HOW ROADSIDE FEATURES AFFECT TRAFFIC ACCIDENT EXPERIENCE

SECOND PROGRESS REPORT

ON THE MICHIGAN STUDY

1951

MICHIGAN STATE HIGHWAY DEPARTMENT

Charles M. Ziegler State Highway Commissioner

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2nd Progress Report On the Michigan Study

Cooperating Agencies:

Michigan State Police

U. S. Department of Commerce
Bureau of Public Roads

Prepared By
Planning and Traffic Division
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FOREWORD

This report describes the current progress of a research project which seeks to determine the relationships between accident occurrence and various features of the road and roadside. This study is an outgrowth of the countrywide program launched in 1945 by the National Safety Council in which each of the states investigated its 1941 accidents.

To remedy certain inadequacies of the data, the Michigan State Highway Department in 1946 initiated the present study in cooperation with the Bureau of Public Roads. A 70-mile stretch of highway on Telegraph Road (US-24) from the Ohio state line across the western side of the Detroit area to Pontiac, was selected for study (See Figure 1). It was divided into 1000-foot sections designated by numbered markers, and all roadway and roadside features in each section were carefully inventoried and located. Starting with 1947, State and local police agencies reported all accidents on the road with reference to the exact location of occurence.

Two methods were employed to analyze the data. The first method was to tabulate frequency distributions of accidents according to their distance from each specified type of feature; from these distributions, accumulative percentages within various distances were computed and rate curves drawn. The second method was to calculate correlation coefficients between the number of accidents and the number of various design and roadside features as they occurred in the several road sections.

In 1949, a report was made of the analysis of 1947 and 1948 accidents. The results presented a clear picture of the importance of intersections and intersection conditions in accident production. However, because roadside establishments of various kinds are so frequently concentrated at intersection locations, it was found to be impossible to satisfactorily analyze the relationships of individual features. For that reason, the present phase of the study was undertaken for the purpose of more clearly segregating the influence of intersection traffic operation and roadside features in intersection locations.

In the field work for this expanded study of the relationship between accident occurence and the features of the roadway and along the roadside, the Department has worked in close cooperation with the Michigan State Police. The quality of the accident data available for analysis is due to the care with which state troopers and enforecment officers from sheriff's and local police departments have recorded the locations of accident occurence. Their cooperation has been helpful and is acknowledged.

