,DEL,DL6, TE(B1 -2,133,38,38	1.)					
9110	38	IF (ICON .EQ. 2) CALL	ANGLE (C4,C3,ALPHA	A.08.06	(X)			
<i>L</i> 1 1 0		CALL FINBR (V25+V210+V	215,42,DEL6)					
0178	33	CALL FINBK(V25,V210,V CONTINUE	215,A2,UL6					
	່ ບ	# 9 						
	<u>ں</u>	CALCULATE L50 AND	L10					
0180	ر	S = DEL1 + DEL2 + DEL	7					
0181		SDEL = S + AMAXI(DEL4 SDFIT = S + DFI3 + AM	.+DEL6,-20.) + DEL  AX](D  4+D  620.)	ຖ				
0183		YA = .119 * VA(J) / S	A (J)					
0184		UA = VA(J) * SA(J) * A150A = 10 * A106107	54(J) * IANH(YA) 1141 - 1 - 50FI					
0186		AA=AMAX1 (VA (J) *DE/SA (	J),21.)					
0187		AT=AMAX1 (VT (J) *DE/ST (	(*12*(P					

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	PAGE 0006					
	15/55/47	A,OL10A •OL10T	P.,14			
	TE = 75058	DELS,DEL6,AL50	· • LANE GROUI			L10 = ',F5.2/) New Data,Stop
	.¥Q	12.0) (J) (5. • SDELT (2.0) (2.0) (2.2.0EL3.0EL4, 0EL2.0EL3.0L4,	10 EMENT NO14. PS		LEMENTS	) VALUES ) = '.F5.2.' ) = '.F5.2.' NEW OBS. DIST. 100
	MAIN	BB10(VAL, ARG, AA, ) 0A + AL10A • TV(J) / ST(J) • TANH(TT) / STT • AL0G10(UT) • • AL0G10(UT) • • AL10T 0T • AL10T • 0. ) G0 T0 S1 • 0. ) G0 T0 S1 • 0. ) TUUCS.J, DEL1, C 0 T + C 0 T + C 0 TOCS.J, DEL1, C 0 TOUCS.J, DEL1, C	HIGLIDA-OLIDT) 20 60 T0 52 1015 F08 R05 F08 1415 F08 R04D F1 1415 F08 R04D F1 1415 F08 F08 F08 1010 F08 1010 F08 1010 F108 F108 F108 1010 F108 F108 F108 1010 F108 F108 F108 F108 1010 F108 F108 F108 F108 F108 F108 F108	50 T0 72 D + 12. + P		<ul> <li>1</li> <li>TING L50 AND L1C</li> <li>2) G0 T0 161</li> <li>10,4L50,4L10</li> <li>UN = '.A3,' L5C</li> <li>UN = '.A3,' L5C</li> <li>MORE PROBLEMS T</li> <li>-1 FOR ITERATE.</li> <li>JOB,ID,NC,ICON,L</li> <li>2) G0 T0 800</li> <li>2) G0 T0 187</li> </ul>
	. 21	$ \begin{array}{l} All 0a = FIG \\ VI 1a = AlS \\ VI 1 = AlS \\ UT = V1(J) = AlS \\ Al101 = F1G \\ 0l101 = F1G \\ 0l101 = AlS \\ 0l101 = AlS \\ 0l101 = AlS \\ 0l101 = 0l1 \\ AlS \\ AlS = DBS \\ 0l20 = DBS \\ 0l101 = 0l1 \\ 0l101 = 0l101 \\ 0l101 = 0l01 \\ 0l101 = 0l101 \\ 0l101 = 0l101 \\ 0l101 = 0l101 \\ 0$	ALI0 = 085U HF(ICON = 085U HF(ICON = 0973) FORMAT(2,9773) FORMAT(2,9773) I L50=*F6.2 CONTINUE CONTINUE F(1,60-1) F(1,60-1) F(1,0-60-1) F(1	IF (J.EQ.N) G XX = AL50 YY = AL10 Ju = J + 1 DNX = DN + ME DNX = DN + ME	THIX(L) = TH ST(L) = ST(L) ST(L) = ST(L) GO TO 98 CHECK IF SA(L) = SA(L) F(INRE EQ.I) IF(INRE EQ.I) IF(INRE EQ.I) ALLO = DBSUM ALLO = DBSUM IF(INRE EQ.U) SODLS = ALSO	RDDL1 = ALIO INTE = INTE 60 T0 93 0UTPUT RESUL CONTINUE WRITE (223) FORMAT( 00R FORMAT( 00R ICON = 2,1,00 FORMAT( 1,444) ICON = 2,1,00 IF (NC 1,444) IF (NC
	IV G LEVEL	្រី	973 52 5	Ç	C 72	C 92 C 23 L 115
)	FORTRAN	0188 0192 0192 0192 0192 0194 0197 0197 0197 0190 0220	0201 0202 0203 0203 0203 0203 0206 0209 0209 0209 0209	0210 0213 0213 0214 0214 0215 0215	0217 0219 0219 0220 0223 0222 0223 0223 0223 0223 022	0220 0229 0231 0233 0233 0233 0233 0233 0236 0233 0236 0235

Figure A-3	(cont.)					
FORTRAN IV	<b>9 LEVEL</b>	21 MAI	Z	DATE = 75058	15/55/47	PAGE 0007
0238	L	IF (ICON) 28+29+30 NFW ORSFRVFR PO	NULLION	: .		
0239	30	CONTINUE			۵	
0240 0241		READ(1,555) JUB, ID, NC, D IF (NC .NE. 2) GO TO 800	0UM • DUM • DUM • DUM • DUM •	NUM • NU		
0242	103	WRITE(2,59]) ID,0N EOBMAT(: :]7(:****)/:	1001M - 1.42.54	ANDSEDVED TO DAM	-1.65 0.1	
6420	140	IFEET•)				
0244		DNX = DN = DN1 DN1 = DN				
0246						
0247 0248		INRE = 1 60 TO A2				
	υ					
0249	C 187	ITERATE LIO Continue				
0250	E O E	WRITE(2,595) L10D				
0252		IF (INRE .EQ. 1 AND. N	-LE 2) 60 TO	145		
0253		WRITE(2,940)				
0254	940	FURMAT(*0** TOU MANY EL ICON = 0	EMENTS OR LANE	GROUPS TO ITERATE	L10")	
0256		ICONB = 1				
0257	045	G0 T0 92 CONTINUE				
0259	C+K	DX = 0				
0260		DELDN = 100.				
0261	161	DXN = ALIO - LIOD				
0262		IF (ABS (DXN) • LT. • 1) 60	0 TO 162			
0264		IF (DELUN (ET. 2.) 00 TU	N = .5 * DELON			
0265		DXX = SIGN (DELDN+DXN)				
0266		DNN = DNI + DXX XXX - DNN				
0268		IF(HE) 144.145.146				
0269	144	DC = DC + DXX				
0.27						
0272	146	DS = DS + DXX				
0273	145	XXX = DS TEVEL EV N 1 EV TO 18				
0275	-	DBN = DB + DXX				
0276	101	XXX = DBN				
0278	101	IF (RL - 2.) 151,149,150				
0279	150	CALL ANGLE (C4+C3+THETA+	(NNQ+ ENQ	:		
0280	151	IF(BL .EQ. 2.) CALL ANG Gn tn 148	SLE (C4+C3+ALPHA	DB+DBN)		
0282	149	CALL ANGLE (C2+C1+THETA+	(NND+IND)			
0283		IF (BL .NE. 2.) GO TO 14	84			
0284	198	ALB = ALPHA + BETA CALL ANGLE(C2-C1-ALB-DN				
0286		CALL ANGLE (C2+C1+BETA+D	(NND • INC			
0287 0288	148	ALPHA = ALB - BETA DN = DNN				
0289	•	NND = IND		and the second sec		
0290		DX = DXN IF(Ri _NF_ 0_)DR = DRN				

A-12

Figure A-3 (cont.)

PAGE 0008

J=1 INRE=1 60 10 82 60 10 82 60 10 82 60 70 162 800 WRITE(2:203) 203 FORMAT(\* TRY CLOSER L10 AFTER RESET OF SITE DATA\*) 800 WRITE(2:305) MC+ICON 800 WRITE(2:305) MC+ICON 10R T00 FEW CARD NO. IS\*,I2:10X\*\*LAST END OF DATA INDICAT 10R T00 FEW CARDS\*/\* WRONG NO. IS\*,I2:10X\*\*LAST END OF DATA INDICAT 900 WRITE(2:300) ID 300 FORMAT(\*-\*\*\*\* CARD NO. IS\*,I2:10X\*\*LAST END OF DATA INDICAT 900 WRITE(2:300) ID 300 FORMAT(\*01NPUT ERROR -- CALCULATIONS WERE NOT PERFORMED FOR RUN \*, 116 IF(WC =0. 4) 60 TO 115 REND(1:444) JOB\*ID\*MC+ICON 28 570P 0001 END 15/55/47 **DATE = 75058** MAIN FORTRAN IV G LEVEL 21 0292 0293 0295 0295 0297 0298 0298 0301 0302 0304 0306 0306 0306

PAGE 0001 15/55/47 DY=+,F8.2, ARG(1)= DY= ... F8.2. ARG(1)=" DATE = 75058SEMILOG GRID = 0 FOR SEMILOG FIGB10 = FIGB10\*(VAL(I)-VAL(I-1))/F + VAL(I-1) 7 IF(DY.LE.ARG(K)) GO TO 8 WRITE(2,21) DY,ARG(1),ARG(K) 21 FORMAT(\* \*\* ARGUMENT LIMITED AT HIGH END \*\* 1...F8.2.\* ARG(K)=\*...F8.2/) 8 DO 1 I = 2.K WRITE(2,20) DY,ARG(1),ARG(K) 20 FORMAT(\*\*\* ARGUMENT LIMITED AT LOW END \*\* 1,F8.2,\* ARG(K)=\*,F8.2/) IF(J.EQ.1) G0 T0 9 FIGB10 = ALOG10(D) -ALOG10(ARG(I-1)) F = ALOG10(ARG(I)) - ALOG10(ARG(I-1)) DIMENSION VAL(1), ARG(1) INTERPOLATES ON EITHER A LINEAR OR IN THE CALL, SET J = 1 FOR LINEAR, D = AMAX1(AMIN1(DY,ARG(K)),ARG(1)) IF(DY,GE.ARG(1)) GO TO 7 FUNCTION FIGBIO (VAL, ARG, DY, K, J) FIG810 IF (D.GT.ARG(I)) GO TO 1 - ARG(I-1) FIGB10 = DF = ARG(I)CONTINUE GO TO 6 G0 T0 8 RETURN RETURN ENO 21 σ 9 Figure A-3 (cont.) FORTRAN IV 6 LEVEL ပပ 0018 0019 0020 002200023 0000 0013 0014 0015 0016 0017 0021 0003 0004 0005 0006 0007 001100012 0001

	PAGE 0001				• •	
1 E / E E / 4 7	14/66/61					
DATF = 75058						
Winsed	DBSUM (A,B)	S THE DB SUM OF A AND B •01) Return •01) Return 0.*Alogi0(10.**(0.1*A)				
3 (cont.) V G LEVEL 21	FUNCTION	C CALCULATES DBSUM = B IF (A.LE.0. DBSUM = A IF (B.LE.0. DBSUM = 10	RE TURN END			
Figure A- FORTRAN I	1000	0002 0003 0005 0005 0006	0007 0008			

Figure A-3 (cont.)

GE 0001			
ΡA			
5/55/47	JSE • )		
-	NOT L		
8	- CAN		
= 7505	GREES		
DATE	180 DE		
	THAN	(NX	
	• XN) TO 10 Eater	× ★	
ANGLE	ANGAX 7) GO GLE GR	NG*B)	
	LE (A.B 1.5707 Put an	(TAN (A	
	HE ANG • LE• 0) ** IN	ATAN	
	ROUTIN ANG*8 TE(2,2 MAT(*0	urn 4	
L 21	SUB IF( WRI ANG	0 ANG Ret	END
) LEVE	5		
I V G			
FORTRAN	0001 0002 0004 0006	0006	0008
	I.		•

A-16

001         SUBROUTINE         DELS(D2.0EL.0ELX.R           0.2         C         CALCULATES         SHIELDING         EFFECTS           0.2         DIMENSION         D2(7)         DEL(7)           0.3         COMMON         ///13.44.45.03.04.0           0.4         DELX = 0.           0.5         SB = H4/D4           0.6         SD = H5/D6		
C CALCULATES SHIELDING EFFECTS 002 DIMENSION D2(7), DEL(7) 003 COMMON /BLK1/H3,H4,H5,D3,D4,D1 004 DELX = 0. 015 SB = H4/D4 016 SD = H5/D6		
02 DIMENSION D2(7),0EL(7) 03 COMMON /BLK1/H3,H4,H5,D3,D4,D1 04 DELX = 0. 05 SB = H4/D4 06 SD = H5/D6		
$\begin{array}{cccccccccccccccccccccccccccccccccccc$		
04 DELX = 0. 05 SB = H4/D4 06 SD = H5/DE		
05 SB = $H4/D4$ 06 SD = $H5/D6$ 07 FF/C0 CT C01 DTTUDU		
$06 \qquad SD = H5/DE$		
08 A = SQRT(H3 * H3 + D3 * D3)		
09 B = SQRT (H4 * H4 + D4 * D4)		
10 $D = SQRT(H5 * H5 + DE * DF)$		
DL = A + B - D		
12 DL=DL*R		
13 IF (DL .LT01) RETURN		
14 DELX = FIGB10(D2+DEL+DL+7+0)		
IS RETURN		
16 END		

Figure A-3 (cont.)

