An Analysis of Random Freeway Traffic Accidents and Vehicle Disabilities

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•THE John C. Lodge Freeway Surveillance Project is being conducted on the John C. Lodge Freeway in Detroit, Mich., between the Davison and Edsel Ford Freeway Interchanges. The project is being conducted jointly by the Michigan State Highway Department, the City of Detroit Streets and Traffic Department, Wayne County Road Commission, in cooperation with the U. S. Bureau of Public Roads.

The study section is 3.2 mi, with television surveillance being accomplished by 14 remotely controlled television cameras. This section has such geometric features as portions of 6- and 8-lane divided, 9 on- and 9 off-ramps, a reverse curve and grades. It has carried as many as 160,000 vehicles per day for both directions. The lane and speed signal controls have been in operation for 1½ yr. and the television system for 3 yr.

Figure 1 indicates the study section's special design features, location of cameras, lane signals, speed signs, and ramp signals.

Trained observers are on duty for a 14-hr period from 6:00 AM to 8:00 PM daily, except weekends and holidays. A general log (see Appendix) is maintained as a permanent record of all vehicular incidents including accidents, vehicle disabilities, maintenance operations, and others such as motorists aiding distressed vehicles. This log contains all the data for this study and analysis of freeway incidents.

PURPOSE

The purpose of this study is to determine the frequency, duration, and character of random freeway traffic incidents, and also to investigate the factors influencing their occurrence.

STUDY DATA

The study data, taken from the general logs, covered the period from June 1, 1962 to June 1, 1963 (255 surveillance days).

Information contained in the general log includes type of accident, time of occurrence, duration, location, lanes affected, assistance, weather, pavement condition, and other pertinent remarks.

This study is limited to random vehicular incidents occurring on the freeway proper and categorized as (a) accidents, and (b) vehicle disabilities. Excluded are (a) maintenance operations, and (b) all other non-random incidents such as vehicles stopping to assist distressed vehicles. All shoulder uses were deleted as these constitute a separate study and the first report on this subject has been published ("Shoulder Usage on an Urban Freeway," January 1962).

ANALYSIS OF DATA

Data were reduced to a presentation of total incidents, accidents, and vehicle disabilities; and analyzed as to location (as indicated by camera field), weather conditions, pavement surface temperature, aid received, lane in which incident occurred, occur-