ACCIDENT ANALYSIS STUDY ROAD U.S.-24 AND M-58

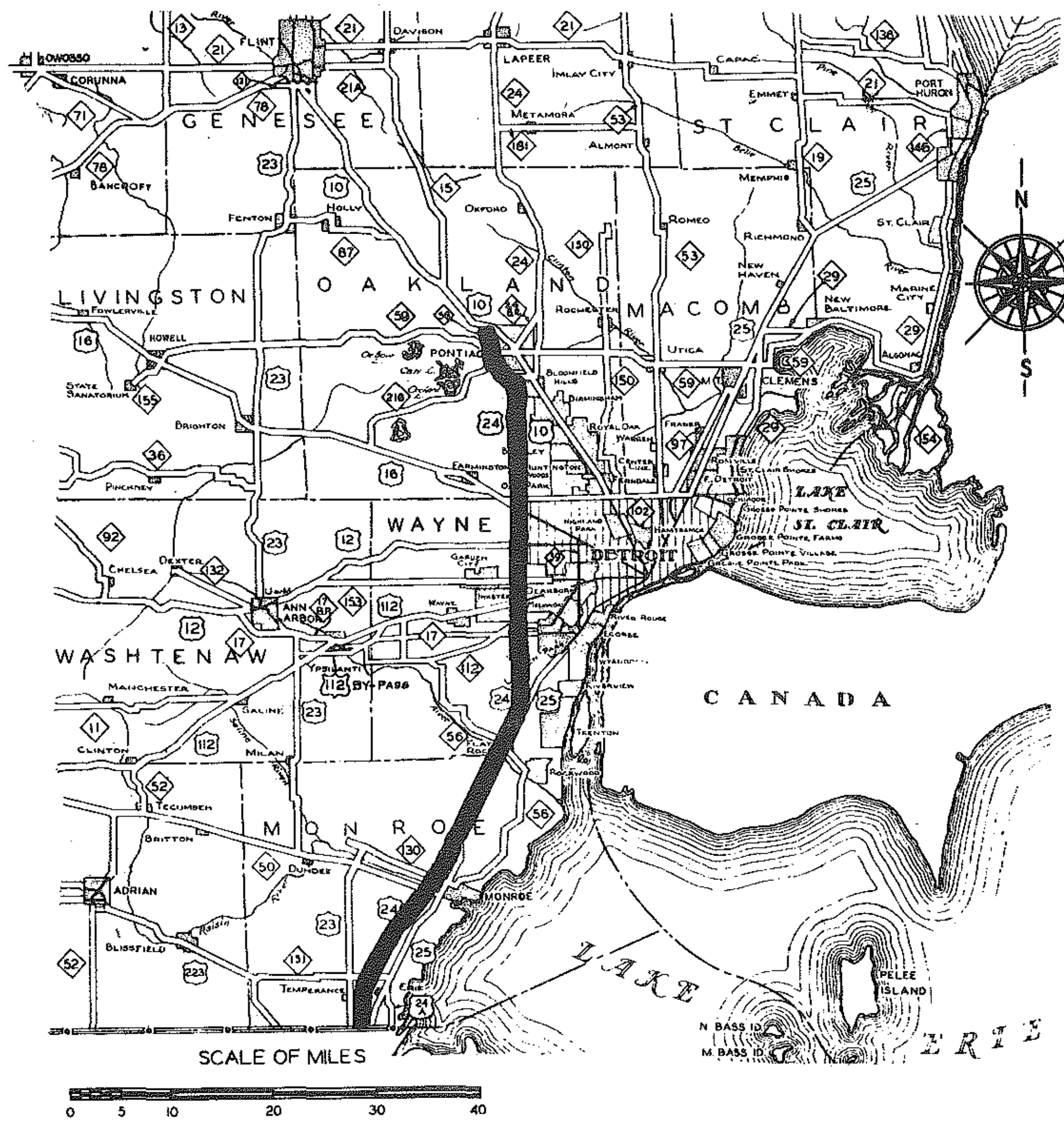

FIGURE I

ROADWAY AND ROADSIDE FEATURES

AND ACCIDENT OCCURENCE

2nd Progress Report

Following the first analysis of the 1947-48 accidents on Telegraph Road and the release of reports thereon in 1949, it was felt by many that the basic methods of approach could be improved. Therefore, starting with the basic data, the accident reports, a re-analysis was made. In an effort to improve the methods certain changes were made which, together with a brief discussion of each, are as follows:

1. Certain urban sections in or near the incorporated areas of Monroe, Flatrock, Dearborn and Pontiac totalling about 6 miles of highway, were not included in the re-analysis. The object of this deletion was to confine the study to accidents occurring in areas more consistently rural in character.

2. Those parts of the route used were divided into two kinds of sections as follows:

   a. Intersection

   b. Non-Intersection

   The intersection sections each included one or more major intersections; two of these sections were slightly over a mile in length and included several major intersections. The non-intersection sections included no major intersections, only minor intersections. The average length of the intersection sections was about 830 feet and of the non-intersection sections about 1,680 feet. This division into two major types of section answered the main criticism of the first analysis and at the same time made possible a more objective analysis of the data.

3. Traffic volume counts were taken at sufficiently short intervals along this route to measure the significant changes in traffic volume. These were used to establish a 1948 annual average daily traffic volume for

each section included in the study. This made possible the computation of number of accidents per million vehicle miles for any section or group of sections.

4. Several minor changes were made in the manner of recording the accidents in the tabulating cards. These changes were based on the experience gained in the first analysis.

The design features, roadside features, classifications of advertising signs and the numbers of each used in the second alaysis were as follows:

	Number in Each Kind of section	
Design Features 1/	Non-Intersection	Intersection
Intersection	3/	3/
Crest of Hill	18	6
Transition in Width or Arrangement of Lanes	10	36
Handrails at Bridges, Culverts, or Grade Separations	27	9
Culvert Posts	37	16
Guardrails	51	13
Roadside Features		
Private Drives	525	170
Parks - Including Roadside and Trailer	33	5
Taverns	13	28
Gasoline Stations and Commercial Garages	25	96
Stores	46	67
Restaurants	26	46
Other Establishments 2/	112	93
Advertising Signs		
Large and Prominent	119	62
Medium Size	191	162
Small Size	250	261
Signs were also classified as follows:		
Illuminated	58	108
Neon and Flashing Neon	68	98
Reflectorized	46	18
Miscellaneous	388	261

1/ Data relating to two other features, Points of Curvature and Grade Separations Abutments and Piers, were recorded in the tabulating cards but were not used in the analysis because of their small number.

2/ In the second analysis "Other Establishments" did not include any of the above listed roadside features as they did in the first analysis.

3/ The number of individual intersections was not recorded in the second analysis.

IBM Card Forms

To facilitate computing and tabulating, the data were placed in two different punch card forms. Of the one form, one card was made for each accident included in the study. These cards contained the usual identifactory items; distance (coded in hundreds of feet) of occurrence of accident from each roadside and design feature and from large and prominent advertising signs; number of roadside features (not including private drives) and number of private drives and number of advertising signs, each within 100, 200, 300, 400, 500, and 600 feet of the accident; 1948 annual average daily traffic; and a few other items.

Of the second punch card form, one was made for each section. These cards contained by way of identification the station number at the north end of the section; number of accidents in the section; number of each design feature, number of each roadside feature and number of advertising signs of each kind; 1948 annual average daily traffic; and section length. Accident density expressed in terms of number of accidents per hundred feet of section length and 1948 annual average daily vehicle miles were added to these cards by means of the automatic multiplying punch.

All cards of both forms contained kind of section identification--intersection or non-intersection. The accident cards contained data for accidents occurring in 1947, 1948, and 1949, while the section cards contained data for only 1947 and 1948. Consequently, part of the analysis and the results presented here are based on three years' accidents and part on two years' accidents.

The second analysis proceeded in many respects the same as the first. However, some of the procedures thought to have little significance in the first analysis were omitted in the second. Some new procedures were introduced in the second analysis. The chief difference between the two analyses was the fact that in the second the data were analyzed for the most part for intersection and non-

Table I

Comparison between Intersection and Non-Intersection Sections of

Number of Accidents, Distance, Vehicle Miles and Accident Rate

Type of Section	1947-48 Accidents		Total Distance Studied		1948 Annual Average Daily Vehicle Miles		Accidents per Year Per Million Vehicle Miles
	Number	Percent	100 Ft.	Percent	Number	Percent	
Intersection	1,384	70	991	29	213,596	30	8.88
Non-Intersection	584	30	2,412	71	500,821	70	1.60
Total	1,968	100	3,403	100	714,416	100	3.77

intersection sections separately.