2055

	PAGE 0001																												
	15/55/47																												
	FINBR DATE = 75058	TINE FINBR(V25,V210,V215,A2,DELX)	ATES FINITE BARRIER ATTENUATION	10N AZ(10), V25(10), V210(10), V215(10) /BLK3/RL, ALPHA, THETA	2.)74.75.76	PHA/180.	17	PHA/(90THETA)	77	PHA/THETA	GE. 1.) RETURN	LE1) GO TO 89	X .6T5.) G0 T0 86	X .6T10.) G0 T0 87	IGB10(V210,A2,A,10,1)	IGB10(V215,A2,A,10,1)	88	0.		ICD10/V35-43-4-10-1)		00 1 GB1 n ( V 25 - 4 2 - 4 - 1 0 - 1 )	7 GR1 n ( V 21 n • 4 2 • 4 • 1 0 • 1 )	] * AINT(10. * A)	L • • 1	(A = AL) * (VL - VU) / (AU - AL) + VU			
t.)	VEL 21	SUBROL	CALCUL	COMMON	IF (RL-	74 A = AL	60 10	75 A = AL	60 10	76 A = AL	77 IF(A •	IF (A	IF (DEL	IF (DEL	VU = F	VL = F	60 T0	BO DELX =	RETURN	86 VU = 0				88 AL = .	AU = A	DELX =	RETURN	END	
igure A-3 (con	ORTRAN IV G LE	0001	C	0002	0004	0005	0006	0007	0008	6000	0010	0011	0012	0013	0014	0015	0016	2100	0018	0019	0200	1200	0023	0024	0025	0026	0027	0028	

A-18

#### <u>Trial Run — Output from Conversion Program</u>

MICNOISE 2 input for the near and far microphones of Test 1, Trial 1 was supplied, exactly as listed in Table A-1 of the original report. Both the input card format and the converted card format are shown in Figure A-4. The converted format is distinguished by the two asterisks preceding it on the same line.

Detailed formats can be inferred from reading the listing of the conversion program. However, prospective users of MICNOISE 5 are cautioned that other functions are available.in the program, such as the ability to obtain contours, which were not used in this evaluation. It is suggested that prospective users contact Mr. Ronald Heisler of the Data Processing Division of the Virginia Department of Highways and Transportation for more information on preparing input decks.

• • • FORMAT (INDICATED BY \*\*) • • • ••• • • • • • Э. : • e. **.** • 13**.** 0. 37. Ι. 26. 0. ۲. • • • • ••••• • • • • • l. •••• 1. •••• •••• MICNOISE 2 INPUT DATA CONVERTED TO MICNOISE 5 .... 0. 0. 0. 0. 106. 1. 0. 0. 0. 237. 0--0 010 58. 63. 0. 106. 2011. 100. 21. 58. 63. 0. 56. 

 20. 59. 64. 0. 2

 0. 0. 0. 0. 237.

 59. 64. 0. 237.

 26. 0. 0. 0. 0.

 0. 0. 0. 56. 0. 63. 63. 2011. 21. 58. 63. 0. 0. 13. 0. 0. 0. 0. 0. 2011. 21. 58. 0 0. 0. 37. 2011. 100. 21. 2414. 100. 20. 0. 0. 2414. 20. 5 0. 0. 2 2 ~ ~ ---00 --

Figure A-4. Trial run - output from conversion program.

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2414. 100.

111F2

111F1

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111F3 111F2 111F3

\* \* \* \*

111F2

111F1 111F1

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1111F3 1111F2 1111F3

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2414. 20. 0. 0. 0. 0. 0. 0. 0. 0. 59. 64. 0. 287. 1. 0. 0. 50. 0. 0. 0. 0.

77

111F4 111F4

\* \*

1111N3 1111N2 1111N3

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111N2

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111N2

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111N0

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111N3 111N2 111N3

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111N4 111N4

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111F0 111F0

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# Trial Run - Output from MICNOISE 5

Figure A-5 shows the output from MICNOISE 5, using the data from Figure A-4 indicated by asterisks. The data summary was extended for the purpose of this evaluation. Prospective users are referred to the cautionary comment on page A-19.

2.8

2059

| ROA<br>TOTAL ROAD ELEMENTS = 2<br>Design Hr. Vol. = 2011. Veh/Hr. 8 T<br>Car Speed = 63. Mph Roa |                                     |                                       |
|--|-------------------------------------|---------------------------------------|
| TOTAL ROAD ELEMENTS = 2 NO.<br>Design_hr.vol., = 2011.veh/hr. 8 T<br>Car Speed = 63.mph Rom      | JAD ELEMENT NO. 1                   |                                       |
| DESIGN_HRVOL. = 2011VEH/HR% 7<br>Car Speed = 63. MPH   | 0. OF LANE GROUPS = 1               |                                       |
| CAR SPEED = 63. MPH  | TRUCK MIX = $21_{\circ}$            | TRUCK SPEED = 58. MPH                 |
|  | AD ELEV. = 0. FEET                  | 08S. TO ROAD = 56. FEET               |
| ROAD LENGTH TYPE = 1. BAR  | RRIER LENGTH = 0.                   | NO. OF LANES PER LANE GROUP = 3.      |
| GRADE CORRECTION = 0. DB   | AD SURFACE CORRECTION = 0. DB       | STRUCTURE SHIELD CORRECTION = 0. DB   |
| MEDIAN WIDTH = 0. FEET   | AD INCLUDED ANGLE = 0. DEGREES      | 085• HT• = 13• FEET                   |
| OBS. TO SHOULDER = 0. FEET OBS   | 15. TO CUT = 0. FEET                | BARKIER HT. = 0. FEET                 |
| 0. FEET BARRIER = 0. FEET  | RRIER INCLUDED ANGLE = 0. DEGREES   | BARRIER END-NORMAL ANGLE = 0. DEGREES |
| UMMARIES FOR AUTOS IN LANE GROUP NO. 1   |                                     |                                       |
| ORRECTIONS, DELI TO DEL6: 2.53 0.0 0.0 0   | 0.0 0.0 0.0 : L50= 69.50 L10= 74.85 |                                       |
| UMMARIES FOR TRUCKS IN LANÉ GROUP NO. 1  |                                     |                                       |
| CORRECTIONS, DEL1 TO DEL6: 2.53 0.0 0.0 0  | 0.0 0.0 0.0 : L50= 74.60 L10= 83.59 |                                       |
| OTALS FOR ROAD ELEMENT NO. 1. LANE GROUP 1   | 1, L50= 75.77, L10= 84.14           |                                       |

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| Figure A-5 (cont.)                       | •  |                                       |
|--|--|---------------------------------------|
| RUN = 11N                                | E MICHIGAN NOISE PREDICTOR PROGRAM                     | COMPUTER JOB NO. 1                    |
|  | ROAD ELEMENT NO. 2                                     |                                       |
| TOTAL ROAD ELEMENTS = 2                  | NO. OF LANE GROUPS = 1                                 | •                                     |
| DESIGN HR. VOL. = 2414. VEH/HR.          | % TRUCK MIX = 20.                                      | TRUCK SPEED = 59. MPH                 |
| CAR SPEED = 64. MPH                      | ROAD ELEV. = 0. FEET                                   | 085. TO ROAD = 237. FEET              |
| ROAD LENGTH TYPE = 1.                    | BARRIER LENGTH = 0.                                    | NO. OF LANES PER LANE GROUP = 3.      |
| GRADE CORRECTION = 0. DB                 | ROAD SURFACE CORRECTION = 0. DB                        | STRUCTURE SHIELD CORRECTION = 0. DB   |
| MEDIAN WIDTH = 0. FEET                   | ROAD INCLUDED ANGLE = 0. DEGREES                       | 085. HT. = 26. FEET                   |
| OBS. TO SHOULDER = 0. FEET               | 085. TO CUT = 0. FEET                                  | BARRIER HT. = 0. FEET                 |
| 085. TO BARRIER = 0. FEET                | BARRIER INCLUDED ANGLE = 0. DEGREES                    | BARRIER END-NORMAL ANGLE = 0. DEGREES |
|  |  |                                       |
| SUMMARIES FOR AUTOS IN LANE GROUP NO. 1  |  | •                                     |
| CORRECTIONS. DELI TO DEL6: -5.65 0.0 0.  | •0 0•0 0•0 0•0 : L50= 62•33 L10= 65•11                 |                                       |
| SUMMARIES FOR TRUCKS IN LANE GROUP NO. 1 |  |                                       |
| CORRECTIONS, DELI TO DEL6: -5.65 0.0 0.  | 0 0.0 0.0 0.0 1.0 0.0 00 00 00 00 00 00 00 00 00 00 00 |                                       |
| TOTALS FOR ROAD ELEMENT NO. 2. LANE GROU | JP ], L50= 68.45, L10= 72,93                           |                                       |
| RUN = IIN L50 = 76.51 L10 = 84.45        |  |                                       |

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| Figure A-5 (cont.)                       |   | ~                                     |
|--|---|---------------------------------------|
| RUN = 11F TH                             | HE MICHIGAN NOISE PREDICTOR PROGRAM     | COMPUTER JOB NO. 1                    |
|  | ROAD ELEMENT NO. 1                      |                                       |
| TOTAL ROAD ELEMENTS = 2                  | NO. OF LANE GROUPS = 1                  |                                       |
| DESIGN HR. VOL. = 2011. VEH/HR.          | % TRUCK MIX = 21.                       | TRUCK SPEED = 58. MPH                 |
| CAR SPEED = 63. MPH                      | ROAD ELEV. = 0. FEET                    | 085. TO ROAD = 106. FEET              |
| ROAD LENGTH TYPE = 1.                    | BARRIER LENGTH = 0.                     | NO. OF LANES PER LANE GROUP = 3.      |
| GRADE CORRECTION = 0. DB                 | ROAD SURFACE CORRECTION = 0. DB         | STRUCTURE SHIELD CORRECTION = 0. DB   |
| MEDIAN WIDTH = 0. FEET                   | ROAD INCLUDED ANGLE = 0. DEGREES        | 08S• HT• = 37• FEET                   |
| OBS. TO SHOULDER = 0. FEET               | 085. TO CUT = 0. FEET                   | BARRIER HT. = 0. FEET                 |
| OBS. TO BARRIER = 0. FEET                | BARRIER INCLUDED ANGLE = 0. DEGREES     | BARRIER END-NORMAL ANGLE = 0. DEGREES |
| SUMMARIES FOR AUTOS IN LANE GROUP NO. 1  |   |                                       |
| CORRECTIONS, DEL1 TO DEL6: -1.03 0.0 0   | 0.0 0.0 0.0 0.0 : L50= 65.94 L10= 69.97 |                                       |
| SUMMARIES FOR TRUCKS IN LANE GROUP NO. 1 |   |                                       |
| CORRECTIONS, DEL1 TO DEL6: -1.03 0.0     | 0.0 0.0 0.0 0.0 : L50= 71.04 L10= 78.24 |                                       |
| TOTALS FOR ROAD ELEMENT NO. 1, LANE GRO  | 0UP 1, L50= 72.21, L10= 78.84           |                                       |
|  |   |                                       |
|  |   |                                       |
|  |   |                                       |

