AIR QUALITY REPORT FOR M 51 RELOCATION - BERRIEN COUNTY

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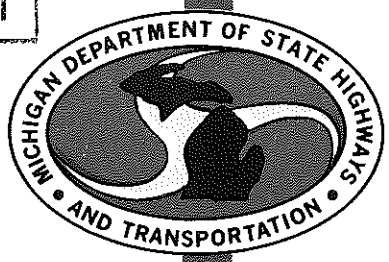

TESTING AND RESEARCH DIVISION
RESEARCH LABORATORY SECTION

AIR QUALITY REPORT FOR M 51 RELOCATION - BERRIEN COUNTY

Research Laboratory Section
Testing and Research Division
Research Project 77 AP-14(A)
Research Report No. R-909R

Michigan State Highway Commission
Peter B. Fletcher, Chairman; Carl V. Pellonpaa,
Vice-Chairman; Hannes Meyers, Jr., Weston E. Vivian
John P. Woodford, Director
Lansing, May 1978

This report presents air quality information for a proposed section of M 51 beginning in Niles Township, Berrien County, and ending at Main St in the City of Niles as shown in Figure 1. Meteorological data, estimates of pollution levels that might occur adjacent to the existing roadway and the proposed roadway, and estimates of the total pollutant burden for the various alternates are included.

Terrain and Demography

The terrain surrounding the City of Niles is flat to gently rolling, so that dispersion of air pollutants is not hindered. Niles has a population of 12,988 according to the 1970 census. The population density in Berrien County is 157 per square mile with only 42 percent of the population living in urban areas.

Meteorology

Meteorological conditions in Michigan are generally good for dispersion and dilution of air pollutants. According to air pollution publication AP 101, U. S. Environmental Protection Agency, 1972 (p. 96) there are few days with a high meteorological potential for air pollution. Figure 2 shows a 36-point bar graph of wind speed and direction occurrences at the Kalamazoo City Weather Station. Hourly weather data (6 a.m. to 11 p.m. only recorded) were obtained from the National Climatic Center at Asheville, N. C. for the years 1967 through 1971 and a one day in three day sampling of the hourly data with a random start each year was used to prepare meteorological data. Figure 3 is a 12-point wind rose obtained by condensing the 36-point wind data.

Figure 4 shows the distribution of wind speeds observed. Wind speeds are greater than 5 mph more than 90 percent of the time. The most probable daytime wind speed was found to be 12 mph.

Existing Ambient Air Quality

No data are available to establish presently existing air quality in the area of this project; however, estimates of background carbon monoxide that exist in other small urban areas similar to Niles are: 1 to 3 mg/cu m for a maximum 8-hour concentration, and 4 to 8 mg/cu m for a maximum 1-hour concentration. These estimates were supplied by the Michigan Department of Natural Resources, Air Pollution Control Division.