As in the first analysis, so in this, the analysis and the conclusions drawn therefrom are based on the philosophy that, regardless of how much data are available, the precise cause of accidents cannot be positively determined. One can only record and study a limited number of conditions under which accidents have been reported to occur. However, by tabulating the data in many ways one can compute various statistics and carry out other analytical procedures in the hope of obtaining a clearer picture of the extent of relationship, if any exists, between the occurrence of accidents and the conditions studied. The purpose of this analysis was to do just this.

Table I

The first analysis pointed clearly to the seriousness of the intersection situation along this route. The second analysis emphasizes it still more. The few figures in Table I will show at a glance that intersection sections have a much worse accident experience than non-intersection sections. The former occupy only 29 percent of the distance under study and generate only 30 percent of the vehicle miles, yet 70 percent of the accidents occurred here. The accident rate on these intersection sections is extremely high-8.88 accidents per year per million vehicle miles. The accident rate on the non-intersection sections is 1.60; this figure compares favorably with that found for all Michigan rural state trunklines with high type surfaces of all widths in 1936-41. The latter rate was 1.68.

Tables II and III

This analysis attacked the problem first from the angle of proximity of accidents to design and roadside features including large and prominent advertising signs. Frequency distributions of the distance (in increments of 100 feet) of accidents from each of the various features were tabulated. The numbers of accidents in each such distribution were divided by the appropriate total number of features to obtain the number of accidents occurring in three years (1947-48-49) per feature

Table II
Rate of Occurrence of Accidents per Feature per 100 Feet
Intersection Sections

Group I - Maximum Rates Exceeding 8.00

Distance (Feet)	Crests of Hill	Inter-Sections	Gasoline Stations & Commercial Garages	Taverns	Restaurants	Parks	Hand-rails
0-99	29.50	14.97	12.38	11.96	10.31	2.80	2.00
100-199	5.33	1.95	1.69	14.61	7.15	4.60	2.67
200-299	4.33	0.68	0.67	2.64	3.41	7.60	5.33
300-399	8.83	0.20	0.49	1.18	1.87	14.20	7.67
400-500	8.00	0.03	0.42	1.07	1.22	6.80	9.00

Group II - Maximum Rate Between 4.01 and 8.00

Distance (Feet)	Guard-rails	Stores	Other Establish-ments	Transition in Width
0-99	7.92	6.51	5.30	4.64
100-199	5.85	3.69	4.49	5.28
200-299	6.26	1.70	2.32	1.25
300-399	3.77	2.19	1.89	0.94
400-500	2.92	0.88	0.84	0.92

Group III - Maximum Rate Never Exceeding 4.00

Distance (Feet)	Large and Prominent Signs	Culvert Posts	Private Drives
0-99	4.00	3.06	1.70
100-199	2.42	1.69	2.18
200-299	1.13	1.63	1.75
300-399	0.77	0.94	0.86
400-500	1.48	1.69	0.79

Table III

Rate of Occurrence of Accidents per Feature per 100 Feet
Non-Intersection Sections

Group I - Maximum Rate Between 2.01 and 3.00

Distance (Feet)	Taverns	Gasoline Stations & Commercial Garages	Restaurants
0-99	2.77	2.08	2.04
100-199	1.62	1.12	1.65
200-299	1.54	1.96	1.77
300-399	2.15	1.84	1.15
400-500	1.31	2.36	0.96

Group II - Maximum Rate Between 1.01 and 2.00

Distance (Feet)	Other Establishments	Guard-rails	Stores	Transition in Width	Crests of Hills	Handrails
0-99	1.68	1.67	1.54	1.20	1.17	1.07
100-199	0.72	0.39	0.74	1.50	0.78	0.81
200-299	0.46	0.37	0.89	1.30	0.56	0.81
300-399	0.37	0.16	1.00	1.40	0.50	0.85
400-500	0.31	0.45	0.96	1.80	1.00	0.56

Group III - Maximum Rate Never Exceeding 1.00

Distance (Feet)	Culvert Posts	Parks	Private Drives	Large and Prominent Signs
0-99	0.92	0.82	0.69	0.47
100-199	0.41	0.64	0.31	0.44
200-299	0.78	0.67	0.15	0.45
300-399	0.73	0.73	0.12	0.46
400-500	0.62	0.58	0.09	0.29

in each 100-foot increment of distance from the feature. This was done for the intersection and non-intersection sections separately. The results are shown in Tables II and III. These results are not comparable to those in the first analysis because they are for 3 years instead of 2 and for two kinds of sections separately. The features have been divided into 3 groups in each of Tables II and III according to maximum rates attained.

These two tables clearly demonstrate the vast difference between intersection and non-intersection sections. The intersection sections have rates of occurrence that are consistently much higher than those of the non-intersection sections. Attention is called to the rapidity with which the rates for some of the features in Group I of intersection sections fall off as compared to that for the same features in the non-intersection sections. The variation of the rates among increments of distance is much less for the same feature in the non-intersection than in the intersection sections. Tables II and III show the effect of the concentration of features about intersections. Undoubtedly hillcrests and intersections are bad combinations.

<u>Correlation Coefficients</u>

The problem was next attacked by way of the correlation coefficient. This coefficient is a relative measure of the amount of association between one variable and one or more other variables. The amount of association is measured on a scale ranging from -1 to +1. It is an abstract number free of any unit of measure. If two variables are perfectly associated; i.e., if one varies directly as the other, their correlation will be exactly one. Or if one varies inversely as the other, their correlation will be exactly -1. If one varies with pefect randomness with respect to the other, their correlation will be zero. Graphically this means that if one variable is plotted against the other, and all the points lie on a straight line, the correlation between the two will be +1 or -1, depending upon whether the line has a positive or negative slope. The correlation coefficient provides a more objective method of approach than that of the proximity of features method.