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|  | ROAD ELEMENT NO. 2                          |                                    |
|--|---|------------------------------------|
|  |   |                                    |
| TOTAL ROAD ELEMENTS = 2                | NO. OF LANE GROUPS = 1                      |                                    |
| DESIGN HR. VOL. = 2414. VEH/HR.        | % TRUCK MIX = 20.                           | TRUCK SPEED = 59. MPH              |
| CAR SPEED = 64. MPH                    | ROAD ELEV. = 0. FEET                        | 085. TO ROAD = 287. FEET           |
| ROAD LENGTH TYPE = 1.                  | BARRIER LENGTH = 0.                         | NO. OF LANES PER LANE GROUP = 3.   |
| GRADE CORRECTION = 0. DB               | ROAD SURFACE CORRECTION = 0. DB             | STRUCTURE SHIELD CORRECTION = 0. D |
| MEDIAN WIDTH = 0. FEET                 | ROAD INCLUDED ANGLE = 0. DEGREES            | 08S• HT• = 50• FEET                |
| OBS. TO SHOULDER = 0. FEET             | 0BS. TO CUT = 0. FEET                       | BARRIER HT. = 0. FEET              |
| OBS. TO BARRIER = 0. FEET              | BARRIER INCLUDED ANGLE = 0. DEGREES         | BARHIER END-NORMAL ANGLE = 0. DEG  |
| CORRECTIONS. DELI TO DELG: -6.75 0.0   | 0.0 0.0 0.0 0.0 0.0 : L50= 61.23 L10= 63.84 |                                    |
| SUMMARIES FOR AUTOS IN LANE GROUP NO.  |   |                                    |
| SUMMARIES FOR TRUCKS IN LANE GROUP NO. |   |                                    |
| CORRECTIONS, DELI TO DEL6: -6.75 0.0   | 0.0 0.0 0.0 0.0 0.0 : L50= 66.14 L10= 70.62 |                                    |
| TOTALS FOR ROAD ELEMENT NO. 2, LANE (  | :ROUP 1, L50= 67.35, L10= 71.45             |                                    |
| RUN = 11F L50 = 73.44 L10 = 79.57      |   |                                    |

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# APPENDIX B

TABLE OF MEASURED AND CALCULATED VALUES USING MICNOISE VERSIONS 2X, 5, 5X and 5V

#### TABLE B-1

COMPARISON OF LEVELS CALCULATED BY MICNOISE 2X WITH MEASURED LEVELS AT SITE 1 ON I-495 NEAR SPRINGFIELD

| TEST # | TRTAL # | MICR. | L     | 50    | L     | 10    |
|--------|---------|-------|-------|-------|-------|-------|
|        |         | LOCN. | MEAS. | CALC. | MEAS. | CALC. |
| 1      | 1       | 56 N  | 76.9  | 76.5  | 85.0  | 84.3  |
| 1      | 1*      | 106 F | 78.7  | 73.4  | 84.8  | 79.6  |
| 1      | 2       | 56 N  | 77.4  | 77.1  | 85.7  | 84.6  |
| 1      | 2       | 206 F | 63.6  | 64.5  | 67.3  | 69.0  |
| 1      | 3       | 56 N  | 76.4  | 76.5  | 85.2  | 84.3  |
| 1      | 3       | 306 F | 58.0  | 58.9  | 62.2  | 63.1  |
| 2      | 1       | 56 N  | 77.9  | 76.4  | 84.7  | 83.8  |
| 2      | 1       | 206 F | 64.1  | 62.9  | 68.3  | 67.8  |
| 2      | 2       | 56 N  | 77.3  | 76.0  | 83.5  | 83.4  |
| 2      | 2*      | 106 F | 76.9  | 72.8  | 81.5  | 78.8  |
| 3      | 1       | 56 N  | 76.4  | 75.9  | 83.3  | 83.4  |
| 3      | 1*      | 106 F | 75.4  | 72.9  | 81.3  | 78.8  |
| 3      | 2       | 56 N  | 75.9  | 76.6  | 83.7  | 84.1  |
| 3      | 2       | 206 F | 60.7  | 64.4  | 63.8  | 68.8  |
| 3      | 3       | 56 N  | 73.5  | 74.4  | 81.7  | 82.4  |
| 3      | 3       | 306 F | 58.0  | 58.6  | 63.2  | 62.8  |
|        |         |       |       |       |       |       |

\*These values not included in statistical analysis.

# COMPARISON OF LEVELS CALCULATED BY MICNOISE 2X WITH MEASURED LEVELS AT SITE 2 ON I-495 NEAR ALEXANDRIA

| TEST # | TRIAL # | MICR. | L     | 50    | Lı    | Liu   |  |
|--------|---------|-------|-------|-------|-------|-------|--|
|        |         | LOCN. | MEAS. | CALC. | MEAS. | CALC. |  |
| 4      | 1       | 66 N  | 75.9  | 76.2  | 82.2  | 83.5  |  |
| 4      | 1       | 106 F | 74.1  | 73.9  | 79.8  | 80.1  |  |
| 4      | 2       | 66 N  | 77.0  | 75.7  | 83.0  | 83.2  |  |
| 4      | 2       | 206 F | 71.8  | 70.1  | 76.4  | 75.0  |  |
| 4      | 3       | 66 N  | 75.9  | 75.1  | 82.3  | 82.7  |  |
| 4      | 3       | 306 F | 67.9  | 67.4  | 71.7  | 71.6  |  |
| 5      | 1       | 66 N  | 75.5  | 76.2  | 82.1  | 83.4  |  |
| 5      | 1       | 306 F | 65.3  | 68.4  | 70.5  | 72.4  |  |
| 5      | 2       | 66 N  | 76.4  | 76.4  | 83.5  | 83.6  |  |
| 5      | 2       | 206 F | 70.5  | 70.8  | 75.8  | 75.5  |  |
| 5      | 3       | 66 N  | 75.5  | 75.3  | 81.4  | 82.8  |  |
| 5      | 3       | 106 F | 72.8  | 73.1  | 78.6  | 79.4  |  |

## TABLE B-3

|        | <br>πρτΔι # | MICR.<br>LOCN. | I     | -50   | Lj    | L <sub>10</sub> |  |
|--------|-------------|----------------|-------|-------|-------|-----------------|--|
| 1631 # |             |                | MEAS. | CALC. | MEAS. | CALC.           |  |
| 7      | 1*          | 50 N           | 53.8  | 62.4  | 63.4  | 74.1            |  |
| 7      | 1*          | 100 F          | 51.7  | 60.9  | 59.8  | 71.3            |  |
| 7      | 2           | 50 N           | 56.1  | 57.1  | 63.7  | 66.8            |  |
| 7      | 2           | 200 F          | 54.1  | 56.4  | 60.7  | 63.8            |  |
| 7      | 3           | 50 N           | 55.4  | 54.4  | 65.3  | 65.8            |  |
|        | 3           | <br>300 F      | 53.2  | 51.4  | 61.7  | 59.5            |  |
| 7      | 4           | 100 N          | 49.1  | 51.5  | 59.4  | 62.2            |  |
| 7      | 4           | 400 F          | 49.7  | 48.3  | 58.7  | 56.0            |  |

COMPARISON OF LEVELS CALCULATED BY MICNOISE 2X WITH MEASURED LEVELS AT SITE 3 ON I-64 NEAR FISHERSVILLE

\*These values were not used in the statistical analysis but were used in the analysis of correction errors.

COMPARISON OF LEVELS CALCULATED BY MICNOISE 2X WITH MEASURED LEVELS AT SITE 4 ON U. S. 29 NEAR RUCKERSVILLE

| TEST # | TRIAL # | MICR.         | L <sub>5</sub> | 0     | Lı    | L <sub>10</sub> |  |
|--------|---------|---------------|----------------|-------|-------|-----------------|--|
|        |         | LOCN.         | MEAS.          | CALC. | MEAS. | CALC.           |  |
| 8      | 1       | <u>50 N</u>   | 51.2           | 58.6  | 68.5  | 70.9            |  |
| 8      | 1       | 100 F         | 46.9           | 52.3  | 55.5  | 63.0            |  |
| 8      | 2       | 50 N          | 59.8           | 61.6  | 71.8  | 73.3            |  |
| 8      | 2       | <u>2</u> 00 F | 47.2           | 48.5  | 53.6  | 58.8            |  |
| 8      | 3       | 50 N          | 56.6           | 60.1  | 70.9  | 70.7            |  |
| 8      | 3       | 100 F         | 49.3           | 51.6  | 55.4  | 60.7            |  |
| 8      | 4       | 300 F         | 42.5           | 45.0  | 46.9  | 53.9            |  |

## TABLE B-5

| TEST # 1 | TRIAL #   | MICR. | L <sub>5</sub> | 0     | L     | L <sub>10</sub> |  |
|----------|-----------|-------|----------------|-------|-------|-----------------|--|
|          | ·         | LOCN. | MEAS.          | CALC. | MEAS. | CALC.           |  |
| 9        | l         | 85 N  | 61.5           | 63.5* | 69.8  | 73.0*           |  |
| 9        | 1         | 150 F | 62.6           | 63.9* | 70.8  | 71.8*           |  |
| 9        | 2         | 150 N | 64.7           | 64.4  | 73.5  | 72.6            |  |
| 9        | 2         | 200 F | 63.9           | 63.6  | 70.4  | 70.6            |  |
| 9        | 3         | 150 N | 65.0           | 63.9  | 74.3  | 72.3            |  |
| 9        | 3         | 300 F | 62.1           | 61.5  | 69.4  | 67.5            |  |
| 9        | 4         | 150 N | 62.6           | 64.7  | 73.9  | 72.8            |  |
| 9        | ц <u></u> | 400 F | 58.3           | 60.8  | 67.2  | 65.9            |  |

COMPARISON OF LEVELS CALCULATED BY MICNOISE 2X WITH MEASURED LEVELS AT SITE 5 ON I-95 NEAR DOSWELL

\*Trucks on side road ignored in these calculations.

| COMPARISON   | OF LEVELS CALCULATED BY MICNOISE 5  |  |
|--------------|-------------------------------------|--|
| (IRUCKS AT 8 | FT.) WITH MEASURED LEVELS AT SITE 1 |  |
| 0.           | N I-495 NEAR SPRINGFIELD            |  |

| שדירים ש |         |       |       | т                                      |  |       |       |
|----------|---------|-------|-------|--|--|-------|-------|
| TE21 #   | TRIAL # | MICR. |       | L50                                    |  | L     | 10    |
| <u> </u> |         | LOCN. | MEAS. | CALC.                                  | CALC.**                                | MEAS. | CALC. |
| 1        | 1       | 56 N  | 76.9  | 76.5                                   | 76.5                                   | 85.0  | 84.5  |
| 1        | 1*      | 106 F |       |  |  |       |       |
| 1        | 2       | 56 N  | 77.4  | 77.1                                   | 77.1                                   | 85.7  | 84.8  |
|          | 2       | 206 F | 63.6  | 61.3                                   | 70.7                                   | 67.3  | 65.6  |
|          | 3       | 56 N  | 76.4  | 76.5                                   | 76.5                                   | 85.2  | 84.5  |
|          | 3       | 306 F | 58.0  | 56.0                                   | 67.8                                   | 62.2  | 60.1  |
| 2        | 1       | 56 N  | 77.9  | 76.4                                   | 76.4                                   | 84.7  | 84.1  |
| 2        | 1       | 206 F | 64.1  | 60.0                                   | 69.8                                   | 68.3  | 64.6  |
| 2        | 2       | 56 N  | 77.3  | 76.0                                   | 76.0                                   | 83.5  | 83.8  |
| 2        | 2*      | 106 F |       |  | ······································ |       |       |
| 3        | 1       | 56 N  | 76.4  | 75.9                                   | 75.9                                   | 83.3  | 83.7  |
| 3        | 1*      | 106 F |       | ······································ |  |       |       |
| 3        | 2       | 56 N  | 75.9  | 76.7                                   | 76.7                                   | 83.7  | 84.4  |
| 3        | 2       | 206 F | 60.7  | 61.1                                   | 70.4                                   | 63.8  | 63.4  |
| 3        | 3       | 56 N  | 73.5  | 74.4                                   | 74.4                                   | 81.7  | 82.9  |
| 3        | 3       | 306 F | 58.0  | 55.5                                   | 66.6                                   | 63.2  | 59.5  |
|          |         |       |       |  |  |       |       |

\*These values are not included in statistical analysis. \*\*Calculated without vertical correction.