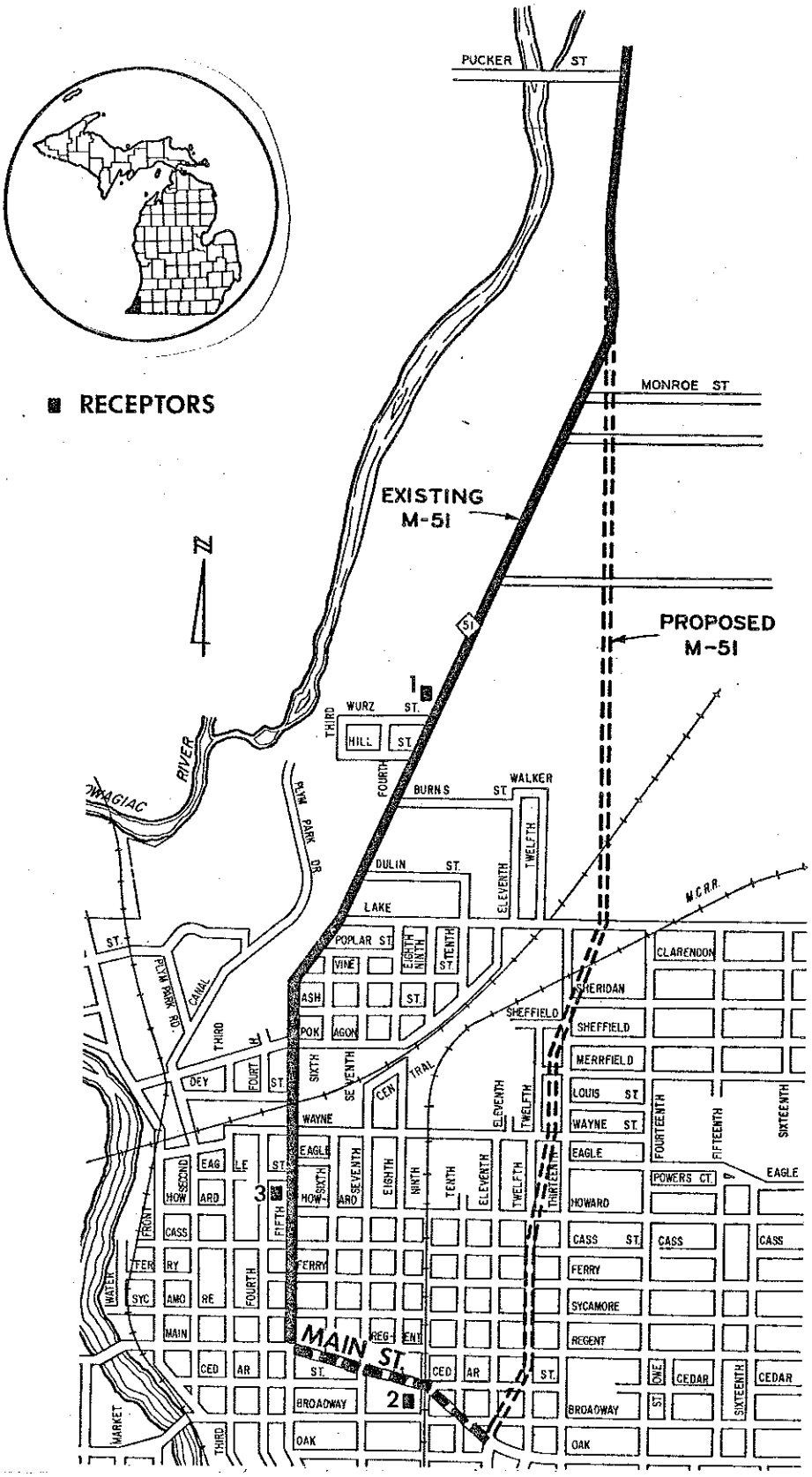

Figure 1. Proposed M 51 in the City of Niles and Niles Township.