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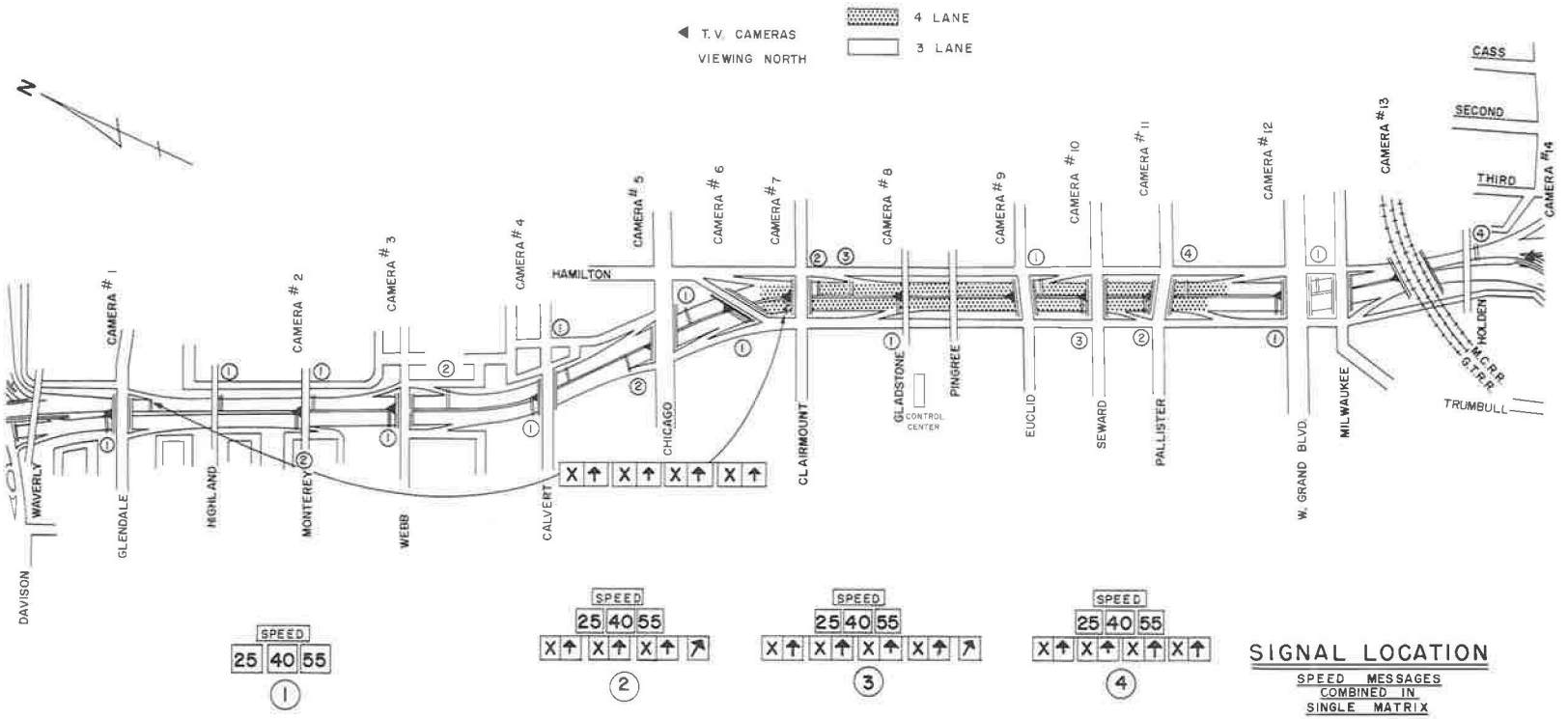


Figure 1. Freeway traffic surveillance and control research project, John C. Lodge Freeway, Detroit, Mich.

rence related to geometric design on 4-lane vs 3-lane sections, day of week, month of year, and time of day. Vehicle disabilities included stalls, flat tires, spin-outs (vehicle spinning on slippery pavement, no collision occurring), and others.

Vehicular Incidents by Location

Figure 2 shows the number of incidents by camera field location and by direction, respectively. Certain camera fields cover 4-lane and 3-lane, respectively, in both directions of travel. The camera fields 7, 8, 9, 10, 11, and 14 cover the 4-lane section inbound, whereas camera fields 8, 9, 10, 11, and 14 cover the 4-lane sections outbound. The greatest number of incidents occurred in camera field 9, which covers a 4-lane section. In the outbound direction, camera field 9 is located in advance of the point where the four lanes converge into three lanes. This factor is responsible for daily congestion and undoubtedly contributes to the occurrence of incidents in this area.

To compare incidents by camera fields, it was decided to determine the number of incidents per $\frac{1}{8}$ mi of camera field. This distance was selected as it is approximately the length of the shortest field. Figure 3 shows total incidents and incidents by direction per $\frac{1}{8}$ mi of camera field. Again, the 4-lane sections revealed a higher rate of incidents than the 3-lane section.

A more detailed analysis of the incidents in the 4- and 3-lane sections provides a better basis for comparison. Table 1 gives the number of vehicle incidents by lane on the 4- and 3-lane sections of the freeway. A greater number of incidents—both accidents and vehicle disabilities—occurred in the 3-lane section. For the 255 surveillance days, there was a daily average of 3.64 incidents (0.90 accidents and 2.74 vehicle disabilities). Of the 3.64 incidents, 2.11 occurred in the 3-lane section (0.54 accidents and 1.57 vehicle disabilities); 1.53 occurred in the 4-lane section (0.36 accidents and 1.17 vehicle disabilities).