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5 (TRUCKS AT 8 FT.) WITH MEASURED LEVELS AT SITE 2 ON I-495 NEAR ALEXANDRIA

|          |         | MICR  | MICR. L <sub>50</sub> |       |        | L <sub>10</sub> |       |
|----------|---------|-------|-----------------------|-------|--------|-----------------|-------|
| IEDI #   | ININD # | LOCN. | MEAS.                 | CALC. | CALC.* | MEAS.           | CALC. |
| <br>4    | 1       | 66 N  | 75.9                  | 76.2  | 76.2   | 82.2            | 83.6  |
| 4        | 1       | 106 F | 74.1                  | 73.9  | 73.9   | 79.8            | 80.1  |
| 4        | 2       | 66 N  | 77.0                  | 75.7  | 75.7   | 83.0            | 83.3  |
| <u>.</u> | 2       | 206 F | 71.8                  | 70.1  | 70.1   | 76.4            | 75.0  |
| <u>+</u> | 3       | 66 N  | 75.9                  | 75.1  | 75.1   | 82.3            | 82.9  |
| 4        | 3       | 306 F | 67.9                  | 67.4  | 67.4   | 71.7            | 71.6  |
|          | 1       | 66 N  | 75.5                  | 76.2  | 76.2   | 82.1            | 83.5  |
| 5        | 1       | 306 F | 65.3                  | 68.4  | 68.4   | 70.5            | 72.4  |
| <br>5    | 2       | 66 N  | 76.4                  | 76.4  | 76.4   | 83.5            | 83.7  |
| 5        | 2       | 206 F | 70.5                  | 70.8  | 70.8   | 75.8            | 75.5  |
| <br>5    |         |       | 75.5                  | 75.3  | 75.3   | 81.4            | 83.0  |
| <u></u>  | 3       | 106 F | 72.8                  | 73.1  | 73.1   | 78.6            | 79.5  |
| J        | 0       | 1001  |                       |       |        |                 |       |

\*Calculated without vertical correction.

| <br>ጥፑርጥ # |         | MTOD  |       | Lic o |         |       |      |  |
|------------|---------|-------|-------|-------|---------|-------|------|--|
|            | IRIAL # | LOCN. | MEAS. | CALC. | CALC.** | MEAS. | CALC |  |
| 7          | 1*      | 50 N  | 53.8  | 61.3  | 68.4    | 63.4  | 73.6 |  |
| 7          | 1*      | 100 F | 51.7  | 63.7  | 64.6    | 59.8  | 74.7 |  |
| 7          | 2       | 50 N  | 56.1  | 54.5  | 65.8    | 63.7  | 65.1 |  |
| 7          | 2       | 200 F | 54.1  | 53.3  | 60.7    | 60.7  | 61.6 |  |
| 7          | 3       | 50 N  | 55.4  | 53.3  | 63.6    | 65.3  | 65.1 |  |
| 7          | 3       | 300 F | 53.2  | 49.1  | 54.7    | 61.7  | 58.5 |  |
| 7          | 4       | 100 N | 49.1  | 52.1  | 58,9    | 59.4  | 63.8 |  |
| 7          | 4       | 400 F | 49.7  | 46.2  | 51.6    | 58.7  | 55.1 |  |
|            |         |       |       |       |         |       |      |  |

## COMPARISON OF LEVELS CALCULATED BY MICNOISE 5 (TRUCKS AT 8 FT.) WITH MEASURED LEVELS AT SITE 3 ON I-64 NEAR FISHERSVILLE

\*These values were not used in the statistical analysis but were used in the analysis of correction errors.

\*\*Calculated without vertical correction.

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5 (TRUCKS AT 8 FT.) WITH MEASURED LEVELS AT SITE 4 ON U. S. 29 NEAR RUCKERSVILLE

| TEST # | T # TRIAL # MI<br>LO | MICR. | L50   |       |        | L     | L <sub>10</sub> |  |
|--------|----------------------|-------|-------|-------|--------|-------|-----------------|--|
|        |                      | LOCN. | MEAS. | CALC. | CALC.* | MEAS. | CALC.           |  |
| 8      | 1                    | 50 N  | 51.2  | 58.6  | 58.6   | 68.5  | 71.0            |  |
| 8      | 1                    | 100 F | 46.9  | 54。4  | 55.1   | 55.5  | 66.2            |  |
| 8      | 2                    | 50 N  | 59.8  | 61.6  | 61.6   | 71.8  | 73.8            |  |
| 8      | 2                    | 200 F | 47.2  | 49.5  | 54.6   | 53.6  | 60.4            |  |
| 8      | 3                    | 50 N  | 56.6  | 60.1  | 60.1   | 70.9  | 71.4            |  |
| 8      | 3                    | 100 F | 49.3  | 51.6  | 56.5   | 55.4  | 60.9            |  |
| 8      | ų                    | 300 N | 42.5  | 43.8  | 52.3   | 46.9  | 52.8            |  |

\*Calculated without vertical correction.

| TEST #      | TRIAL #     | MICR.                   | L <sub>50</sub>      |                      |                      | L <sub>10</sub>      |       |
|-------------|-------------|-------------------------|----------------------|----------------------|----------------------|----------------------|-------|
|             |             | LOCN.                   | MEAS.                | CALC.                | CALC.**              | MEAS.                | CALC. |
| 9           | 1           | 85 N                    | 61.5                 | 66.7 *               | 69.9*                | 69.8                 | 77.3* |
| 9           | 1           | 150 F                   | 62.6                 | 63.8*                | 67.0*                | 70.8                 | 72.2* |
| 9           | 2           | 150 N                   | 64.7                 | 64.1                 | 67.4                 | 73.5                 | 72.7  |
| 9           | 2           | 200 F                   | 63.9                 | 62.6                 | 65.9                 | 70.4                 | 70.1  |
| 9           | 3           | 150 N                   | 65.0                 | 63.7                 | 67.0                 | 74.3                 | 72.5  |
| 9           | 3           | 300 F                   | 62.1                 | 61.3                 | 63.2                 | 69.4                 | 67.6  |
| 9           | 4           | 150 N                   | 62.6                 | 64.5                 | 67.3                 | 73.9                 | 73.0  |
| 9           | 4           | 400 F                   | 58.3                 | 60.4                 | 61.9                 | 67.2                 | 65.8  |
| 9<br>9<br>9 | 3<br>4<br>4 | 300 F<br>150 N<br>400 F | 62.1<br>62.6<br>58.3 | 61.3<br>64.5<br>60.4 | 63.2<br>67.3<br>61.9 | 69.4<br>73.9<br>67.2 |       |

## COMPARISON OF LEVELS CALCULATED BY MICNOISE 5 WITH MEASURED LEVELS AT SITE 5 ON I-95 NEAR DOSWELL

\*Trucks on side road ignored in these calculations.

\*\*Calculated without vertical correction.

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5X (TRUCKS AT HALF FREQUENCY) WITH MEASURED VALUES AT SITE 1 ON I-495 NEAR SPRINGFIELD

| TEST # | TRIAL # | MICR. | L <sub>5</sub> | 0     | L <sub>1</sub> | L <sub>10</sub> |  |  |
|--------|---------|-------|----------------|-------|----------------|-----------------|--|--|
| ·      |         | LOCN. | MEAS.          | CALC. | MEAS.          | CALC.           |  |  |
| 1      | 1       | 56 N  | 76 <b>.</b> 9  | 76.5  | 85.0           | 84.5            |  |  |
| 1      | 1*      | 106 F |                |       |                |                 |  |  |
| 1      | 2       | 56 N  | 77.4           | 77.1  | 85.7           | 84.8            |  |  |
| 1      | 2       | 206 F | 63.6           | 61.4  | 67.3           | 65.7            |  |  |
| 1      | 3       | 56 N  | 76.4           | 76.5  | 85.2           | 84.5            |  |  |
| 1      | 3       | 306 F | 58.0           | 56.4  | 62.2           | 60.5            |  |  |
| 2      | 1       | 56 N  | 77.9           | 76.4  | 84.7           | 84.1            |  |  |
| 2      | 1       | 206 F | 64.1           | 60.1  | 68.3           | 64.7            |  |  |
| 2      | 2       | 56 N  | 77.3           | 76.0  | 83.5           | 83.8            |  |  |
| 2      | 2*      | 106 F |                |       |                | · ·             |  |  |
| 3      | 1       | 56 N  | 76.4           | 75.9  | 83.3           | 83.7            |  |  |
| 3      | 1*      | 106 F |                |       |                |                 |  |  |
| 3      | 2       | 56 N  | 75.9           | 76.7  | 83.7           | 84.4            |  |  |
| 3      | 2       | 206 F | 60.7           | 61.2  | 63.8           | 65.5            |  |  |
| 3      | 3       | 56 N  | 73.5           | 74.4  | 81.7           | 82.9            |  |  |
| 3      | 3       | 306 F | 58.0           | 55.8  | 63.2           | 59.9            |  |  |

\*These values not included in statistical analysis.

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COMPARISON OF LEVELS CALCULATED BY MICNOISE 5X (TRUCKS AT HALF FREQUENCY) WITH MEASURED LEVELS AT SITE 2 ON I-495 NEAR ALEXANDRIA

| TEST # | TRIAL # | MICR.        | L <sub>5</sub> | 0     | L_1   | L <sub>10</sub> |  |  |
|--------|---------|--------------|----------------|-------|-------|-----------------|--|--|
|        |         | LOCN.        | MEAS 。         | CALC. | MEAS. | CALC.           |  |  |
| 4      | 1       | 66 N         | 75.9           | 76.2  | 82.2  | 83.6            |  |  |
| 4      | 1       | 106_F        | 74.1           | 73.9  | 79.8  | 80.1            |  |  |
| 4      | 2       | 66 N         | 77.0           | 75.7  | 83.0  | 83.3            |  |  |
| 4      | 2       | 206 F        | 71.8           | 70.1  | 76.4  | 75.0            |  |  |
| 4      | 3       | 66 N         | 75.9           | 75.1  | 82.3  | 82.9            |  |  |
| 4      | 3       | <u>306 F</u> | 67.9           | 67.4  | 71.7  | 71.6            |  |  |
| 5      | 1       | 66 N         | 75.5           | 76.2  | 82.1  | 83.5            |  |  |
| 5      | 1       | 306 F        | 65.3           | 68.4  | 70.5  | 72.4            |  |  |
| 5      | 2       | <u>66 N</u>  | 76.4           | 76.4  | 83.5  | 83.7            |  |  |
| 5      | 2       | 206 F        | 70.5           | 70.8  | 75.8  | 75.5            |  |  |
| 5      | 3       | 66 N         | 75.5           | 75.3  | 81.4  | 83.0            |  |  |
| 5      | 3       | 106 F        | 72.8           | 73.1  | 78.6  | 79.5            |  |  |

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#### TABLE B-13

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5X (TRUCKS AT HALF FREQUENCY) WITH MEASURED LEVELS AT SITE 3 ON I-64 NEAR FISHERSVILLE

| TEST # | TRIAL # | MICR. | L <sub>5</sub> | 0     | L <sub>10</sub> |       |
|--------|---------|-------|----------------|-------|-----------------|-------|
|        |         | LOCN. | MEAS.          | CALC. | MEAS.           | CALC. |
| 7      | 1*      | 50 N  | 53.8           | 58.7  | 63.4            | 71.0  |
| 7      | 1*      | 100 F | 51.7           | 56.2  | 59.8            | 67.1  |
| 7      | 2       | 50 N  | 56.1           | 54.8  | 63.7            | 64.7  |
| 7      | 2       | 200 F | 54.1           | 52.2  | 60.7            | 59.3  |
| 7      | 3       | 50 N  | 55.4           | 52.7  | 65.3            | 64.2  |
| 7      | 3       | 300 F | 53.2           | 47.6  | 61.7            | 55.4  |
| 7      | 4       | 100 N | 49.1           | 49.2  | 59.4            | 59.3  |
| 7      | 4       | 400 F | 49.7           | 44.9  | 58.7            | 52.2  |

\*These values were not used in the statistical analysis but were used in the analysis of correction errors.

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5X (TRUCKS AT HALF FREQUENCY) WITH MEASURED LEVELS AT SITE 4 ON U. S. 29 NEAR RUCKERSVILLE

| TEST # | TRIAL # | MICR. | Lį    | 50    | $L_{1}$ | 10    |  |
|--------|---------|-------|-------|-------|---------|-------|--|
|        |         | LOCN. | MEAS. | CALC. | MEAS.   | CALC. |  |
| 8      | 1       | 50 N  | 51.2  | 58.6  | 68.5    | 71.0  |  |
| 8      | 1       | 100 F | 46.9  | 51.2  | 55.5    | 61.4  |  |
| 8      | 2       | 50 N  | 59.8  | 61.6  | 71.8    | 73.8  |  |
| 8      | 2       | 200 F | 47.2  | 45.9  | 53.6    | 56.1  |  |
| 8      | 3       | 50 F  | 56.6  | 60.1  | 70.9    | 71.4  |  |
| 8      | 3       | 100 F | 49.3  | 51.5  | 55.4    | 60.7  |  |
| 88     | 4       | 300 F | 42.5  | 42.9  | 46.9    | 51.4  |  |
|        |         |       |       |       |         |       |  |

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#### TABLE B-15

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5X (TRUCKS AT HALF FREQUENCY) WITH MEASURED LEVELS AT SITE 5 ON I-95 NEAR DOSWELL

| TEST # | TRIAL #                                       | MICR.        | Lį    | L <sub>50</sub> |       | 10    |  |
|--------|---|--------------|-------|-----------------|-------|-------|--|
|        | ···· <u>···</u> ····························· | LOCN.        | MEAS. | CALC.           | MEAS. | CALC. |  |
| 9      | 1   | 85 N         | 61.5  | 60.2*           | 69.8  | 69.9* |  |
| 9      | 1   | 150 F        | 62.6  | 59.2*           | 70.8  | 67.2* |  |
| 9      | 2   | <u>150 N</u> | 64.7  | 59.9            | 73.5  | 68.2  |  |
| 9      | 2   | 200 F        | 63.9  | 58.6            | 70.4  | 65.1  |  |
| 9      | 3   | 150 N        | 65.0  | 59.4            | 74.3  | 67.9  |  |
| 9      | 3   | 300 F        | 62.1  | 56.8            | 69.4  | 62.4  |  |
| 9      | 4   | 150 N        | 62.6  | 59.9            | 73.9  | 68.2  |  |
| 9      | 4   | 400 F        | 58.3  | 56.0            | 67.2  | 60.9  |  |