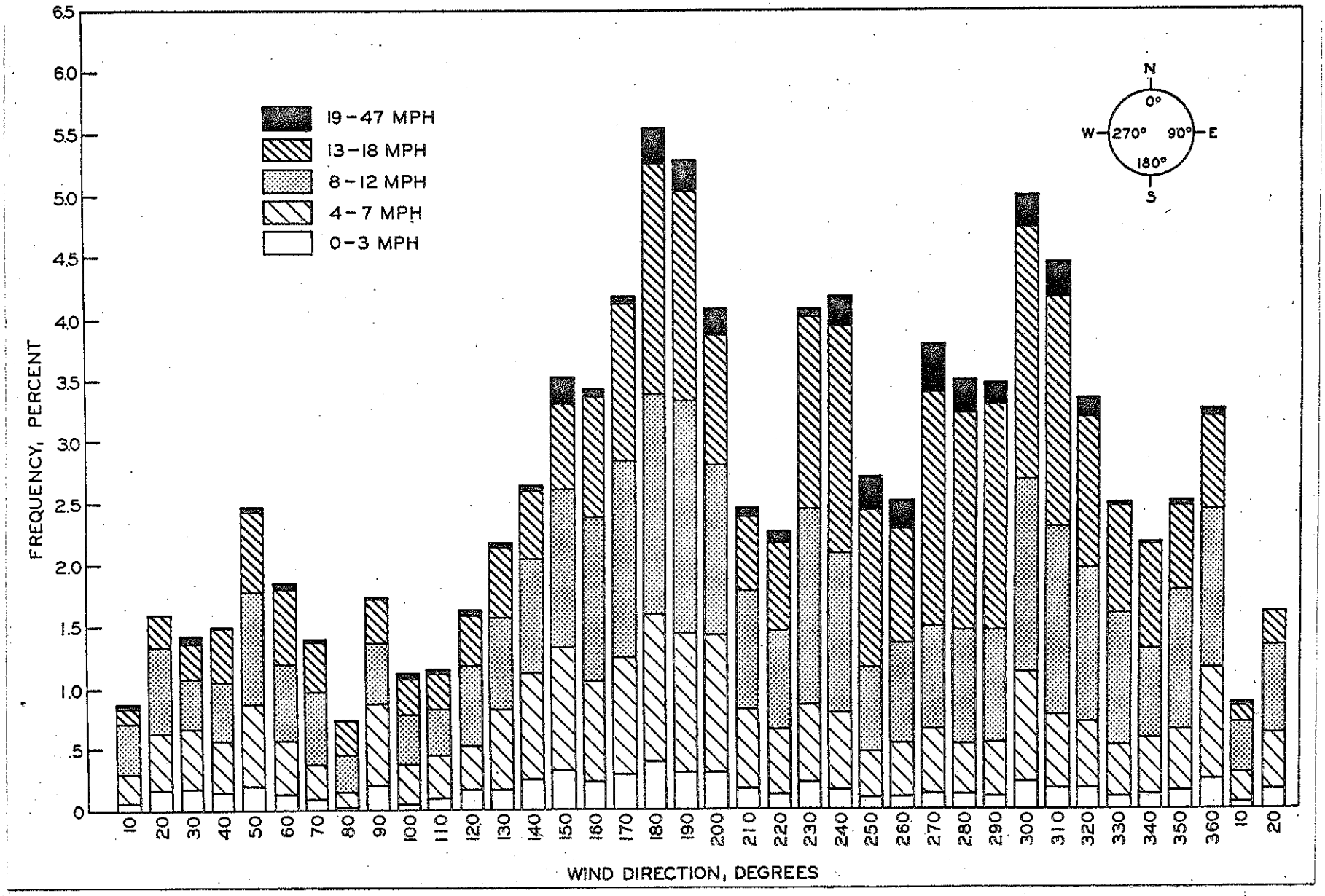

Figure 2. Wind speed and direction occurrences at Kalamazoo city weather station, 6 a.m. to 11 p.m.

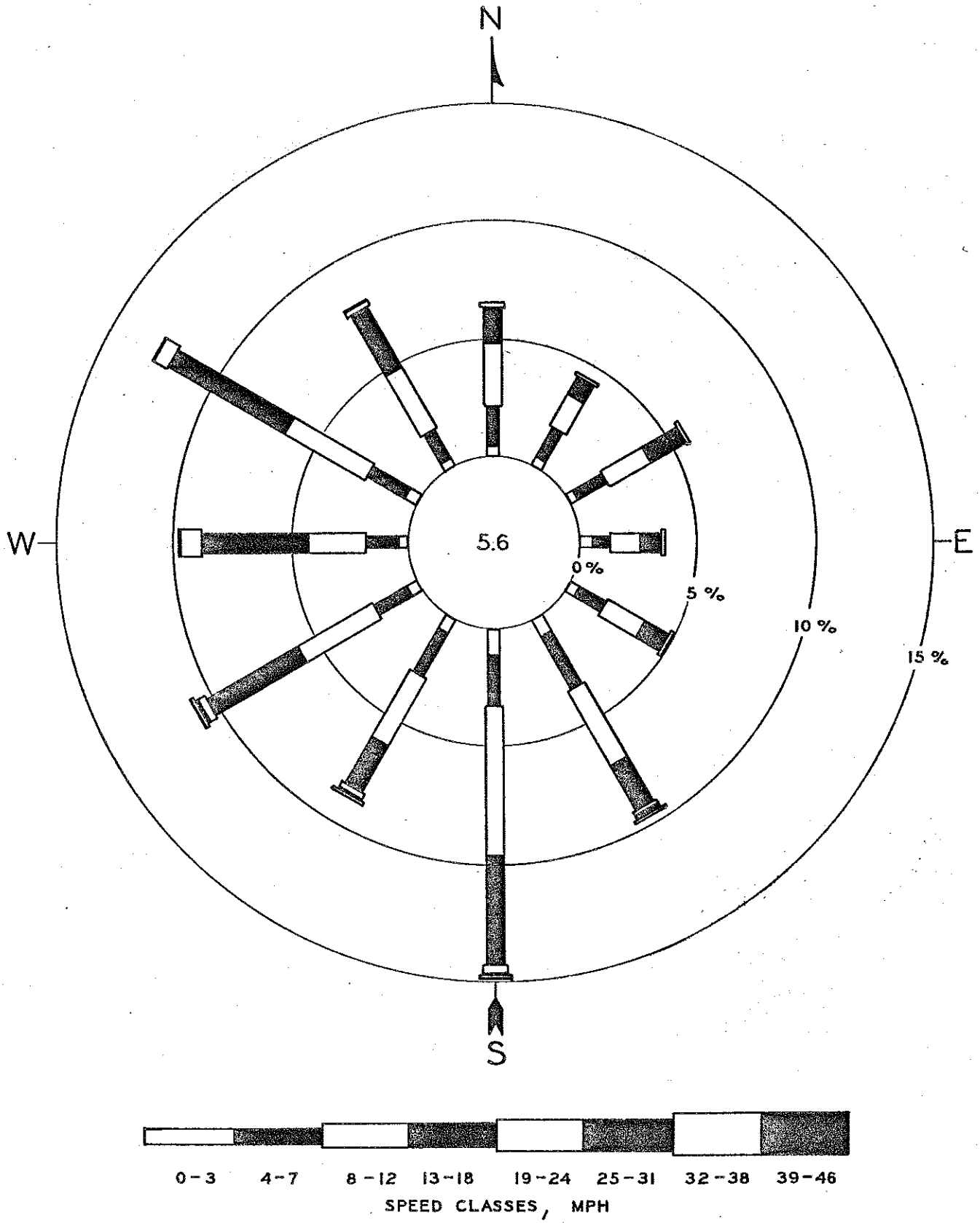

Figure 3. Frequency of wind direction and speed, percent (calms distributed).