Table IV

The correlation coefficients were computed from the data recorded in the section cards of which, as explained above, there was one for each intersection section and one for each non-intersection section. They are based on the accidents for the two years, 1947-1948. There were 119 intersection and 144 non-intersection sections. All correlation coefficients were computed for each kind of section separately. The correlation between accidents and the several design features, roadside features and advertising signs are shown in Table IV.

Most of these coefficients are higher for intersection than for non-intersection sections. Notable exceptions are culvert posts, large and prominent signs and reflectorized signs. Considering each kind of feature or advertising sign individually, the difference between the correlation coefficients for intersection and non-intersection sections is hardly significant in most cases. But using the method of weighted average correlation coefficients, it was found that the association of accidents with these features and advertising signs combined is very significantly greater in intersection than in non-intersection sections. By the same procedure design features and advertising signs show no significant difference between the two types of sections while roadside features show a highly significant difference. From this we can safely conclude that:

1. Accidents are associated with design features to about the same extent in both intersection and non-intersection sections.
2. Accidents are associated with roadside features significantly more in intersection sections than in non-intersection sections.
3. Accidents are associated with advertising signs to about the same extent in both intersection and non-intersection sections.

Nearly all the correlation coefficients for design features are too small to be given serious consideration. Many are insignificantly small. The importance of crests of hills indicated by the proximity study does not appear in the

Table IV

Correlation Coefficients of Accidents with Features and Advertising Signs for Non-Intersection Sections and for Intersection Sections

Features Correlated with Accidents	Correlation Coefficient Non-Intersection	Correlation Coefficient Intersection
Design Features:		
Crest of Hill	-.002*	.374
Transition in Width or Arrangement of Lanes	-.016*	.206*
Handrails at Bridge, Culvert or Grade Separation	.164*	.197*
Culvert Posts	.353	-.137*
Guard Rails	.131*	.217*
Weighted Average	.129	.228
Roadside Features:		
Private Drives	.513	.264
Parks	.455	.162*
Taverns	.313	.698
Gas Stations and Commercial Garages	.442	.666
Stores	.321	.526
Restaurants	.438	.651
Other Establishments	.443	.720
Weighted Average (excluding Private Drives and Parks)	.393	.657
Advertising Signs:		
Large and Prominent	.418	.367
Medium Size	.597	.578
Small Size	.482	.695
Illuminated	.561	.588
Neon and Flashing Neon	.428	.660
Reflectorized	.304	.130*
Miscellaneous	.484	.559
Weighted Average	.472	.530
1948 Annual Average Daily Vehicle Miles	.680	.720
Section Length	.719	.687
Multiple Correlations:		
Design Features	.393	.480
Roadside Feature Less Private Drives and Parks	.640	.859
Large, Medium and Small Advertising Signs	.606	.710
Illuminated, Neon and Flashing Neon, Reflectorized and Miscellaneous Advertising Signs	.635	.758

*Insignificantly small

correlation coefficient because of the very small number of this feature. Nevertheless, they do show greater association in intersection sections than any other design feature and are not to be ignored. Generally speaking, the association of accidents with design features is significantly less in both kinds of section than the association of accidents with roadside features or with advertising signs.

The difference between the association of accidents with roadside features (not including private drives and parks) and of accidents with advertising signs is hardly significant in the non-intersection sections. This difference is highly significant in the intersection sections where the accidents are associated with roadside features (not including private drives and parks) very much more closely than with advertising signs.

In computing the correlation coefficients, as well as in this discussion of them, private drives and parks are not included in the general term "roadside features". Although it is true that these two features are roadside features in one sense and are included under roadside features in Table IV, it was desired to treat commercial establishments only as a separate group. The term "roadside features" has generally been used for commercial establishments as a group.

It is worthwhile to note that accidents are significantly more closely associated with private drives and parks in non-intersection than in intersection sections. In fact, these two are more closely associated with accidents than are any of the other roadside features in intersection sections.

In all fairness to design and roadside features and to advertising signs, accidents were correlated with 1948 annual average daily vehicle miles and with section length. These coefficients are shown in Table IV. That there is little difference between the association of accidents with vehicle miles and with section length is not surprising since one is a function of the other. While it is true that vehicle miles and section length are much more closely associated with accidents than are roadside features and advertising signs (according to the weighted average coefficients of the latter), it is also true that section length is as closely or more closely associated with roadside features and advertising signs than are accidents. The following table shows the correlation among accidents, section length, vehicle miles, roadside features and advertising signs:

	Total Roadside Features 1/	Total Advertising Signs	Vehicle Miles	Section Length
Non-Intersection Sections -				
Accidents	.393	.472	.680	.719
Section Length	.353	.565	---	---
Intersection Sections -				
Accidents	.657	.530	.720	.687
Section Length	.734	.759	---	---

This means that, in the non-intersection sections, accidents tend to be somewhat evenly distributed spatially along the study route without much regard for roadside features and advertising signs. Roadside features and advertising signs are not so evenly distributed spatially along the study route, but tend to be grouped. At the same time, accidents are occurring more closely associated with section length, and hence vehicle miles, than with roadside features and advertising signs.

In the intersection sections, accidents again tend to be somewhat evenly distributed with respect to section length. But here the roadside features and advertising signs are much more evenly distributed with respect to section length; the association is significantly higher than in non-intersection sections. At the same time the association of accidents with roadside features has risen significantly over that found in non-intersection sections. The association of accidents with advertising signs has also risen appreciably, although not by a statistically significant amount.

All this is not to belittle the importance to accident occurrence of vehicle miles generated, but to point out that accidents, roadside features, advertising signs and vehicle miles appear to be interlocked. To completely isolate these various cross-influencesis a very difficult problem. It has been one of the

1/ Less private drives and parks.

primary aims of the analysis to bring about this isolation.