\*Trucks on side road ignored in these calculations.

| COMPA   | ARISON | I OF | - LEVI | ELS C | ALCH  | LATED  | BY   | MTON | ιοτο | יד ב | 17     |   |
|---------|--------|------|--------|-------|-------|--------|------|------|------|------|--------|---|
| (TRUCKS | AT 13  | 3.5  | FT.)   | WITH  | I MEA | SURED  | VAI  | LUES |      | STT  | v<br>F | 1 |
|         |        | ON   | I-49   | 5 NEA | AR SP | RINGFI | LELI | )    |      |      | Ц      | - |

| TEST # | TRIAL # | MICR.       | Lg    | 50    | L <sub>10</sub> |       |  |
|--------|---------|-------------|-------|-------|-----------------|-------|--|
|        |         | LOCN.       | MEAS. | CALC. | MEAS 。          | CALC. |  |
| 1      | 1       | 56 N        | 76.9  | 76.5  | 85.0            | 84.5  |  |
| 1      | 1*      | 106 F       |       |       |                 |       |  |
|        | 2       | 56 N        | 77.4  | 77.1  | 85.7            | 84.8  |  |
| 1      | 2       | 206 F       | 63.6  | 62.0  | 67.3            | 66.6  |  |
| 1      | 3       | 56 N        | 76.4  | 76.5  | 85.2            | 84.5  |  |
| 1      | 3       | 306 F       | 58.0  | 57.0  | 62.2            | 61.1  |  |
| 2      | 1       | <u>56 N</u> | 77.9  | 76.4  | 84.7            | 84.1  |  |
| 2      | 1       | 206 F       | 64.1  | 60.7  | 68.3            | 65.5  |  |
| 2      | 2       | 56 N        | 77.3  | 76.0  | 83.5            | 83.8  |  |
| 2      | 2*      | 106 F       |       |       |                 |       |  |
| 3      | 1       | 56 N        | 76.4  | 75.9  | 83.3            | 83.7  |  |
| 3      | 1*      | 106 F       |       |       |                 |       |  |
| 3      | 2       | 56 N        | 75.9  | 76.7  | 83.7            | 84.4  |  |
| 3      | 2       | 206 F       | 60.7  | 61.8  | 63.8            | 66.2  |  |
| 3      | 3       | 56 N        | 73.5  | 74.4  | 81.7            | 82.9  |  |
| 3      | 3       | 306 F       | 58.0  | 56.2  | 63.2            | 60.4  |  |

\*These values not included in statistical analysis.

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## TABLE B-17

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5V (TRUCKS AT 13.5 FT.) WITH MEASURED VALUES AT SITE 2 ON I-495 NEAR ALEXANDRIA

| TEST # | TRIAL ∦ | MICR. | L <sub>5</sub> | 0     | L <sub>10</sub> |       |
|--------|---------|-------|----------------|-------|-----------------|-------|
|        |         | LOCN. | MEAS.          | CALC. | MEAS.           | CALC. |
| 4      | 1       | 66 N  | 75.9           | 76.2  | 82.2            | 83.6  |
| 4      | 1       | 106 F | 74.1           | 73.9  | 79.8            | 80.1  |
| 4      | 2       | 66 N  | 77.0           | 75.7  | 83.0            | 83.3  |
| 4      | 2       | 206 F | 71.8           | 70.1  | 76.4            | 75.0  |
| 4      | 3       | 66 N  | 75.9           | 75.1  | 82.3            | 82.9  |
| 4      | 3       | 306 F | 67.9           | 67.4  | 71.7            | 71.6  |
| 5      | 1       | 66 N  | 75.5           | 76.2  | 82.1            | 83.5  |
| 5      | 1       | 306 F | 65.3           | 68.4  | 70.5            | 72.4  |
| 5      | 2       | 66 N  | 76.4           | 76.4  | 83.5            | 83.7  |
| 5      | 2       | 206 F | 70.5           | 70.8  | 75.8            | 75.5  |
| 5      | 3       | 66 N  | 75.5           | 75.3  | 81.4            | 83.0  |
| 5      | 3       | 106 F | 72.8           | 73.1  | 78.6            | 79.5  |

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| TEST # | TRIAL # | MICR.         | L <sub>5</sub> | 0     | L <sub>10</sub> |       |
|--------|---------|---------------|----------------|-------|-----------------|-------|
|        |         | LOCN.         | MEAS.          | CALC. | MEAS.           | CALC. |
| 7      | 1*      | 50 N          | 53.8           | 67.7  | 63.4            | 80.0  |
| 7      | 1*      | 100 F         | 51.7           | 63.7  | 59.8            | 74.7  |
| 7      | 22      | 50 N          | 56.1           | 56.9  | 63.7            | 68.5  |
| 7      | 2       | 200 F         | 54.1           | 54.3  | 60.7            | 62.3  |
| 7      | 3       | <u>50 N</u>   | 55.4           | 56.7  | 65.3            | 69.2  |
| 7      | 3       | 300 F         | 53.2           | 51.6  | 61.7            | 60.6  |
| 7      | 44      | <u> 100 N</u> | 49.1           | 52.2  | 59.4            | 63.9  |
| 7      | 4       | 400 F         | 49.7           | 47.2  | 58.7            | 56.4  |

### COMPARISON OF LEVELS CALCULATED BY MICNOISE 5V (TRUCKS AT 13.5 FT.) WITH MEASURED VALUES AT SITE 3 ON I-64 NEAR FISHERSVILLE

\*These values were not used in the statistical analysis but were used in the analysis of correction errors.

# TABLE B-19

COMPARISON OF LEVELS CALCULATED BY MICNOISE 5V (TRUCKS AT 13.5 FT.) WITH MEASURED VALUES AT SITE 4 ON U. S. 29 NEAR RUCKERSVILLE

| TEST # | TRIAL #  | MICR. | L <sub>5</sub> | 0     | Ll    | L <sub>10</sub> |  |
|--------|----------|-------|----------------|-------|-------|-----------------|--|
|        | ·        | LOCN. | MEAS.          | CALC. | MEAS. | CALC.           |  |
| 8      | <u> </u> | 50 N  | 51.2           | 58.6  | 68.5  | 71.0            |  |
| 8      | 11       | 100 F | 46.9           | 54.4  | 55.5  | 66.2            |  |
| 8      | 2        | 50 N  | 59.8           | 61.6  | 71.8  | 73.8            |  |
| 8      | 2        | 200 F | 47.2           | 51.5  | 53.6  | 63.0            |  |
| 8      | 3        | 50 N  | 56.6           | 60.1  | 70.9  | 71.4            |  |
| 8      | 3        | 100 F | 49.3           | 51.6  | 55.4  | 60.9            |  |
| 8      | 4        | 300 F | 42.5           | 47.7  | 46.9  | 58.1            |  |
# TABLE B-20

# COMPARISON OF LEVELS CALCULATED BY MICNOISE 5V (TRUCKS AT 13.5 FT.) WITH MEASURED VALUES AT SITE 5 ON I-95 NEAR DOSWELL

| TEST # | TRIAL # | MICR.<br>LOCN. | L5    | 0     | L10   |       |
|--------|---------|----------------|-------|-------|-------|-------|
|        |         |                | MEAS. | CALC. | MEAS. | CALC. |
| 9      | 1       | 85 N           | 61.5  | 66.7* | 69.8  | 77.3* |
| 9      | 1       | 150 F          | 62.6  | 63.9* | 70.8  | 72.2* |
| 9      | 2       | <u>150 N</u>   | 64.7  | 64.2  | 73.5  | 72.8  |
| 9      | 2       | 200 F          | 63.9  | 63.8  | 70.4  | 71.1  |
| 9      | 3       | <u>150 N</u>   | 65.0  | 63.8  | 74.3  | 72.6  |
| 9      | 3       | 300 F          | 62.1  | 61.3  | 69.4  | 67.6  |
| 9      | 4       | <u>150 N</u>   | 62.6  | 64.6  | 73.9  | 73.1  |
| 9      | 4       | 400 F          | 58.3  | 60.4  | 67.2  | 65.8  |

\*Trucks on side road ignored in these calculations.

# FIELD EVALUATIONS OF WATERPROOF MEMBRANE SYSTEMS FOR BRIDGE DECKS 1972-1974

by

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# SUMMARY

Waterproof membrane systems are being studied by many agencies from the standpoint of their effectiveness in protecting the reinforcing steel in concrete bridge decks against corrosion. Trial applications and evaluations of six such systems, including both preformed sheet and liquid membranes, were made in Virginia during the period from 1972 through 1974. These field evaluations included observations of the installation procedures and assessments of the subsequent waterproofing effectiveness of the systems through electrical resistivity measurements. While none of the systems could be considered an unqualified success, four of the systems showed promise, with modification of the application techniques used in the study, of providing the desired degree of long-term protection.

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Specific details of the application techniques and performances of each of the membrane systems are presented as is an evaluation of the effectiveness of earlier epoxy resin sealcoats.

# FIELD EVALUATIONS OF WATERPROOF MEMBRANE SYSTEMS FOR BRIDGE DECKS 1972-1974

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# INTRODUCTION

It is generally agreed that corrosion of the top reinforcing steel in a concrete bridge deck in the presence of chloride ions that have entered the concrete through its pores or cracks is a primary cause of spalling of the deck. In many areas the correction of spalling is a major maintenance expense, and much effort is being devoted to its prevention. One of several schemes being evaluated as a means of preventing corrosion of the steel is the installation of a waterproof membrane on the top surface of the deck. Trials of bridge deck membranes are being conducted by many transportation agencies, and among these are nationwide investigations under the auspices of the Federal Highway Administration (NEEP No. 12) and the Transportation Research Board (NCHRP Project 12-11).

The emphasis on the use of waterproof membrane systems has caused a proliferation in the number of systems available to the highway engineer since 1972. Some of the new membranes are very promising; they appear to offer better protection and the potential of greater economy than earlier systems such as the coal tar epoxy sealcoat widely used in Virginia. For these reasons, a limited program of field trials of promising membrane systems was proposed by the Virginia Highway and Transportation Research Council in 1972.

# PURPOSE AND SCOPE

The purpose of the subject study was to evaluate a number of new membrane systems and to compare their application procedures and subsequent performances with those of the epoxy resin sealcoats. It was initially envisioned that the study would be limited to products which showed promise of success based on their trial by other agencies, but trials of experimental membranes were later included. While the determination of an effective system was a primary goal, the research was also intended to provide the Department of Highways and Transportation with sufficient background information to allow the adoption of the findings of more extensive studies being conducted by other agencies.

The project began in July 1972, with a survey of the waterproofing systems then used by the Department, followed by evaluations of the six membrane systems listed below.

- 1. Heavy Duty Bituthene 3 installations.
- 2. Protecto Wrap 2 installations.
- 3. Witmer System 1 installation.
- 4. Polytok Membrane 165 1 installation.
- 5. Chevron's System 1 installation.
- 6. Two-Coat Coal Tar Epoxy Sealcoat 1 installation.

The performances of the membranes at these nine installations were evaluated using the electrical resistivity test procedure developed by Spellman and Stratfull of California.<sup>(1)</sup> Only limited laboratory tests were performed.

# THE ELECTRICAL RESISTIVITY TEST

The electrical resistivity test, reported in 1971, remains virtually the only way to evaluate the effectiveness of a membrane in place on a bridge deck. The resistance is measured in the circuit shown in Figure 1, in which an ohmeter is connected to the deck reinforcement and to a copper plate and sponge on the wetted deck surface. Water, with a wetting agent added, is applied to the surface of the overlay and given time to permeate the asphaltic concrete, and a reading is taken. If the membrane, which must be of a dielectric material, is completely waterproof, the resistance will be infinite. Holes in the membrane, which allow the passage of water, reduce the resistance. On the basis of laboratory tests Spellman and Stratfull initially established a value of 500,000 ohms per square foot (0.09 m<sup>2</sup>) as being indicative of an effective membrane. At this writing there appears to be a widely held, but unwritten, opinion that values above 200,000 ohms per square foot  $(0.09 \text{ m}^2)$  are acceptable.