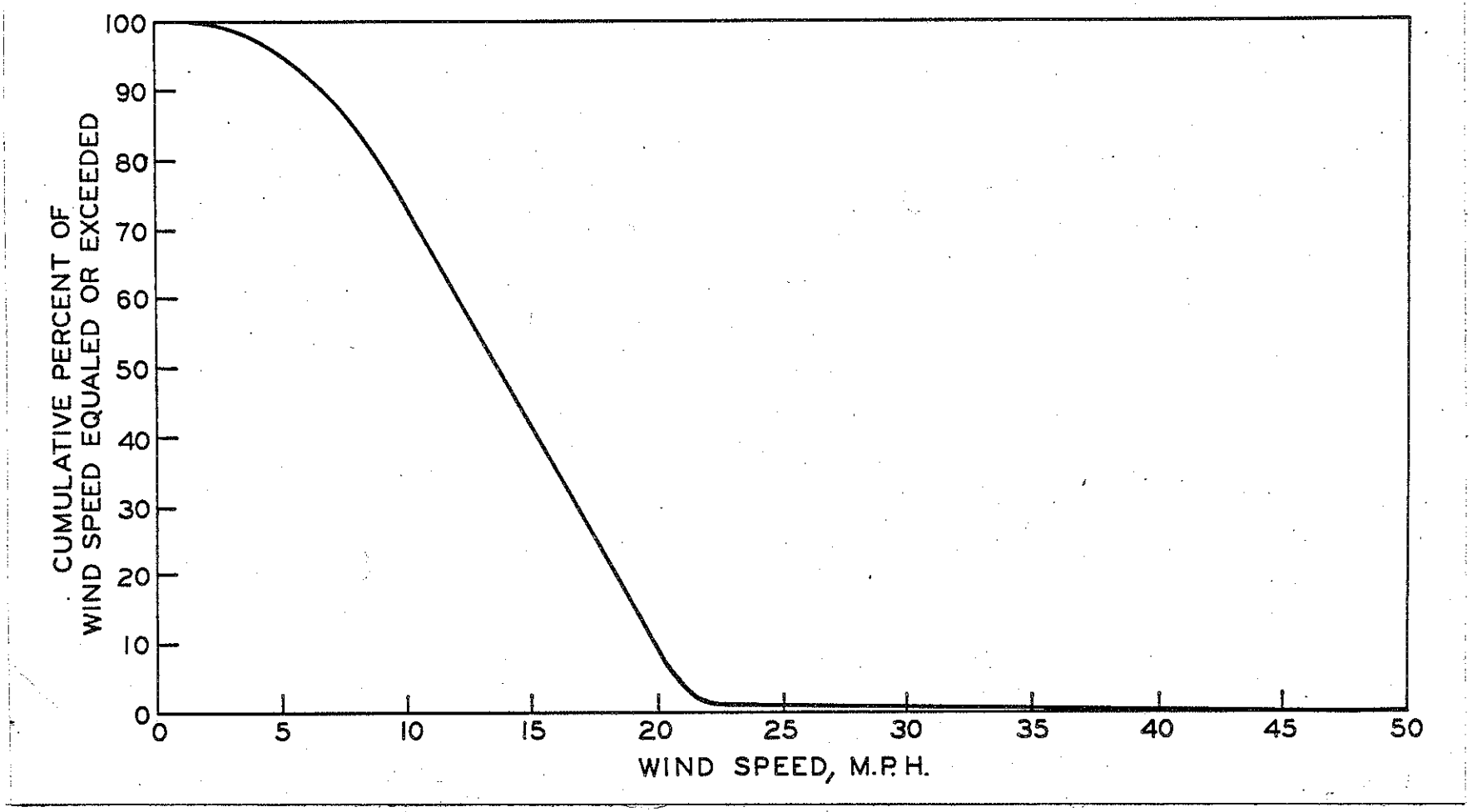

Figure 4. Wind speed distribution at Kalamazoo city weather station.

Pollution Estimates

Estimates of carbon monoxide concentrations were made at a height of 1.5 meters (5 ft) above the roadway. A mathematical model based on the Gaussian diffusion equation, modified for a line source, was used[1]. Inputs to the model include wind speed and direction, traffic volumes, vehicle emission factors and design of the highway.

Carbon monoxide concentrations were estimated for:

1) Four alternate alignments identified as follows:

Alternate 1 - "Do Nothing" - existing roadways.