In order to more completely exhaust the possibilities of the correlation coefficient, multiple correlations were computed. Multiple correlation permits measuring the association of one variable with two or more other variables simultaneously. It permits the independent variables to exert their influence jointly upon the amount of association existing. Multiple correlation coefficients for accidents with design features, roadside features less private drives and parks, advertising signs classified by size, and advertising signs classified by type of lighting were computed for each kind of section. These are shown at the bottom of Table IV. These coefficients are much higher than the corresponding single coefficients because they reflect the additive effect of features and signs. Accident occurrence is much more closely associated with all roadside features or all advertising signs than with any one kind of feature or sign individually. The same is also true for design features. These multiple coefficients substantiate very well the findings from the simple coefficients.

The very high multiple correlation of 0.859 between accidents and roadside features in intersection sections is the most significant point in the correlation phase of this analysis. The coefficients of 0.710 and 0.758 for accidents with advertising signs rank second in this respect.

The difference between the coefficients for advertising signs classified by size and by type of lighting is not significant in either kind of section.

Table V

While the use of correlation coefficients makes possible a somewhat more precise analysis and one whose results can be tested for significant differences, the results are more difficult to interpret properly and explain in writing. Therefore the problem was again attacked by the method of accident density. In each section card the total number of accidents occurring in the two years, 1947 and 1948, was divided by the section length in hundreds of feet. Thus accident density

Table V.

Percent of Section Length and Accidents and Number of Roadside Features
and Advertising Signs Per 100 Feet
For Each of Five Groups of Accident Density

	Accident Density (Number of Accidents per 100 Ft.)					
	None	0.01-0.49	0.50-0.99	1.00-3.99	4.00 & Up	Total
Intersection Sections						
Section Length (percent)	4.4	18.5	28.5	44.8	3.8	100.0
Accidents (percent)	0.0	4.0	14.8	61.1	20.1	100.0
			(number per 100 feet)			
Private Drives	.114	.208	.262	.115	.053	
Taverns	-o-	-o-	.014	.041	.158	
Gas Stations & Commercial Garages	-o-	.011	.092	.115	.448	
Stores	.023	.016	.060	.088	.184	
Restaurants	-o-	-o-	.046	.065	.105	
Other Establishments	.023	.027	.082	.128	.184	
Total Roadside Features	.045	.054	.294	.437	1.079	
Large & Prominent Signs	-o-	.055	.060	.077	.026	
Medium Sized Signs	.068	.087	.160	.185	.421	
Small Signs	.045	.082	.308	.290	.737	
Signs Illuminated or Reflectorized	.023	.033	.216	.275	.895	
Signs Not Illuminated or Reflectorized	.091	.191	.312	.277	.289	
Total Signs	.114	.224	.528	.552	1.184	
Non-Intersection Sections						
Section Length (percent)	10.4	81.2	7.8	0.6	-o-	100.0
Accidents	-o-	74.7	20.2	5.1	-o-	100.0
			(number per 100 feet)			
Private Drives	.171	.220	.261	.143	-o-	
Taverns	-o-	.004	.021	.071	-o-	
Gas Stations & Commercial Garages	.008	.009	.027	.071	-o-	
Stores	.008	.015	.064	.143	-o-	
Restaurants	-o-	.010	.016	.214	-o-	
Other Establishments	.024	.039	.117	.572	-o-	
Total Roadside Features	.040	.077	.245	1.071	-o-	
Large & Prominent Signs	.040	.051	.048	.071	-o-	
Medium Sized Signs	.056	.079	.096	.286	-o-	
Small Signs	.068	.101	.149	.500	-o-	
Signs Illuminated or Reflectorized	.028	.068	.122	.571	-o-	
Signs Not Illuminated or Reflectorized	.135	.162	.170	.286	-o-	
Total Signs	.163	.231	.293	.857	-o-	

is the number of accidents per hundred feet of section length. The several items pertaining to accidents, section length, features, signs and vehicle miles were tablulated by accident density. From these tabulations percent of section length, percent of accidents, density of roadside features, and density of advertising signs were computed for each of five accident density groups. This was done for each kind of section separately. The results are shown in Table V.

In this table, attention is called first of all to the almost perfect consistency with which roadside feature density and advertising sign density increases as the accident density increases. Although it indicates only a general trend rather than specific relationships, it does lend considerable support to the correlation coefficients of Table IV. One might say that it explains in a way the coefficients of Table IV. It is worthwhile to note the difference in the various types of features and signs between the two kinds of section at the same accident density level. Table V explains the relatively low correlation of accidents with private drives and large and prominent signs in intersection sections.

The percentages of section length and accidents by accident density groups indicate clearly the seriousness of the accident situation in intersection sections as compared to that in non-intersection sections. For example: In the intersection sections 81.2 percent of the accidents occurred at accident densities of 1.00 or more; while in the non-intersection sections only 5.1 percent of the accidents occurred at accident densities of 1.00 or more.

Table VI

Table VI is presented to show the nature of the relationship between accidents and traffic volumes. Accident rates and accident densities are shown by 1000-vehicle increments of 1948 annual average daily traffic volume. These data fail to show any evidence that accident rates or accident densities increase significantly as traffic volumes increase on the study route. The correlation coefficients of traffic volumes with accident rates and with accident densities are shown at the bottom of Table VI. Only one of these four correlations is significantly large.