Because of several factors that can cause significant errors in the readings, proper application of the electrical resistivity test requires considerable judgment. The most critical factor appears to be the size of the wetted area in the asphaltic concrete overlay. Conventionally, the wetted area is assumed to be equal to the area of the copper plate, and the resistance reading is reported in relation to the area of the plate. Obviously, however, the resistance is read over the entire wetted area, and care must be used in minimizing the spread of water on the surface of and within the asphaltic concrete layer. The overlay must be dry initially, but it is difficult to determine when this condition is met. In

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order to approach the desired dryness, a period of about one week without rain was allowed before the readings in this study were taken.



Figure 1. Assumed circuit for the electrical resistivity test.

Although difficulty is seldom encountered, care must also be exercised in selecting a proper connection to the reinforcing steel, because the connection can influence the resistivity readings. It is also important that no part of the wetted area touch bare concrete at the edge of the membrane. Several other factors that can significantly affect the reliability of the readings have been cited in a recent "Paving Information Bulletin" published by Phillips Petroleum.(2) Among these were the distance between the electrodes, the specific resistivity of the wetting agent, and the quantity of residual soluble salts in the overlay or the concrete.

The factors cited previously indicate the need for care in obtaining resistance readings. Newly placed membranes should be evaluated as soon as possible after paving, preferably before rain has fallen, to avoid the effects of moisture in the overlay. Reliable data can be obtained on new installations, but as pointed out in a recent FHWA notice, the interpretation of resistivity data taken on in-service decks requires both experience and judgment.<sup>(3)</sup> The pattern of resistance values at various points on the decks, as well as the values themselves, were found to be important in the interpretation of the data taken in this study.

# EVALUATION OF MEMBRANES IN USE IN 1972

The Virginia study began with an assessment of those waterproofing systems in use in 1972. The then applicable specifications allowed two systems: Class I, a coal tar epoxy resin applied at a rate of one gallon per 30 square feet  $(1.36 \ \text{k/m^2})$ , upon which grit was applied at a rate of 11 to 15 pounds per square yard  $(6.0-8.1 \ \text{kg/m^2})$ ; and Class II, a built-up multilayer system consisting of three layers of fiberglass alternated with four moppings of asphalt, applied at a total rate of not less than 16 gallons per 100 square feet  $(6.5 \ \text{k/m^2})$ , on a previously primed deck.<sup>(4)</sup> Both the Class I and Class II systems were generally protected by an asphaltic concrete overlay. A few variant systems had also been placed on an experimental basis.

Unfavorable experiences with the Class II system had resulted in an overwhelming predominance of the Class I epoxy system, to the extent that it could be considered the Virginia standard. In fact, conditions did not allow the testing of a Class II system, which in the majority of cases was used on prestressed concrete box superstructures that were not suited to the resistivity tests. The effectiveness of those systems tested during the summer of 1972 is described below; a short discussion of systems similar to the Class II system is also included.

# Class I - Coal Tar Epoxy Resin Sealcoats

Twenty-three bridges waterproofed through the use of an epoxy sealcoat with grit and an asphalt wearing course were evaluated. Most of the decks were sealed with a single coat of epoxy, but some had areas with a double coating. The results of the electrical resistivity tests are shown in two forms in Figures 2 and 3.

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- 5 -



Figure 3. Percentage of points with effective waterproofing on 23 bridges with coal tar modified epoxy resin sealcoats.

Figure 2 is a plot of the percentages of all of the resistivity readings from the 23 bridges falling in several arbitrarily selected ranges of resistance in ohms per square foot. It is important to note that 69.1 percent of the readings were below 100,000 ohms per square foot  $(0.09 \text{ m}^2)$ , which is indicative of an ineffective waterproof membrane, while only 15.1 percent were above 500,000 ohms per square foot  $(0.09 \text{m}^2)$ , which is considered to be indicative of an excellent waterproofing system.(1) Thus, in general, the epoxy sealcoats did not appear to be providing satisfactory protection.

Figure 3 provides an indication of the effectiveness of the epoxy resin sealcoats on individual bridges. Here, the percentage of points at which effective waterproofing was indicated is plotted versus the number of bridges. Thus, for example 12 bridges each had 0 to 10 percent of their readings above 500,000 ohms per square foot ( $0.09 \text{ m}^2$ ), based on a 5-foot (1.52 m) coordinate grid system in most cases. It is important to note that of the 23 bridges tested only two had epoxy resin sealcoats that could be considered more than 50 percent effective. The best of these had only 57 percent of the readings above 500,000 ohms per square foot ( $0.09 \text{ m}^2$ ). Similar data, not shown, based on the failure criteria indicated that 17 bridges had 50 percent or more readings below 100,000 ohms.

Thus it appears, on the basis of electrical resistivity measurements, that a single application of an epoxy resin sealcoat does not provide effective waterproofing. Similar results were found later in the study when single coatings of an epoxy system without grit were tested, and the findings are consistent with those of a nationwide survey conducted by the Federal Highway Administration.(5) Those deck areas with double coatings of epoxy, while not uniformly satisfactory, yielded higher resistance readings.

# Coal Tar Emulsion Sealcoats

Sealcoats consisting of a single coating of a coal tar emulsion were tried in a few instances prior to the summer of 1972 in an attempt to find an economical waterproofing system. Resistivity tests on two structures with such membranes gave unimpressive results. The great majority of the readings were below 100,000 ohms per square foot (0.09 m<sup>2</sup>), and use of the system has been discontinued.

# <u>Class II - Asphalt-Fiberglass</u> Multilayer Membrane

The Class II waterproofing system has not been popular in Virginia because of application difficulties and the possibility of the membrane sliding under traffic. No representative installation was found for testing, but the results of studies of similar systems by other agencies are available.

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A report from the Federal Highway Administration's National Experimental and Evaluation Program Project Number 12 stated that the performance of a similar coal tar-fiberglass layered system "varies between good and bad depending on construction practice."(5) Tests of similar systems using hot mopped asphalt and coal tar emulsion performed in Vermont indicated that the membranes were not waterproof before paving, but the pavement and membrane systems initially were waterproof in both cases.<sup>(6)</sup> However, neither system was recommended for further use as a bridge deck membrane, possibly because neither exhibited good flexibility and elongation at low temperatures.

# Summation

There is ample evidence that a single layer epoxy membrane cannot be considered waterproof, and that the coal tar emulsion system appears similarly weak. Further testing of a double layer epoxy system in which the first layer was applied without grit will be described in more detail later, but this system also failed. The poor electrical resistivity results plus the inherent expense of the epoxy systems argue strongly for trials of the newer membranes described later. While no firm data on the Class II layered system are available, the national consensus cannot be considered promising.

# TESTS OF NEW MEMBRANE SYSTEMS

# Heavy Duty Bituthene (W. R. Grace & Co.)

# Installations

- Route 340 over Harners Run, Augusta County, Deck area 2,535 s.f. (235.5 m<sup>2</sup>), September 1972.
- Route 19 over Little River, Tazewell County, Deck area 6,525 s.f. (606.2 m<sup>2</sup>), August 1973.
- 3. (a) Route 64 (EBL) over Burcher Road, City of Newport News, Deck area 7,560 s.f. (702.4 m<sup>2</sup>), July 1974.
  - (b) Route 64 (WBL) over Burcher Road, City of Newport News, Deck area 7,560 s.f. (702.4 m<sup>2</sup>), August 1974.

# Description

Heavy Duty Bituthene is a prefabricated sheet membrane consisting of a woven mesh sandwiched between a layer of adhesive grade rubberized asphalt and a layer of non-tacky bituminous compound, and has a total thickness of 65 mils (1.7 mm). It is produced in rolls 3 feet (0.9 m) wide by 60 feet (18.3 m) long interwound with a release paper.

#### Application Procedure

The steps in a typical application of the Bituthene system are shown in Figures 4-8. The deck surface (Figure 4) was cleaned of all soil, loose debris, and accumulations of oil or grease. This required only a light brush sandblasting, after which the deck was blown clean. Bituthene primer was then applied to the decks and the faces of the wheel guards (Figure 5) and allowed to cure to a non-tacky state. Application of the sheet membrane began with the placement of short strips at the wheel guards (Figure 6) in order to provide a shingling of subsequent laps toward the low points of The membrane was extended up the face of the wheel guards the deck. for a distance equal to the depth of the overlay. Subsequent strips of the membrane were unrolled by pulling the release paper (Figure 7). After placement of the membrane its free edges were sealed with mastic and it was rolled lightly with a garden roller to ensure proper contact with the deck surface (Figure 8). Finally a 1½-inch (3.8 cm) thick asphaltic concrete overlay meeting the requirements of Table 1 was placed directly on the membrane. The treatment of the filled expansion joints in the deck consisted of placing 8-12 inch (20-30 cm) strips of the membrane along their lengths, covering them with the uncut deck membrane, and paving continuously across them.

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Figure 4. Deck surface prepared for application of Bituthene membrane.



Figure 5. Application of Bituthene primer.



# Table 1

Specification Requirements for Type S-5 Bituminous Concrete Mixture Used to Overlay Bridge Deck Membrane Systems(4)

|   | PERCENTAGE  | BY WEIGHT | PASSING | SQUARE | MESH | SIEVES* |         |  |
|---|---|-----------|---------|--------|------|---------|---------|--|
| 1/2 in.                                 | 3/8 in.   | No. 4     | No. 8   | No.    | 30   | No. 50  | No. 200 |  |
| 12.7 mm                                 | 9.5 mm  | 6.4 mm    | 3.2 mm  | 0.8    | mm   | 0.5 mm  | 0.1 mm  |  |
| 100                                     | 80-100  |           | 35-55   | 15-3   | 30   | 7-22    | 2-10    |  |
| PERCENT BITUMINOUS MATERIALS: 5.0 - 8.5 |   |           |         |        |      |         |         |  |
| <u></u>                                 | MIX TEMPERATURE (AT PLANT): 225 - 300 <sup>0</sup> F<br>107 - 149°C |           |         |        |      |         |         |  |

\*Numbered sieves are those of the U. S. Standard Sieve Series.



Figure 8. Rolling of the membrane to assure contact with the deck.

#### Evaluation

1 A. A.

The application of a Heavy Duty Bituthene membrane, while more difficult than that of other systems because of its strong adhesion, is relatively easy to master. Pieces of the material must not be allowed to double over and care must be used in unrolling the material since it cannot easily be removed from the deck. In spite of the obvious need for careful placement of the membrane, each of the four installations was completed in one day by inexperienced personnel with the guidance of representatives of the manufacturer.

Hot weather can render the application more difficult as the adhesion of the membrane to the backing paper is increased. Sizeable blisters are also formed beneath the membrane during warm weather, but no distress resulting from the blisters has been noted. Paving has proved to be the most critical phase in the placement of any of the newer membrane systems. The asphaltic concrete overlay must be placed before the bridge is opened to traffic, but the quantity of material required is not large. Coordination of the paving operation is, therefore, difficult, but care must be exercised to avoid damaging the membrane.

With proper care, good initial results can be attained. The Route 340 bridge over Harners Run was first tested on October 2, 1972, at which time only 4 out of 120 points on a 5 x 5 foot (1.5 x 1.5 m) grid had resistivity readings below 500,000 ohms per square foot (0.09 m<sup>2</sup>). Two of these initial readings occurred in an area at which the asphalt overlay was thin. However, resistivity readings taken on August 31, 1973, approximately one year after installation, had the pattern shown in Table 2. It can be seen that while the readings remain generally high in the shoulder areas, they have dropped to unsatisfactory levels in the wheel path areas. The readings at the centerline, while somewhat higher, are also unsatisfactory. The structure was considered dry at the time of testing; there was good provision for drainage and no rain had fallen for ten days.

This characteristic pattern of low resistivity readings in the traffic lanes was noted on all of the other applications and it was apparent, though not as severe, in the case of the Burcher Road bridges approximately two months after installation. The cause of the deterioration has not been determined with certainty. Attempts to remove the overlay from the Little River bridge were hampered by the excellent bond of the asphalt to the membrane. It did appear, however, that some of the membrane constituents had migrated into the rather coarse asphalt overlay. Similar problems were noted in the case of the two Protecto-Wrap installations described in the next section of this report.