Alternate 2 - "Low Cost Capital Improvement" - Fifth St (existing M 51) widened to four 11-ft lanes within existing 66-ft right-of-way. Main St widened to five 11-ft lanes within existing 78 ft of right-of-way.

Alternate 3 - "M 51 Reconstructed Along Fifth St" (existing M 51) - Five 12-ft lanes along existing alignment in 120 ft of right-of-way from Main St to the city limits (north of Wurz St) and in 150 ft of right-of-way from the city limits to the end of the project (north of Pucker St). Main St widened to five 11-ft lanes within existing 78 ft of right-of-way.

Alternate 4 - "M 51 Relocated Along Twelfth St" - Five 12-ft lanes in 120 ft of right-of-way from Main St to the city limits and in 150 ft of right-of-way from the city limits to the end of the project (north of Pucker St). Main St widened to five 11-ft lanes within existing right-of-way. It has not yet been determined whether the widening of M 51 described in Alternates 3 and 4 will occur to the east or to the west of the existing roadway.

2) At the estimated distance from the edge of the roadway to the nearest receptor for each alternate: Alternate 1, 7 m, Alternate 2, 4 m, Alternates 3 and 4, 9 m.

3) One major cross-street, Main St, at a distance of 7 m from the edge of the roadway for Alternate 1 and 4 m from the edge of the roadway for Alternates 2, 3, and 4 (estimated distance to the nearest receptor).

[1] Beaton, J. L., Ranzieri, A. J., Shirley, E. C., and Skog, J. B., "Mathematical Approach to Estimating Highway Impact on Air Quality," Prepared by California Division of Highways, Report No. FHWA-RD-72-36. CALINE 2 modification, programmed March 1975, was used.

4) At three sensitive receptors described later.

5) The years 1980, 1985, and 2000.

Information used as input to the model consisted of:

1) Vehicle emission factors, shown in the following table, were calculated using procedures from "Compilation of Air Pollution Emission Factors," AP 42, Supplement No. 5, December 1975 edition, U. S. Environmental Protection Agency. Emission factors were calculated at temperatures of 30 F and 60 F with 20 percent of vehicles in a cold start condition, 27 percent of vehicles in a hot start condition, and the remainder of vehicles in a hot operation mode. Vehicle age mix data used were for Michigan registrations obtained from the Secretary of State. National estimates from AP 42 for average annual miles driven for various age vehicles were used.

EMISSION FACTORS FOR
CARBON MONOXIDE, g/mi

Temp.	Year	Average Vehicle Speed, mph								
		10 (2)*	10 (5)	15 (2)	15 (5)	25 (2)	25 (3)	30 (2)	30 (3)	30 (4)
30 F	1980	--	113.3	65.7	67.8	--	--	32.6	33.0	33.4
	1985	--	66.7	37.2	39.5	--	23.1	18.4	--	19.3
	2000	42.7	45.6	--	--	15.2	15.7	--	--	13.2
60 F	1980	--	72.7	41.3	44.2	--	--	20.6	21.1	21.7
	1985	--	39.4	21.1	23.8	--	13.4	10.4	--	11.5
	2000	23.9	27.4	--	--	8.7	9.2	--	--	8.1

* (0) Percent heavy duty vehicles

2) Estimated yearly hour peak (4:00 p.m. to 5:00 p.m.), traffic volumes. Traffic estimates are shown in Table 1.

3) Meteorological Conditions.

a) Worst meteorological conditions were taken as a 2.2 mph (1 m/sec) wind parallel to the roadway, under atmospheric stability class D.

b) Most probable meteorological conditions, a 12 mph wind at 180 degrees under atmospheric stability class D.

TABLE 1

TRAFFIC ESTIMATES FOR PROPOSED M 51 AND ONE MAJOR CROSS STREET (MAIN ST) IN THE CITY OF NILES AND NILES TOWNSHIP

Location	Year	Alternate			
		Do Nothing	Low Cost Capital Improvement	Reconstruction Along Fifth St	Relocated Along Twelfth St
M 51	1980	1,920(10)	1,920(15)	1,920(15)	1,520(30)
	1985	2,070(10)	2,070(15)	2,070(15)	1,650(30)
	2000	2,540(10)	2,540(10)	2,540(10)	2,140(30)
Main St	1980	2,190(30)	2,190(30)	2,190(30)	1,920(30)
	1985	2,390(25)	2,390(25)	2,390(25)	2,110(30)
	2000	2,550(25)	2,550(25)	2,550(25)	2,330(25)
Fifth St After M 51 Relocated Along Twelfth St	1980	---	---	---	1,370(15)
	1985	---	---	---	1,480(15)
	2000	---	---	---	1,810(10)

Commercial Vehicles:
Alternates 1, 2, and 3 - M 51, 5 percent; Main St, 3 percent
Alternate 4 - M 51, 4 percent; Main St, 3 percent; Fifth St, 2 percent

000 = Yearly peak hour traffic, vehicles per hour
(00) = Average traffic speeds, mph

4) Road Profile. All alternates are at grade.