Table VI

Accidents per Year per Million Vehicle Miles and Accidents per Hundred Feet 1/ in Each Kind of Section by 1948 Annual Average Daily Traffic Volumes

1948 Annual Average Daily Traffic Volumes	Accident Rates		Accident Densities	
	Intersection Sections	Non-Intersection Sections	Intersection Sections	Non-Intersection Sections
5,000 - 5,999	15.65	1.61	1.23	0.13
6,000 - 6,999	10.18	2.73	0.90	0.25
7,000 - 7,999	9.49	2.86	0.98	0.29
8,000 - 8,999	8.02	1.95	0.92	0.22
9,000 - 9,999	8.05	1.64	1.07	0.21
10,000 -10,999	6.73	1.77	0.98	0.26
11,000 -11,999	9.22	1.74	1.48	0.28
12,000 -12,999	2.39	0.95	0.43	0.17
13,000 -13,999	9.79	1.61	1.87	0.31
14,000 -14,999	7.95	1.18	1.61	0.24
15,000 -15,999	9.56	1.15	2.05	0.25
16,000 -16,999	18.38	2.34	4.23	0.54
17,000 -17,999	2/	2/	2/	2/
18,000 -18,999	2.67	0.85	0.69	0.22
19,000 -19,999	4.88	1.11	1.32	0.30
Correlation with 1948 Annual Average Daily Traffic Volumes	-0.302	-0.609	0.365	0.419

1/ In two years

2/ No traffic volumes in this range on the study route.

This is the one for accident rates with traffic volumes in the non-intersection sections, and since it is negative it indicates a tendency for the accident rates to decrease as traffic volumes increase.

Table VI is not meant to end a controversy. It is meant only to show the conditions relative to accidents and traffic volumes existing on the route under study.

Figure II

Figure II shows accident rates and roadside features per 100 feet by number of lanes and surface width, along the entire study route (except those sections omitted in Monroe, Flatrock, Dearborn and Pontiac). The figure also shows the 1948 annual average daily traffic volume along the route, and the principal intersecting routes. The figure is drawn to scale along the route.

From this figure it is clear that the northern portion of Telegraph Road, starting at about the north junction with US-25, is much worse than the southern portion. This is true not only in terms of accident rates, but also in terms of number of accidents. About 66.5 percent of all accidents in 1947-48 on those parts of Telegraph Road included in this study occurred north of the north junction with US-25. This portion contains 51.7 percent of the total length of the study route. The number of roadside features per 100 feet south of the north junction with US-25 is 0.122, while north of this junction the feature density is 0.200 - almost double that on the southern portion of the route. This close association between accident rates and density of roadside features is shown.

This figure shows why the correlation coefficients between accident rates and traffic volumes (shown in Table VI) were negative. The portion of Telegraph Road lying between the two junctions with US-25 has the highest traffic volumes to be found along the route - reaching a peak of over 19,000 vehicles per day. Yet this same portion of the route has the lowest accident rate to be found along the route except for a short distance between M-151 and Dewar Road. The portion of the