# Table 2

Array of Resistivity Readings, ohms x 10<sup>-3</sup> Per Square Foot (0.09 m<sup>2</sup>) Taken on a 5 x 5 ft. (1.5 x 1.5 m) Grid, Rte. 340 Bridge Over Harners Run, 8/31/73

|    | Curb  | Wheelpath | Wheelpath | £    | Wheelpath | Between<br>Wheelpaths | Curb  |
|----|-------|-----------|-----------|------|-----------|-----------------------|-------|
|    | 1     | 2         | 3         | 4    | 5         | 6                     | 7     |
| 1  | 1.80  | 0.012     | 0.01      | 2.00 | 0.07      | 0.02                  | 20.00 |
| 2  | 4.00  | 0.02      | 0.03      | 2.00 | 0.06      | 0.02                  | 20.00 |
| 3  | .30   | 0.03      | 0.05      | 0.70 | 0.02      | 0.02                  | 20.00 |
| 4  | 1.08  | 0.02      | 0.08      | 0.07 | 0.02      | 0.02                  | 20.00 |
| 5  | .30   | 0.03      | 0.03      | 0.14 | 0.03      | 0.04                  | 0.65  |
| 6  | 5.00  | 0.02      | 0.02      | 0.19 | 0.07      | 0.03                  | 20.00 |
| 7  | 1.10  | 0.02      | 0.05      | 0.12 | 0.03      | 0.05                  | 20.00 |
| 8  | .80   | 0.02      | 0.03      | 0.11 | 0.03      | 0.02                  | 1.50  |
| 9  | .40   | 0.02      | 0.03      | 0.13 | 0, 06     | 0.03                  | 0.70  |
| 10 | .64   | 0.04      | 0.06      | 0.18 | U . 22    | 0.04                  | 3.00  |
| 11 | 20.00 | 0.05      | 0.03      | 0.28 | 0.06      | 0.04                  | 1.20  |
| 12 | 20.00 | 0.04      | 0.02      | 0.03 | 0.07      | 0.04                  | 20.00 |
| 13 | 5.00  | 0.04      | 0.02      | 0.11 | 0.05      | 0.02                  | 1.25  |
| 14 | 10.00 | 0.03      | 0.02      | 0.12 | 0.05      | 0.03                  | 0.46  |
| 15 | .28   | 0.02      | 0.04      | 0.06 | 0.05      | 0.35                  | 0.82  |
| 16 | 1.50  | 0.03      | 0.02      | 0.03 | 0.05      | 20.00                 | 0.35  |
| 17 | 20.00 | 0.04      | 0.04      | 0.10 | 0.02      | 20.00                 | 0.71  |
| 18 | 20.00 | 0.03      | 0.06      | 0.11 | 0.10      | 20.00                 | 0.32  |
| 19 | .80   | 0.03      | 0.08      | 0.04 | 20.00     | 20.00                 | 1.25  |
| 20 | .60   | 0.04      | 0.05      | 0.09 | 20.00     | 0.22                  | 0.69  |

The rather simple treatment of the deck expansion joints worked well on the short, rigid concrete beam spans of the Harners Run Bridge, in which little movement would be expected. However, cracking and raveling of the overlay has occurred over the joints between the longer spans of the Burcher Road Bridges. Additional consideration will have to be given to the treatment of the joints in all but the shortest spans if Bituthene and, possibly, other newer membrane systems are used.

## Costs

The recent costs of installing the Bituthene membranes with 165 pound (74.8 kg) asphalt overlays on the two Burcher Road bridges, including materials, equipment and labor, were \$1.04 per square foot (0.09 m<sup>2</sup>) for the eastbound lane structure and \$0.97 per square foot (0.09 m<sup>2</sup>) for the westbound lane structure. Both installations were made by state maintenance forces.

#### Protecto Wrap M-400

# Applications

- (1) Route 81 (SBL) over Route 260, Shenandoah County, Deck area 8,232 s.f. (764.8 m<sup>2</sup>), October 1972.
- (2) Route 19 over Indian Creek, Tazewell County, Deck area 6,020 s.f. (559.3 m<sup>2</sup>), August 1972.

# Description

Protecto Wrap M-400 is a prefabricated sheet membrane composed of a non-woven synthetic fiber between layers of coal tar modified with synthetic resins, with a total thickness of approximately 70 mils (1.8 mm). It is generally available in rolls 30 inches (0.7 m) and 60 inches (1.5 m) in width and 50 feet (15.2 m) long. One side of the membrane has a polyethlene separator sheet which is removed after placement.

# Application Procedure

The application of a Protecto Wrap membrane, shown in Figures 9-12, was similar to that for the Bituthene membrane described previously. The deck, which had been cleaned of all loose material, and the faces of the wheel guard were primed with Protecto Wrap No. 80 primer (Figure 9), and allowed to dry to a tack-free condition.



Figure 9. Application of Protecto-Wrap membrane.



Figure 10. Unrolling of Protecto-Wrap membrane.



Figure 11. Rolling with light truck to set the laps between adjacent membrane sheets.



Figure 12. View of completed Protecto-Wrap membrane before paving.

Placement of the membrane began at the curb and at the low end of the bridge. The sheets were unrolled as shown in Figure 10 and lapped a minimum of 3 inches (7.62 cm) at the sides and ends of the preceding strips. A light truck was used to set the laps between rolls (Figure 11). Expansion joints were coated with mastic and the membrane was cut over the joint after placement. Finally the polyethylene separator sheet was removed (Figure 12) and the membrane was paved.

# Evaluation

The Protecto Wrap membrane is easily applied. Because the membrane is not of an extremely adhesive nature, it can be adjusted once it has been placed. Some difficulty was noted in unrolling the 5-foot (1.5 m) wide rolls used on the Tazewell County bridge, but this may have been a temporary defect in the materials. Although more personnel were required, in that case, to unroll the material, the work proceeded with efficiency. The placement of the Protecto Wrap membrane is easily mastered.

Placement of the asphaltic concrete overlay requires care to avoid damage to the Protecto Wrap membrane, as with other systems. Some damage was noted during the paving operations on the Route 19 bridge. This difficulty could have been avoided had the paving operations proceeded more slowly, but the bridge overlay was only a small part of a large resurfacing contract on Route 19. It should be noted that only a tracked paver was available rather than a rubber tired machine recommended by the manufacturer.

Weather conditions did not allow the obtaining of initial readings on either bridge, and poor drainage of the deck of the Route 81 bridge prevented any meaningful resistivity evaluations. Resistivity measurements made on the Route 19 membrane about one year after placement showed a pattern similar to that described previously for the Bituthene membrane; the readings were low in the traffic areas and higher at the edges of the roadway.

Raveling of the asphaltic concrete overlay over the filled expansion joints (Figure 13) was noted in both installations. An attempt to attain better protection of the deck by leaving the membrane intact over the joint failed through raveling within two months, and this practice should be discontinued. Loss of the overlay was subsequently noted in areas where the membrane had been cut over the joint in accordance with the manufacturer's recommendations. The adhesion of the overlay to the membrane is not strong enough to prevent raveling, so treatment of the overlay at the joints should receive consideration.



Figure 13. Raveling of asphaltic concrete overlay over deck expansion joints.

# Cost

The cost of the installation on the Route 81 bridge was \$1.12 per square foot (0.09  $m^2$ ), including materials, equipment and labor.

# Witmer Bridge Decking Membrane System (Witco Chemical)

# Applications

(1) Route 250 over C & O Railroad, Albemarle County, Deck area 5,965 s.f. (554.2 m<sup>2</sup>), June-July 1974.

### Description

The Witmer Bridge Decking Membrane System is a two-component, bitumen extended, polyurethane elastomer, applied cold in liquid form in two coats to attain a minimum total thickness of 60 mils (1.5 mm).

# Application Procedure

Both coats of the Witmer membrane were applied by squeegees.

The deck, which was surface dry and free of dust, dirt, grease or oil, was primed by squeegee with a mixture of 1 part of each of the two components and 1 part of solvent (Figure 14). After the prime coat had cured sufficiently to permit access, approximately three hours later, the second coat, composed of one part of each of the two components, with sufficient solvent for proper flow, was applied. The second application was allowed to cure for 24 hours before paving. No protective board or roofing sheet was applied to the membrane before paving, although the manufacturer's literature stated that "ideally" a layer of protection board was recommended.

# Evaluation

Installation of the Witmer membrane is basically a simple process, although attention must be given to maintaining the proper rate of application. The only difficulty encountered in placing the liquid was the formation of a great many bubbles (Figure 15) in the first coat. These were probably due to the hot weather, temperatures over 90° F (32° C), and, possibly, the presence of air entrapped in the liquid during mixing. Unfortunately, it was impossible to compact the asphaltic concrete overlay because of poor bond between it and the membrane. As a result, the overlay failed quickly under traffic (Figure 16). Attempts to achieve bond through the use of a cutback asphalt tack coat and, later, the dusting of the tacky membrane with sand, were to no avail. Laboratory tests in which the specified overlay material and the membrane were placed on concrete cylinders and compacted in a Marshall mold disclosed no significant bond unless a piece of roofing sheet was placed on the tacky membrane. It appears that use of some sort of protective layer, placed while the membrane is still tacky, is mandatory to provide bond between the courses.



Figure 14. Application of Witmer liquid membrane with squeegees.



Figure 15. Bubbles in first coat of Witmer membrane.



Figure 16. Failure of asphaltic concrete overlay on Witmer membrane.

Resistivity tests taken on the membrane after the application of the second coat, but before paving, indicated that a waterproof barrier existed; all readings were above 500,000 ohms per square foot ( $0.09 \text{ m}^2$ ). Slight damage to the membrane in the truck wheelpaths was seen during paving, but subsequent resistivity readings were below 500,000 ohms per square foot ( $0.09 \text{ m}^2$ ) in many areas across the deck. Some of the loss in effectiveness may have been due to the effect of bubbles in the membrane.

Further use of the Witmer membrane without a proper protective layer on the membrane is not recommended. Such a layer, which might possibly be only a compatible roofing sheet, would, most importantly, provide sufficient bond to allow successful paving, but it might also improve the system as a waterproof barrier.

Because of the paving problems the Witmer membrane was removed and the two-coat coal tar modified epoxy system described in the next section was substituted for it.

### Costs

The application of the Witco membrane installed by a contractor was initially bid at \$1.78 per square foot (0.09 m<sup>2</sup>). Additional work caused by the paving difficulties was negotiated on a work order basis.

# Two-Coat Coal Tar Modified Epoxy Resin Membrane

# Applications

(1) Route 250 over C & O Railroad, Albemarle County, Deck area 5,965 s.f. (554.2 m<sup>2</sup>), July 1974. (Replaced previously described Witmer membrane.)

# Description

Coal tar modified epoxy resin sealcoats have been widely used in Virginia for several years. As described previously, resistivity tests have indicated that these sealcoats, most of which were composed of a single application of epoxy with sand cast on the surface, were inadequate as waterproof barriers. It was desired to test a two-coat application in which sand is cast only on the second coat. The average rate of application, including both coats, was 0.5 gallon per square yard (0.7  $l/m^2$ ), or 1.67 gallons per 30 square feet, (2.3  $l/m^2$ ), as opposed to the rate of 1 gallon per 30 square feet (1.4  $l/m^2$ ) specified for a single-coat application.

# Application Procedure

Application of the epoxy membrane was routine. The surface of the deck was scarified to remove the preceding membrane, sandblasted, and blown clean, and the epoxy was applied with squeegees. Sufficient time, about three hours, was allowed for curing of the first coat before placement of the second. Sand was applied only to the surface of the second coat.

# Evaluation

A large number of bubbles (Figure 17) were apparent in the first coating of epoxy, which was applied early in the day during hot weather, with temperatures approaching 90° F ( $32^{\circ}$  C). The bubbles were covered by the second coat, and resistivity measurements taken before paving indicated that the double coating was completely waterproof. Resistivity readings taken after paving showed a drop in effectiveness; approximately half of the readings were below 200,000 ohms per square foot ( $0.09 \text{ m}^2$ ). The drop in resistivity readings was probably caused by bursting of the bubbles in the membrane under the heat of the overlay asphalt. The extent of the bubbles might have been lessened, and the performance of the overlay improved, had the first coat of epoxy been applied late in the day, during a falling temperature cycle.



Figure 17. Bubbles in first coat of coal tar epoxy sealcoat.

# Costs

No reliable cost data were developed for the membrane on the C & O bridge, because the price was negotiated through a work order. However, a similar application by the same contractor on a 11,655 square foot (1,082.8 m<sup>2</sup>) deck in Northern Virginia was bid at \$1.78 per square foot (0.09 m<sup>2</sup>).

# Polytok Membrane 165 (Carboline Company)

#### Applications

(1) Route 250 over Rivanna River, Albemarle County, Deck area 11,455 s.f. (1,064.2 m<sup>2</sup>), September 1974.

# Description

Polytok Membrane 165 is a two-component, modified polyurethane elastomer, applied cold in liquid form by spray or squeegee at a 40 mil (1.0 mm) film thickness, topped by 50 pound (23 kg) asphalt impregnated roofing sheet. Solvent can be added if required for easier application.

# Application Procedure

Figures 18 and 19 show the application of the Polytok membrane. The liquid membrane was applied as a single coat by spray (Figure 18) and in two coatings by squeegee when the spray equipment malfunctioned. The membrane was allowed to dry to a tacky condition, usually in about one full hour, after which the roofing sheet was placed (Figure 19) and rolled with a garden roller to ensure firm contact with the membrane. Adjacent strips of the roofing sheet were butted together at their edges. The joints at the ends of the continuous spans of the bridge were raised to the level of the top of the overlay.