5) Roadway Widths. The widths for each of the alternates are described in Item 1, under carbon monoxide concentrations.

All estimates of carbon monoxide levels represent 1-hour concentrations and are in addition to existing background levels. Table 2 presents estimates of carbon monoxide, excluding background, at the nearest receptor to the roadway for the highest traffic volume section within each alternate and for Main St. Also included in Table 2 are estimates of carbon monoxide adjacent to the M 51/Main St intersection and for Fifth St (present M 51) if M 51 is relocated along Twelfth St.

Comparison of Estimates with Air Quality Standards

a) Eight-hour carbon monoxide air quality standard - 10 mg/cu m (9 ppm)

The Federal Highway Administration's report "Project Level Considerations to Assure Adequate Air Quality Analyses" suggests a technique

TABLE 2
ESTIMATES OF CARBON MONOXIDE FROM THE ROADWAY
(Not Including Background)

Location	Traffic Projection Year	Worst Condition, Parallel Wind, 1 m/sec, Stability D, Peak Traffic				Most Probable Condition,[1] Stability D, Peak Traffic			
		Alternate[2]				Alternate[2]			
		1	2	3	4	1	2	3	4
M 51	1980	16.8	13.7	9.5	3.7	2.0	1.7	1.2	0.4
	1985	10.6	8.6	6.0	2.3	1.2	1.0	0.7	0.3
	2000	8.9	12.2	8.5	2.1	1.0	1.4	0.9	0.2
Main St	1980	5.7	7.6	7.6	6.6	0.2	0.3	0.3	0.3
	1985	4.4	5.8	5.8	4.1	0.2	0.2	0.2	0.2
	2000	3.2	4.2	4.2	3.7	0.1	0.2	0.2	0.1
Adjacent to M 51-Main St Intersection[3]	1980	18.6	16.2	12.0	7.7	---	---	---	---
	1985	12.0	10.5	7.9	4.8	---	---	---	---
	2000	9.9	13.6	9.9	4.3	---	---	---	---
Fifth St after M 51 relocated along Twelfth St	1980	--	--	--	6.9	---	---	---	0.8
	1985	--	--	--	4.2	---	---	---	0.4
	2000	--	--	--	6.0	---	---	---	0.6

[1] Most probable wind: 12 mph; angle between wind direction and roadway direction, 0 degrees for M 51, 75 degrees for Main St.

[2] Alternate 1 - Do Nothing
Alternate 2 - Low Cost Capital Improvement
Alternate 3 - M 51 Reconstruction Along Fifth St
Alternate 4 - M 51 Relocated Along Twelfth St

[3] The worst condition for the Main St intersection was found to be the wind parallel to M 51 and 90 degrees to Main St for Alternates 1, 2, and 3 and the wind parallel to Main St and 90 degrees to M 51 for Alternate 4.

for determining the 8-hour carbon monoxide concentration from the 1-hour concentrations.

$$\frac{V_8}{V_1} \times (\text{1-hr CO concentration}) \times P = \text{8-hr CO concentration}$$

where V_8 = average hourly traffic volume in both directions during the 8-hour period of interest

V_1 = peak hour traffic volume in both directions

P = 1 to 8-hour meteorological persistence factor for the 8-hour period

A value of P = 0.6 is suggested unless data are available to calculate a persistence factor for the proposed highway projects.

If this technique is used to calculate the 8-hour carbon monoxide level in 1980 for each alternate, and also adjacent to the Main St intersection the highest 8-hour concentration from the roadway for the four alternates are:

$$\text{Alternate 1} = \frac{680 \text{ vehicles per hour}}{1,920 \text{ vehicles per hour}} \times 16.8 \text{ mg/cu m} \times 0.6 = 3.6 \text{ mg/cu m}$$

$$\text{Alternate 2} = \frac{680 \text{ vehicles per hour}}{1,920 \text{ vehicles per hour}} \times 13.7 \text{ mg/cu m} \times 0.6 = 2.9 \text{ mg/cu m}$$

$$\text{Alternate 3} = \frac{680 \text{ vehicles per hour}}{1,920 \text{ vehicles per hour}} \times 9.5 \text{ mg/cu m} \times 0.6 = 2.0 \text{ mg/cu m}$$

$$\text{Alternate 4} = \frac{540 \text{ vehicles per hour}}{1,520 \text{ vehicles per hour}} \times 3.7 \text{ mg/cu m} \times 0.6 = 0.8 \text{ mg/cu m}$$