To effect proper comparison of 4- vs 3-lane sections, the difference in length must be considered. Table 1 gives the incident rate per mile of section. The daily average of incidents for the 3-lane section was 0.51 (0.13 accidents and 0.38 vehicle disabilities) per mile; for the 4-lane section 0.69 (0.16 accidents and 0.53 vehicle disabilities) per mile. Again, the rate of incidents in the 4-lane section is higher. Comparison also can be made on a per lane basis in the respective sections.

Another basis of comparison for 4- vs 3-lane section can be made from Table 1 which gives the total incidents per million vehicle-miles.

On the basis of a daily volume of 116,000 vehicles for the 255 surveillance days, Table 1 indicates there were 3.2 more incidents per million vehicle-miles in the 4-lane section—an increase of 36 percent over the 3-lane section. The difference is reflected primarily in vehicle disabilities. For the total 3.2 mi of study section, the rates per million vehicle-miles are as follows: accidents = 2.4, vehicle disabilities = 7.4; total incidents = 9.8 per million vehicle-miles.

Vehicular Incidents by Time of Day, Direction of Travel, and Day of Week

Figures 4, presents total and directional occurrence of incidents by time of day and follows approximately the same pattern as do the daily volume distributions for this section of freeway.

Comparable to the volume pattern, the occurrence of incidents reached a peak inbound between 7:30 and 9:30 AM and reached an even higher peak outbound between 3:30 and 6 PM. There was a difference of only 11 incidents—inbound, 458 incidents; outbound, 469 incidents. It is evident, and expected, that the probability of an incident occurring increased as traffic exceeded the maximum density of the freeway.

Table 2 is a comparison of the daily averages of vehicular incidents by day of week. Analysis shows no significant influence of any particular day although Friday exhibited a deviation. The higher total rate may be attributable to the higher traffic volumes and prolonged periods of congestion on Fridays.