ACCIDENT RATES, TRAFFIC VOLUMES, NUMBER OF LANES, SURFACE WIDTH AND ROADSIDE FEATURES

TELEGRAPH ROAD
1947 – 1948

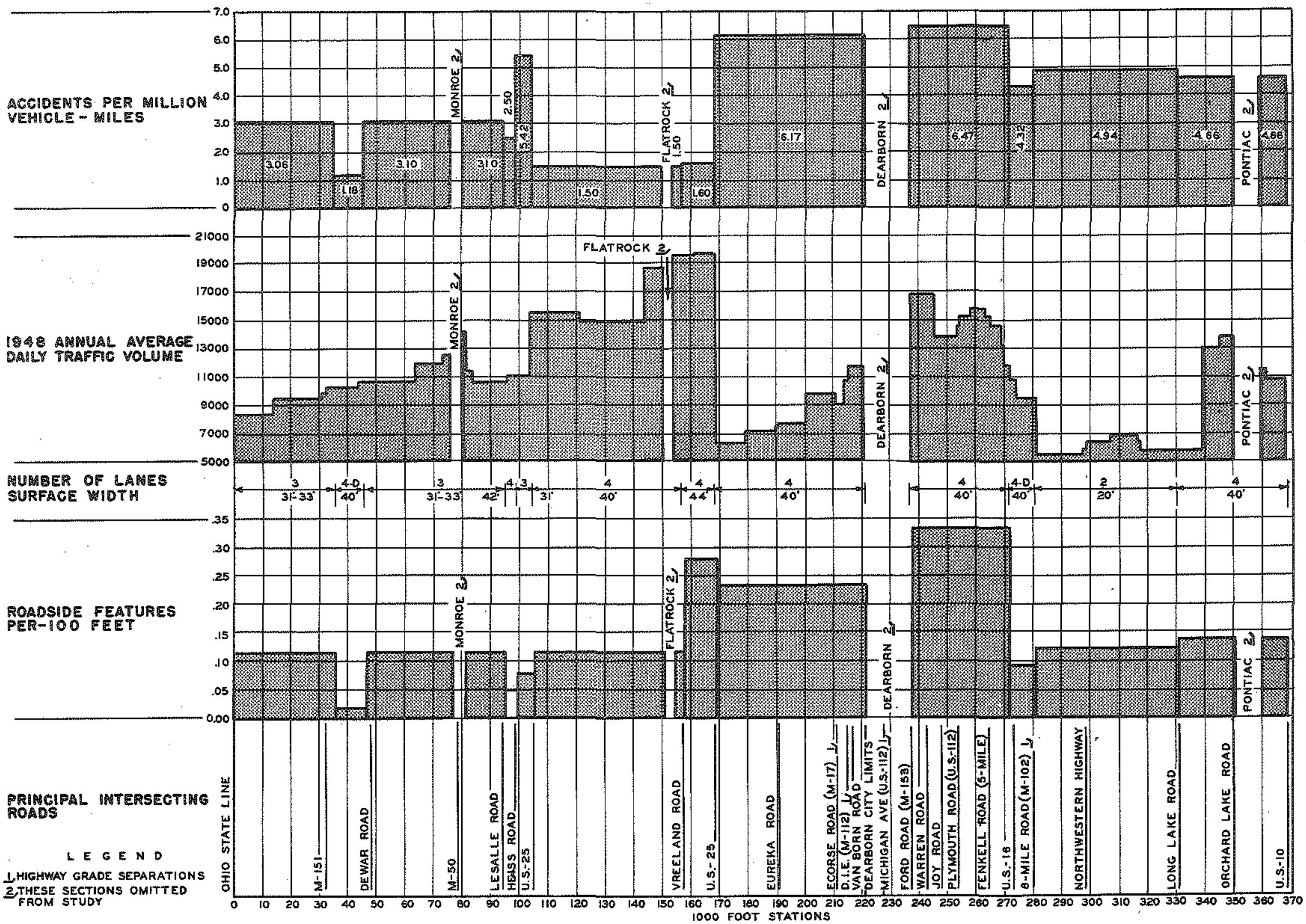

FIGURE II

route lying north of 8 Mile Road (M-102) has the lowest traffic volumes and yet has a relatively high accident rate.

There appears to be little relationship between number of lanes and accident rate. For any apparent trend in this respect there can be found an exception. There is much more relationship between number of lanes and traffic volume. This is clearly shown by Figure II. Generally speaking, the 4-lane portions carry higher traffic volumes than the 3-lane portions which in turn carry higher volumes than the 2-lane portion.

An analysis of accidents occurring in 1936-41 on Michigan rural state trunklines with high type surfaces revealed that when a 2-lane road was loaded beyond about 4,000 vehicles per day the accident rate increased sharply. This fact is very well substantiated by the 2-lane portion of Telegraph Road lying between 8 Mile Road and Long Lake Road. This portion has traffic volumes which are very low compared to the remainder of Telegraph Road, but they are far beyong the critical 4,000 vehicles per day, and the accident rate of 4.94 is among the highest along the route.

Tables VII and VIII

The question has come up repeatedly as to whether intersections are hazardous simply because they are intersections or whether they are hazardous because roadside features are built up around them. To answer this question the intersection sections were divided into three groups of roadside feature density (number of roadside features per 100 feet). For each group there was tabulated the number of sections, accidents, roadside features and advertising signs, section length and 1948 annual average daily vehicle miles. These are shown in Table VII. Then for each roadside feature density group there was computed percentage of accidents, roadside features, advertising signs, section length and 1948 annual average daily vehicle miles, accidents per 100 feet and accidents per year per million vehicle miles. These are shown in Table VIII. Both these Tables are based only on intersection sections.

Table VII

Number of Sections, Accidents, Roadside Features, Advertising Signs; Section Length,
1948 Annual Average Daily Vehicle Miles
For Each of 3 Groups of Roadside Feature Density

Intersection Sections

Roadside Feature Density	NUMBER OF				Section	1948 Annual
(Number of Roadside Features per 100 Feet)	Sections	Accidents	Roadside Features	Advertising Signs	Length (100's of Feet)	Average Daily Vehicle Miles
-0-	46	139	-0-	41	277	50,899
0.001 - 0.399	50	730	179	252	494	110,373
0.400 - and up	23	515	151	192	220	52,324
Total	119	1,384	330	485	991	213,596

Table VIII

Percent of Accidents, Roadside Features, Advertising Signs, Section Length, 1948 Annual Average Daily Vehicle Miles; Accidents per 100 Feet and Accidents per Year per Million Vehicle Miles for Each of 3 Groups of Roadside Feature Density

Intersection Sections

Roadside Feature Density (Number of Roadside Features per 100 Feet)	PERCENTAGE OF: Accidents	Roadside Features	Advertising Signs	Section Length (100's of Feet)	1948 Annual Average Daily Vehicle Miles	Accidents per 100 Feet	Accidents per Year per Million Vehicle Miles
- 0 -	10.0	- 0 -	8.4	28.0	23.8	0.50	3.74
0.001 - 0.399	52.7	54.2	52.0	49.8	51.7	1.48	9.06
0.400 and up	37.2	45.8	39.6	22.2	24.5	2.34	13.48
Total	100.0	100.0	100.0	100.0	100.0	1.40	8.88

In the first roadside feature density group containing no roadside features of any kind, 28.0 percent of the section length and 23.8 percent of the vehicle miles, there occurred only 10.0 percent of the accidents. This group contained at least 46 intersections. On the other hand, the last roadside feature density group which accounts for only 22.2 percent of the section length and 24.5 percent of the vehicle miles of travel contained 45.8 percent of the roadside features and 37.2 percent of the accidents. The last two columns of Table VIII show the rapid increase in accident density and accident rate as roadside feature density is increased. These two columns furnish the answer to our question. Intersections are hazardous in themselves as indicated by the accident rate of 3.74 in 46 intersection sections containing no roadside features. Considering the manner in which accident density and accident rate increases as roadside feature density increases, it is evident that intersections are not only hazardous in themselves but that they become much worse as roadside features are built up around them.

Table IX

Another approach was made to the problem of accidents and roadside features by the way of frequency distributions. Accidents for the three years 1946, 1947 and 1948 and all roadside features except private drives, were used. The data for both kinds of sections were combined. Frequency distributions of number of accidents and of number of 200-foot units of distances by number of roadside features (less private drives) were constructed. Two other similar pairs of frequency distributions were constructed--one for 400-foot units of distance and one for 600-foot units of distance. The 400-foot units overlapped 200 feet and the 600-foot units overlapped 400 feet. The purpose of this overlapping was to obtain the same number of units of distance in all three pairs of distributions.