The highest 8-hour concentration adjacent to the Main St intersection for the four alternates are:

$$\text{Alternate 1} = \frac{680 + 1,130 \text{ vehicles per hour}}{1,920 + 2,190 \text{ vehicles per hour}} \times 18.6 \text{ mg/cu m} \times 0.6$$

$$= 4.9 \text{ mg/cu m}$$

$$\text{Alternate 2} = \frac{680 + 1,130 \text{ vehicles per hour}}{1,920 + 2,190 \text{ vehicles per hour}} \times 16.2 \text{ mg/cu m} \times 0.6$$

$$= 4.3 \text{ mg/cu m}$$

$$\text{Alternate 3} = \frac{680 + 1,130 \text{ vehicles per hour}}{1,920 + 2,190 \text{ vehicles per hour}} \times 12.0 \text{ mg/cu m} \times 0.6$$

$$= 3.2 \text{ mg/cu m}$$

$$\text{Alternate 4} = \frac{540 + 990 \text{ vehicles per hour}}{1,520 + 1,920 \text{ vehicles per hour}} \times 7.7 \text{ mg/cu m} \times 0.6$$

$$= 2.1 \text{ mg/cu m}$$

Adding these concentrations to the 1-3 mg/cu m estimated maximum 8-hour background results in total carbon monoxide concentrations of 4.6-6.6, 3.9-5.9, 3.0-5.0, and 1.8-3.8 mg/cu m for Alternates 1, 2, 3, and 4, respectively, and 5.9-7.9, 5.3-7.3, 4.2-6.2, and 3.1-5.1 mg/cu m

adjacent to the Main St intersection for each of the alternates. Carbon monoxide levels adjacent to all of the alternates are below the air quality standard. For the years 1985 and 2000 the carbon monoxide concentrations are estimated to be much lower than 1980 concentrations due to vehicle exhaust controls required by Federal Law.

b) One-hour carbon monoxide standard - 40 mg/cu m (36 ppm)

The maximum estimated 1-hour concentrations of carbon monoxide adjacent to the roadway in 1980 are 16.8, 13.7, 9.5, and 3.7 mg/cu m for Alternates 1, 2, 3, and 4, respectively, and 18.6, 16.2, 12.0, and 7.7 mg/cu m adjacent to the Main St intersection for each of the alternates. Adding these concentrations to the 4-8 mg/cu m estimated background results in total 1-hour concentrations of 20.8-24.8, 17.7-21.7, 13.7-17.7, and 7.7-11.7 mg/cu m for Alternates 1, 2, 3, and 4, respectively, and 22.6-26.6, 20.2-24.2, 16.0-20.0, and 11.1-15.1 mg/cu m adjacent to the Main St intersection for each of the alternates. All are below the 40 mg/cu m standard.

The estimated concentrations of carbon monoxide including existing estimated background adjacent to all of the alternates of the proposed roadway are within national air quality standards. Alternates 2, 3, and 4 offer a significant reduction in carbon monoxide levels over Alternate 1 (Do Nothing) with Alternate 4 offering the greatest reduction. However, if M 51 is relocated along Twelfth St carbon monoxide concentrations of 6.9, 4.2, and 6.0 mg/cu m, excluding background, will continue to exist adjacent to Fifth St for the years 1980, 1985, and 2000, respectively. The project is consistent with the State implementation plan for meeting national air quality standards for carbon monoxide.

Additional Information for Receptor Sites

Concentrations of carbon monoxide were estimated at two schools, and a playground near the proposed route (Fig. 1). The locations are as follows:

1. The school located near Wurz St approximately 60 ft west of the existing M 51 right-of-way.

2. The school located approximately 100 ft south of the existing Main St right-of-way.

3. The playground located in the southwest quadrant of the intersection of existing M 51 and Eagle St. The playground extends to the right-of-way.

Estimated worst case levels of carbon monoxide from the roadway under peak traffic conditions, with a 1 m/sec wind blowing parallel to the roadway (Main St for Receptor 2) under stability D for each receptor for Alternates 1, 2, and 3 are shown in Table 3. Alternate 4 is several blocks from the above receptors so would have no significant influence on carbon monoxide levels in their proximity. The highest carbon monoxide levels from any of the alternates adjacent to any of the receptors is 15.7 mg/cu m for Alternate 1. If the highest estimated 1-hour background of 8 mg/cu m is added, the highest 1-hour carbon monoxide concentration at any of the receptors is 23.7 mg/cu m which is below the Federal Air Quality Standard.