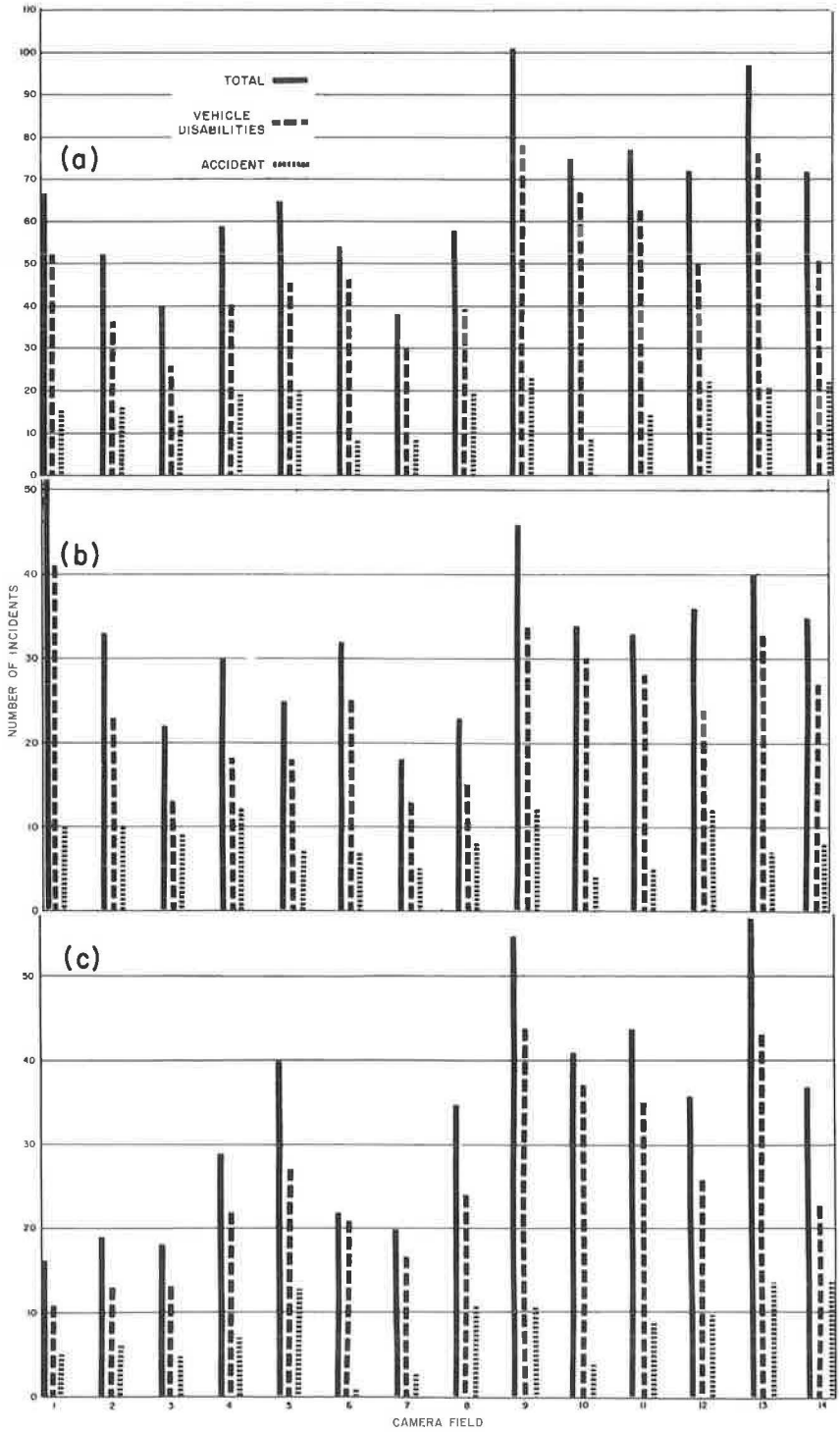


Figure 2. Incidents by camera field: (a) total, (b) inbound, and (c) outbound.