# Evaluation

Although the application of the Polytok membrane is relatively simple, in itself, the waterproofing of the Rivanna River bridge extended over a period of weeks, primarily because of equipment malfunctions. The spray equipment required that the polyurethane and catalyst be mixed using an electric drill before pumping, so there was little time savings over a squeegee application. Air was entrapped in the liquid during mixing, and blisters were noted in the wet membrane. No detrimental effects of the blisters were apparent in the final system, however.

Considerable difficulties were encountered in the paving operation. Although it was not clearly expressed, the manufacturer preferred a tracked paver to the rubber tired paver that was available. During the initial paving operation it was noted that the asphalt roofing sheet was shearing at the edge of the main paver wheels (Figure 20), and at times, possibly when the asphalt delivery truck drivers braked their vehicles, the membrane was torn from the deck. The damaging of the membrane was finally averted by loading the hopper of the paver only half full of asphalt and having the delivery truck pull off.

Initial resistivity readings recorded after the previously described precautions were taken were well above 500,000 ohms per square foot (0.09 m<sup>2</sup>) at all but one of 47 points, indicating that, with due care, satisfactory results can be attained. Long-term evaluations are, of course, not yet available.

# Costs

Placement of the Polytok Membrane 165 on the deck of the Rivanna River Bridge by a contractor cost \$1.78 per square foot (0.09 m<sup>2</sup>). The price may be too high to be representative, as only one bid was received, and the contractor had had no previous experience with the material.



Figure 18. Spray application of Polytok liquid membrane.



Figure 19. Placement of roofing sheet on Polytok membrane.



Figure 20. Shearing of roofing sheet under main paver wheels.

# Chevron's Bridge Deck Membrane System (Chevron Asphalt Company) Applications

(1) Route 58 over Route 95, Greensville County, Deck area 10,800 s.f. (1,003.4 m<sup>2</sup>), September 1974.

# Description

Chevron's Bridge Deck Membrane System is a two-component asphalt-urethane elastomer applied cold in liquid form. It is sprayed on the deck to an average thickness of 100 mils (2.5 mm); the minimum specified thickness is 80 mils (2.0 mm).

# Application Procedure

Figures 21 and 22 show the application of the Chevron system to the Route 58 bridge. The deck, which was sound and cleaned of all loose debris, was heated to a temperature at least 30° F (17° C) above ambient using a propane fired infrared heater (Figure 21).

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Figure 21. Infrared heater and truck mounted spray equipment used in applying Chevron's membrane system.



Figure 22. Spray application of Chevron's membrane system.

Truck mounted spray equipment developed by Chevron mixed the two components of the membrane which was applied to the deck within five minutes after heating. The rate of application of the spray equipment was coordinated with the rate of forward movement of the heater to ensure the proper rate of application of the liquid membrane. Boards placed at the side of the lane (Figure 22) were moved forward in stages with the heater to mark the area to be sprayed for the workmen and to keep them a fixed distance behind the heater. The spray operator continued to spray the given area until the heater moved forward, at which time the last board was moved. The membrane was allowed to cure overnight, primed with an uncut liquid asphalt, and paved.

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#### Evaluation

Application of the Chevron system was somewhat more involved than those of the other liquid systems because of the heating and spraying requirements, but these operations were found to yield a blister-free membrane. The heating of the deck allows placement of the membrane under falling temperatures, which minimizes the effect of vapor pressure in the deck, and the mixing of the components in the lines avoids the entrapment of air. Blisters were noted only when small patches of sand, which held moisture, were accidentally left on the deck and when the liquid membrane was mixed in a pail and applied by squeegee. Based on the one experimental application, spreading of the premixed material by squeegee on a heated deck would not seem advisable.

Difficulties were encountered in maintaining operation of the spray equipment, which had been developed for laboratory use, but these should be remedied eventually. Unfortunately, failure of the bond of the asphaltic concrete overlay to the membrane occurred in portions of two of the four traffic lanes within five months after installation. It appears that proper bond has not been attained at the interface of the asphaltic concrete and the comparatively smooth surface of the cured urethane elastomer.

Initial resistivity readings, taken after the membrane and overlay had been open to traffic only one day, were excellent. The readings taken at points on an 8 x 8 foot (2.4 x 2.4 m) grid in one lane ranged from three million ohms per square foot (0.09 m<sup>2</sup>) to infinity, the majority being infinity. The excellent performance of the Chevron system in this regard indicates that further study of the previously cited problem of bonding the asphaltic overlay to the membrane would be worthwhile.

Cracking of the overlays was noted over the expansion joints, but no raveling of the asphaltic concrete has been noted.

# Costs

The cost of the Chevron membrane application by state forces, including materials, equipment and labor, was \$1.25 per square foot (0.09 m<sup>2</sup>).

# DISCUSSION

The trials of six membrane systems have shown that with due care four of the systems, Bituthene, Protecto Wrap, Polytok and Chevron, can be installed and paved over with no initial loss of waterproofing effectiveness. None of the epoxy systems have shown similarly good results after paving, nor did the Witmer membrane. The drop in resistance readings after paving would appear to be due to the bursting of bubbles in these liquid systems when the hot asphalt overlay is applied. Field observations showed a strong tendency to the formation of bubbles in liquid systems in which the components were stirred together, possibly due to the entrapment of air. The formation of bubbles was nearly eliminated in the case of the Chevron system, but poor adhesion of the asphaltic concrete overlay has emerged as a problem. The good initial performance of the Bituthene and Protecto Wrap systems and the poor performance of the epoxy sealcoats is in line with the experience of other states. (5,6) Longterm evaluations are available only on the two sheet membrane systems.

Unfortunately, the two sheet membrane systems, Bituthene and Protecto Wrap, appear to require an additional protective layer over the membrane to provide long-term stability and, possibly, to prevent penetration by aggregate in the overlay. The cause of the drop in resistivity values over a period of one year or less from those taken just after paving is difficult to ascertain, but it would seem to be related to the effect of traffic. A pattern of high readings at the low shoulder areas and low readings in the wheel paths would not be expected if the asphaltic concrete overlay were moist. Attempts to remove the overlay from atop the membrane were inconclusive, but it appeared that some of the components of the membrane may have migrated into the overlay. At this writing the addition of a protective layer between the membrane and the overlay seems advisable. Such added protection would also aid in preventing damage to the membrane during paving.

A small variety of protective layer materials have been used by states other than Virginia. Among these are the use of a 1/2inch (13 mm) layer of sand asphalt, asphalt board, and 65 pound (30.4 kg) roofing sheet.<sup>(5,7,8)</sup> An additional protective layer,
P-100 Protection Sheet, is also being marketed by the Protecto Wrap Company. Of these, the 65 pound (30.4 kg) roofing sheet, presently required on a limited basis in Virginia, may be the simplest alternative.<sup>(9)</sup> Its use on future sheet membrane applications is recommended.

The four initially effective membrane systems were relatively easily applied, and all required less effort in surface preparation than do the more rigid epoxy systems. This fact, coupled with the good initial resistivity evaluations, indicates the need for continued trials of membrane systems to find one that offers longterm effectiveness.

Other methods of deck protection are available, including epoxy coated or galvanized reinforcing steel, construction of the deck in two courses to ensure a proper cover of high quality concrete over the steel, and the provision of cathodic protection for the steel. Trials of these techniques, which are suitable for use at the time of construction, would provide an alternative to the use of membranes. Virginia's policy of using membranes in maintenance operations should be viewed realistically. The permanence of a completely effective membrane is assured only if the concrete does not contain sufficient salt to support corrosion. Application of a membrane to a deck in which spalling has occurred and been patched is probably, in fact, only "buying time".

The critical phase of the membrane application has proven to be the placement of the asphaltic concrete overlay. Proper care in and control of the paving operation is essential to prevent damage to the membrane and assure satisfactory performance of the overlay itself. Coordination with a paving contractor is often difficult because only a small quantity of material is required, sometimes at an isolated location.

All of the new membrane systems can be damaged by abuse during paving. As much as possible, the manufacturer's recommendations should be followed as to procedures and the type of paving machine, wheel or track, to be used. Unfortunately a selection of the type of paver is not always possible in rural areas, and, in such a case, great care is required in the use of available equipment. Damage to the membrane can be averted by requiring that the hopper of the paver be loaded only approximately halffull and having the dump truck pull away. While this is a departure from normal paving operations, it is not considered a difficult requirement because of the relatively small material quantities involved. Control of the paving operation must not be abandoned. The asphaltic concrete should meet the requirements of Table 1, and the manufacturer's recommended application temperatures, most of which are more limited than those shown in the table. Proper compaction of a bridge overlay may also require a delay between the passes of the roller. The thickness of the overlay should be at least 1½ inches (38 mm) before the roadway is open to traffic.

A final consideration in the design of a membrane system is the treatment of the expansion joints in the deck. While epoxy sealcoats can be paved over at the joints with cracking but no loss of the overlay, this is not the case with some of the newer systems. The best solution would be to raise the joints to the level of the top of the overlay, but this is expensive and time-consuming. A simpler, but untried, solution might be to saw the overlay over the joint to provide crack control.

#### FUTURE WORK

The initial field tests covered in this report left several important questions unanswered. While much of the needed information should become available through the work of other agencies, continued trials of new and modified membrane systems should be continued by the Virginia Department of Highways and Transportation, and long-term data should be obtained on the more recent applications covered in this report. Research personnel will assist in these evaluations and report the findings.

#### CONCLUSIONS

The following conclusions are based on the field evaluations described previously. Qualifications, if any, are also noted.

- Epoxy sealcoats, designated as Class I waterproofing in the Virginia Specifications, (10) do not appear to be effective on the basis of electrical resistivity tests.
- 2. Four relatively new membrane systems, Bituthene, Protecto Wrap, Polytok 165, and Chevron's system, provide good initial protection, if due care is used in installation. Long-term evaluations have not been made of the latter two of these products. The further qualifications shown in conclusions 3 and 4, below, should also be noted.

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- 3. The two prefabricated sheet membrane systems, Bituthene and Protecto Wrap, appear to require an additional compatible protective layer over the membrane for long-term stability, based on interpretation of electrical resistivity results. Such a protective layer would also provide a desirable degree of protection during paving operations.
- 4. Modification of the application procedure used in conjunction with Chevron's membrane system will apparently be required to improve the adhesion between the asphaltic concrete overlay and the membrane. The excellent initial effectiveness shown by Chevron's system warrants further study of the adhesion problem.
- 5. Further use of the Witmer membrane system without a protective layer is not advisable, because of difficulties resulting from poor bond between the membrane and the asphaltic concrete overlay. The elimination of the adverse effect of bubbles in the liquid membrane on its initial effectiveness must also be considered.
- 6. Placement of the 1½ inch (38 mm) asphaltic concrete overlay, a required part of the waterproofing systems evaluated, is the critical operation in the application procedure. Care in and control of the paving operation is essential to the satisfactory overall performance of the system.
- 7. Treatment of the expansion joints in bridge decks must receive consideration if the membrane systems considered in this study are used, in order to prevent possible loss of the asphalt overlay through raveling. Raising the joints to the level of the top of the membrane is an ideal solution; sawing a groove over the length of the joint may suffice for structures in less than critical locations.
- 8. Premixing of two-component liquid systems through the use of a paddle appears to entrap air which forms bubbles in the membrane to the detriment of its effectiveness. The use of a pump system in which the components are mixed in the lines is preferable.

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## RECOMMENDATIONS

The field evaluations conducted by the Virginia Department of Highways and Transportation have not fully resolved the problem of effectively protecting bridge decks through the use of waterproofing membranes. Questions such as the long-term effectiveness of those systems evaluated and the measures required to obtain high quality remain unanswered. However, some information has been developed, and the following recommendations are offered as a result of the work to date.

- 1. The Virginia Department of Highways and Transportation should begin using the newer membrane systems in lieu of the currently specified epoxy sealcoats. Electrical resistivity data taken in this study indicate that the epoxy sealcoats do not provide a waterproof barrier.
- 2. While it is acknowledged that the long-term effectiveness of the systems evaluated must be determined, the four systems listed below now appear to warrant further use, based on their good initial performance.
  - Heavy Duty Bituthene Future applications should include a protective layer acceptable to the Department and the manufacturer for protection during paving and for long-term stability.
  - (2) Protecto Wrap The use of a protective layer, cited previously, should be included, for the same reasons.
  - (3) Polytok 165 The long-term effectiveness of this system has not yet been evaluated.
  - (4) Chevron's System The further use of this system must include modifications to improve the bond between the membrane and the asphaltic concrete overlay.
- 3. Further trials of new systems and long-term evaluations of those systems shown above should be performed.
- 4. Any bridge deck membrane application should be viewed as a whole system, no part of which can be neglected. Due care must be provided in the application of the membrane, in the control of the placement of the asphaltic concrete overlay, which must be of sufficient thickness, and in the treatment of the expansion joints to ensure an effective installation.

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