TABLE 3
CARBON MONOXIDE, mg/cu m

Receptor	Traffic Projection Year	Alternate			
		Do Nothing	Low Cost Capital Improvement	M 51 Reconstruction Along Fifth St	
				Widened to East of Existing Roadway	Widened to West of Existing Roadway
Edge of School Grounds	1980	16.8	13.7	9.5	9.5
	1985	10.6	8.6	6.0	6.0
	2000	8.9	12.2	8.5	8.5
School Building	1980	13.5	7.6	7.6	8.4
	1985	8.5	4.8	4.8	5.3
	2000	7.2	6.8	6.7	7.5
Edge of School Grounds	1980	5.7	7.6	7.6	7.6
	1985	4.4	5.8	5.8	5.8
	2000	3.2	4.2	4.2	4.2
School Building	1980	4.4	4.1	4.1	4.1
	1985	3.3	3.2	3.2	3.2
	2000	2.4	2.3	2.3	2.3
Edge of Playground	1980	16.8	13.7	9.5	9.5
	1985	10.6	8.6	6.0	6.0
	2000	8.9	12.2	8.5	8.5

Total Pollutant Burden Analysis

A total pollutant burden analysis for carbon monoxide, hydrocarbons, and oxides of nitrogen is included for each of the alternates for the years 1980, 1985, and 2000. Information used included:

1) Vehicle emission factors calculated as described previously in Item (1), under information used as input to the model.

2) Estimates of daily vehicle miles traveled, average vehicle speeds, and percent heavy duty vehicles (Table 4). The total pollutant burden data presented in Table 5 show a reduction in all pollutants if either Alternates 2, 3, or 4 are constructed with Alternate 4 showing the greatest reduction.

TABLE 4
TRAFFIC ESTIMATES FOR M 51 TOTAL POLLUTANT BURDEN (MESOSCALE) ANALYSIS

Roadway	Alternate 1[1]			Alternates 2 and 3[2]			Alternate 4[3]		
	1980	1985	2000	1980	1985	2000	1980	1985	2000
M 51									
Main to Sycamore									
VMT	1,130	1,250	1,770	1,130	1,250	1,770	3,230	3,610	5,090
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	5	5	5	5	5	5	6	6	6
Sycamore to Wayne									
VMT	3,940	4,570	7,120	3,940	4,570	7,120	4,200	4,700	6,620
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	6	6	6	6	6	6	6	6	6
Wayne to Lake									
VMT	6,060	6,920	10,460	6,060	6,920	10,460	4,620	5,160	7,220
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	5	5	5	5	5	5	7	7	7
Lake to Francis									
VMT	21,030	23,740	34,960	21,030	23,740	34,960	12,510	14,200	20,930
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	6	6	6	6	6	6	7	7	7
Francis to Pucker									
VMT	5,710	6,590	10,280	5,710	6,590	10,280	5,710	6,590	10,280
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	8	8	8	8	8	8	8	8	8
Pucker to End of Project									
VMT	1,420	1,640	2,530	1,420	1,640	2,530	1,420	1,640	2,530
Average Speed	10	10	10	20	20	20	30	30	30
Percent Commercial	9	9	9	9	9	9	9	9	9
Main St									
Fifth to Ninth									
VMT	5,270	6,030	7,010	5,270	6,030	7,010	4,350	4,990	5,780
Average Speed	30	30	30	30	30	30	30	30	30
Percent Commercial	5	5	5	5	5	5	3	3	3

[1] Alternate 1 - Do Nothing
[2] Alternate 2 - Low Cost Capital Improvement; Alternate 3 - M 51 Reconstruction Along Fifth St
[3] Alternate 4 - M 51 Relocated Along Twelfth St

TABLE 5
ESTIMATES OF TOTAL POLLUTANT BURDEN

Traffic Projection Year	Alternate	Pollutant (tons/day)					
		Carbon Monoxide		Hydro-carbons		Oxides of Nitrogen	
		30 F*	60 F	30 F	60 F	30 F	60 F
1980	Do Nothing	5.14	3.34	0.44	0.35	0.22	0.20
	Low Cost Capital Improvement	2.49	1.65	0.31	0.25	0.21	0.19
	M 51 Reconstructed Along Fifth St	2.49	1.65	0.31	0.25	0.21	0.19
	M 51 Relocated Along Twelfth St	1.37	0.92	0.21	0.17	0.19	0.17
1985	Do Nothing	3.47	2.10	0.25	0.19	0.16	0.15
	Low Cost Capital Improvement	1.67	1.04	0.18	0.14	0.16	0.14
	M 51 Reconstructed Along Fifth St	1.67	1.04	0.18	0.14	0.16	0.14
	M 51 Relocated Along Twelfth St	0.92	0.58	0.12	0.10	0.14	0.13
2000	Do Nothing	3.57	2.20	0.25	0.19	0.20	0.18
	Low Cost Capital Improvement	1.72	1.10	0.17	0.14	0.19	0.18
	M 51 Reconstructed Along Fifth St	1.72	1.10	0.17	0.14	0.19	0.18
	M 51 Relocated Along Twelfth St	0.93	0.61	0.11	0.09	0.17	0.16

* Ambient air temperature.