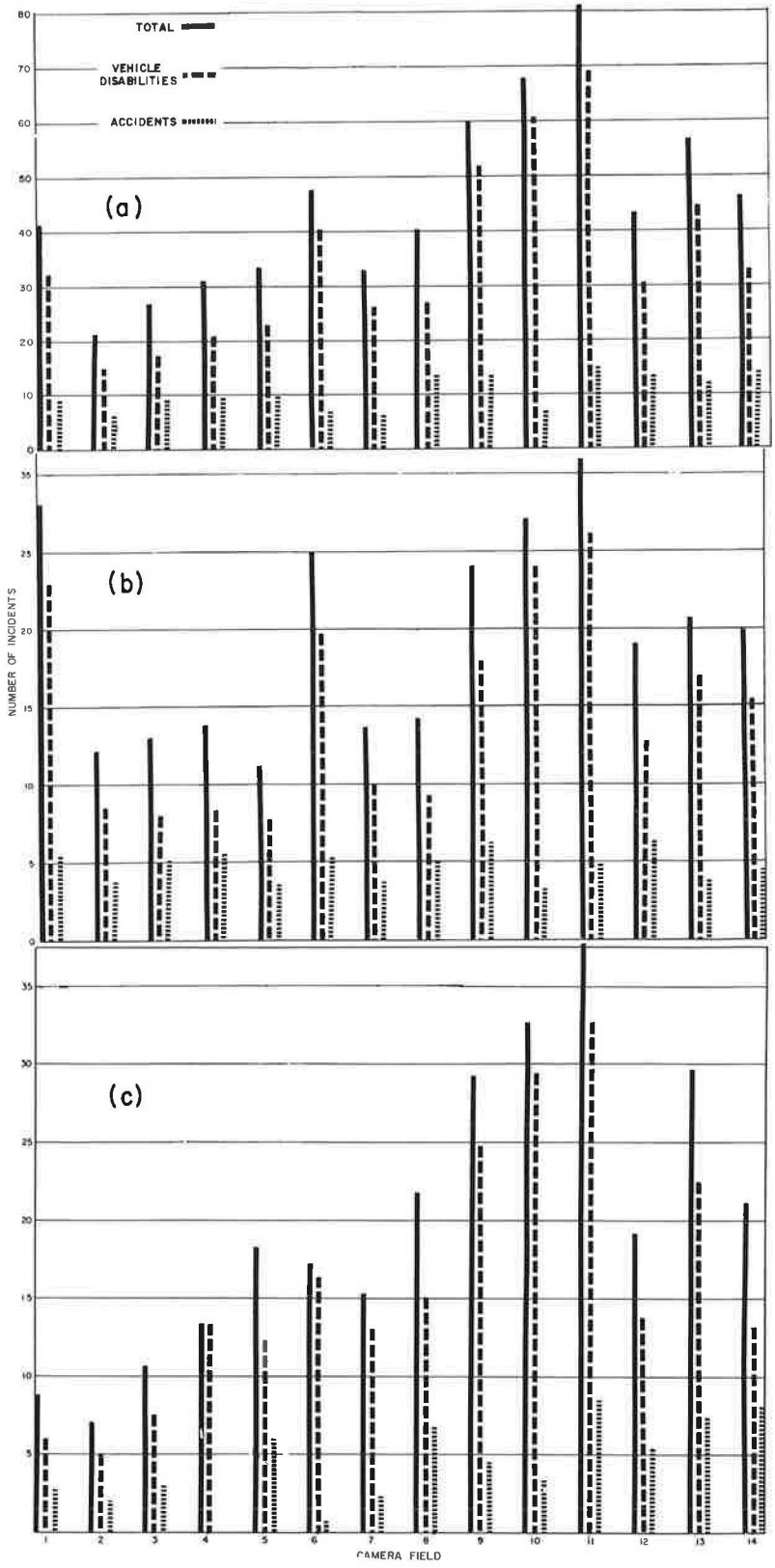


Figure 3. Incidents per $^1/_8$ mi of camera field: (a) total, (b) inbound, and (c) outbound.