Then for each of the three pairs of distributions the number of accidents was divided by the number of units of distance at each number of roadside features. The results are shown in Table IX.

Table IX

Accidents per Unit of Distance by Number of Roadside Features 1/

Number of Roadside Features	Accidents per Unit of Distance 200-Foot Units	400-Foot Units	600-Foot Units
0	0.813	0.730	0.722
1	2.31	1.59	1.27
2	6.51	2.69	1.98
3	6.56	3.66	2.70
4	40.38	9.54	4.39
4 or more	51.11	14.33	8.78
5	111.00	14.94	10.31
6		24.30	13.24
6 or more		29.08	14.10
7		14.00	10.36
8 or more			20.67

1/ Less private drives.

Table X

Partial and Total Correlation Coefficients of Accidents with Roadside Features for Non-Intersection and for Intersection Sections

Features Correlated with Accidents	Non-Intersection Sections		Intersection Sections	
	Total	Partial	Total	Partial
Taverns	.313	.303	.698	.510
Gas Stations and Commercial Garages	.442	.295	.666	.350
Stores	.321	.034	.526	.161
Restaurants	.438	.198	.651	.105
Other Establishments	.443	.300	.720	.313

Attention is called to the perfect consistency with which the number of accidents decreases as the unit of distance increases from 200 feet through 600 feet for a fixed number of roadside features. The implication of this is that the smaller the concentration of roadside features, the smaller will be the number of accidents.

Table X

We come now to a part of the analysis which the reader may accept or reject as he likes. This part has to do with a phase of correlation not too frequently used. It is called "partial" correlation. Heretofore we have used only "total" correlations, whether single, multiple or weighted average.

The meaning of partial correlation and its possibilities may best be explained by an example. If three or more variables are related, the correlation between any two may be unduly increased or decreased by the correlation of the third with each of the two. It is possible by means of partial correlation to compute the correlation between any two of them with the effect of the third eliminated or held constant. In other words, the partial correlation measures the effect of one variable in its own right upon a second variable and independently of the effect of a third or other variables.

It should be pointed out that partial correlation implies cause and effect. There is no point in accepting and using partial correlation unless one is willing to admit the existence of a system of causality among the variables correlated. Also, it should be pointed out that such an admission is contrary to the philosophy of the impossibility of determining accident causes stated at the beginning of this report.

More than one variable may be eliminated from the correlation of two others; but as the number of variables eliminated increases, the computations increase rapidly.

Since accidents are closer associated with roadside features (excluding private drives and parks) than with design features and advertising signs, the decision was made to apply partial correlation to this part of the data. Therefore the partial correlation coefficients of accidents with each of the roadside features, taverns, gas stations and commercial garages, stores, restaurants, and other establishments were computed holding the other four roadside features constant in each instance. This was done for both kinds of section. The results are shown in Table X along with the corresponding total coefficients from Table IV.

Table X shows that in non-intersection sections the association of accidents with Taverns and Other Establishments is not materially reduced when in each instance the effect of the other four features is eliminated. By contrast, the association of accidents with Gas Stations and Commercial Garages, Stores, and Restaurants is tremendously reduced when in each instance the effect of the other four features is eliminated. In the intersection sections only Taverns is not materially reduced when the effect of the other four roadside features is eliminated.

Therefore, if one is willing to admit that roadside features and accidents are a case of cause and effect, the conclusion to be drawn from Table X is that taverns in both kinds of section and other establishments in non-intersection sections are making a material contribution to the production of accidents on the study route. While gas stations and commercial garages, stores and restaurants in both kinds of section, and other establishments in intersection sections make only a very small contribution to the production of accidents.

CONCLUSION

The continuing analysis of data has provided further evidence of the seriousness of the accident hazards at intersections as compared with other portions of the highways. It indicates that these locations are approximately five times as hazardous as the sections between and it gives further proof of the danger of concentrations of features around intersections.

In working toward the principal objective of the present phase of this analysis - the segregation of intersections from the roadside features at intersections - definite progress has been made. It is now clear that the intersections themselves create definite hazards and that the development of roadside establishments at these points intensifies the danger.

As a result of the more specialized analysis of data, the earlier determined order in which various factors are associated with accident occurrence has been revised. The initial studies indicated that roadside features were most closely associated with accidents, that design features came next, and that advertising signs were only slightly associated. It now appears that association with accidents is highest and about equal for roadside features and advertising signs, and that design features are rather far behind. The frequency with which signs occur in connection with roadside establishments is recognized as having a bearing on this problem, but it has not yet been thoroughly investigated.

While the association of design features as a whole with accident occurrence was found to be low, two physical manifestations of design were proved to be highly important. One, of course, is the grade intersection which is repeatedly indicated as the outstanding element in this study. The other is the number of lanes in relation to traffic volume. This latter may well be a factor in the rather surprising findings reported regarding the relationship of accident rates to traffic volumes.

The use of the method of partial correlation is an interesting development of the present phase of the study. The resulting indications regarding the particularly close association of Taverns and Other Establishments with accident occurrence are steps toward setting up definite cause-and-effect relationships in the accident field.

Several of the desirable analytical projects listed in the first progress report for future accomplishment have not been undertaken as yet. However, the results so far clearly demonstrate that every effort should be made to create arteries for main streams of traffic which are at least relatively free from roadside business development, not only at intersections, but throughout their length.

The study is continuing and it is hoped it will yield more and valuable information.