Figure 4. By time of day: (a) total incidents,

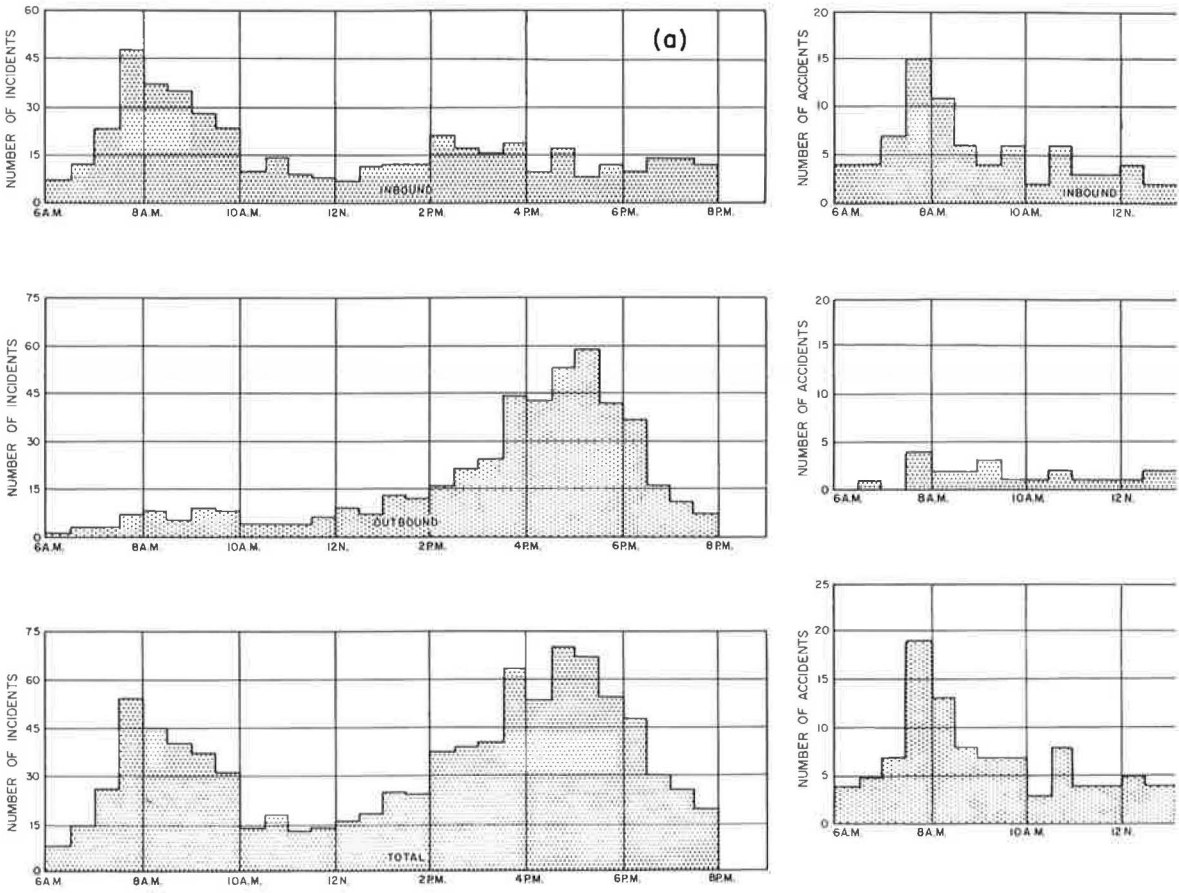


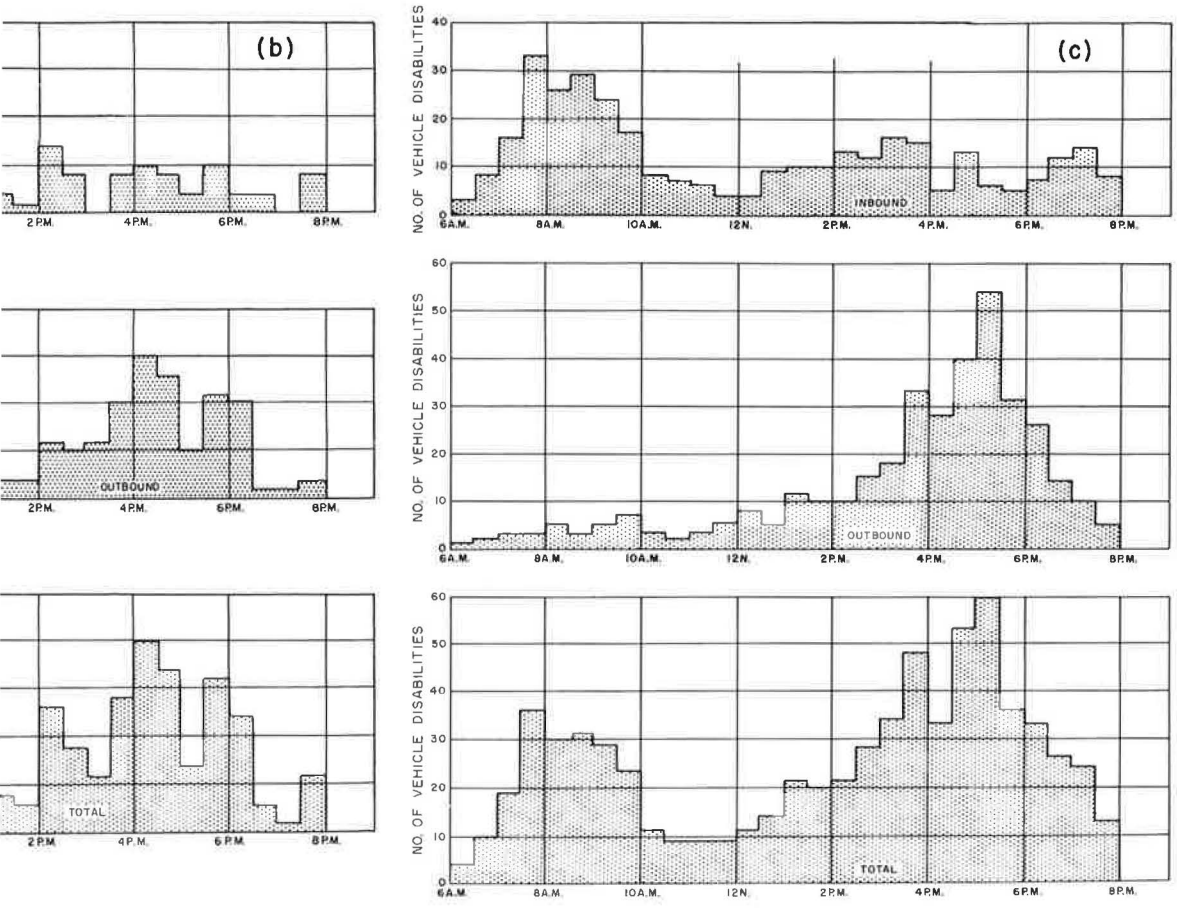
TABLE 1

VEHICULAR INCIDENTS[a]

Lane	Accidents			Vehicle Disabilities			Total Incidents		
	3-Lane Section[b]	4-Lane Section[c]	Total	3-Lane Section[b]	4-Lane Section[c]	Total	3-Lane Section[b]	4-Lane Section[c]	Total
				(a) Total, by Lane					
1	45	36	81	209	134	343	254	170	424
2	35	23	58	89	61	150	124	84	208
3	53	18	71	96	45	141	149	63	212
4	—	6	6	—	52	52	—	58	58
Multiple	4	9	13	9	3	12	13	12	25
Total	137	92	229	403	295	698	540	387	927
				(b) By Lane, per Mile					
1	10.7	16.4	12.7	49.8	60.9	53.6	60.5	77.3	66.3
2	8.3	10.5	9.1	21.7	27.7	23.4	29.5	38.2	32.5
3	12.6	8.2	11.1	22.9	20.5	22.0	35.5	28.6	33.1
4	—	2.7	2.7	—	23.6	23.6	—	26.4	26.4
Multiple	1.0	4.1	2.0	2.1	1.4	1.9	3.1	5.5	3.9
Total	32.6	41.9	35.8	96.0	134.1	109.1	128.6	176.0	144.8
				(c) Total, per Million Vehicle-Miles					
—	2.2	2.8		6.5	9.1		0.7	11.9	

[a]Total for both directions. [b]21.2 mi both directions. [c]4.2 mi both directions.

(b) accidents, and (c) vehicle disabilities.



Vehicular Incidents Related to Climatic Conditions

Climatic conditions, especially seasonal variations, contribute to the cause of incidents and influence the frequency. Figure 5 shows the vehicular incidents by month of year. The greatest number of incidents occurred during the months when driving conditions were made more hazardous by low temperatures or sudden changes in the weather.

To compare frequency of incidents according to climatic and pavement conditions, and temperature, climatic data were obtained from the U. S. Weather Bureau publications "Local Climatological Data" for the study year. Applicable data are given in Table 3. Weather and temperature data were obtained from the U. S. Weather Bureau. Pavement conditions and durations were obtained from the general log.

Vehicular incidents, by types, were compared by pavement, weather, and temperature conditions. The daily average of vehicular incidents, by climatic condition, was computed by dividing the total number of incidents per climatic condition by the number of equivalent days of each condition. The day referred to is the 14-hr surveillance day. Table 4

TABLE 2

AVERAGE NUMBER OF INCIDENTS PER DAY BY DAY OF WEEK

Day	Accidents	Vehicle Disabilities	Total
Monday	0.74	2.37	3.11
Tuesday	0.90	2.66	3.56
Wednesday	0.82	2.77	3.59
Thursday	1.08	2.52	3.60
Friday	0.96	3.28	4.24
Daily Avg.	0.90	2.74	3.64

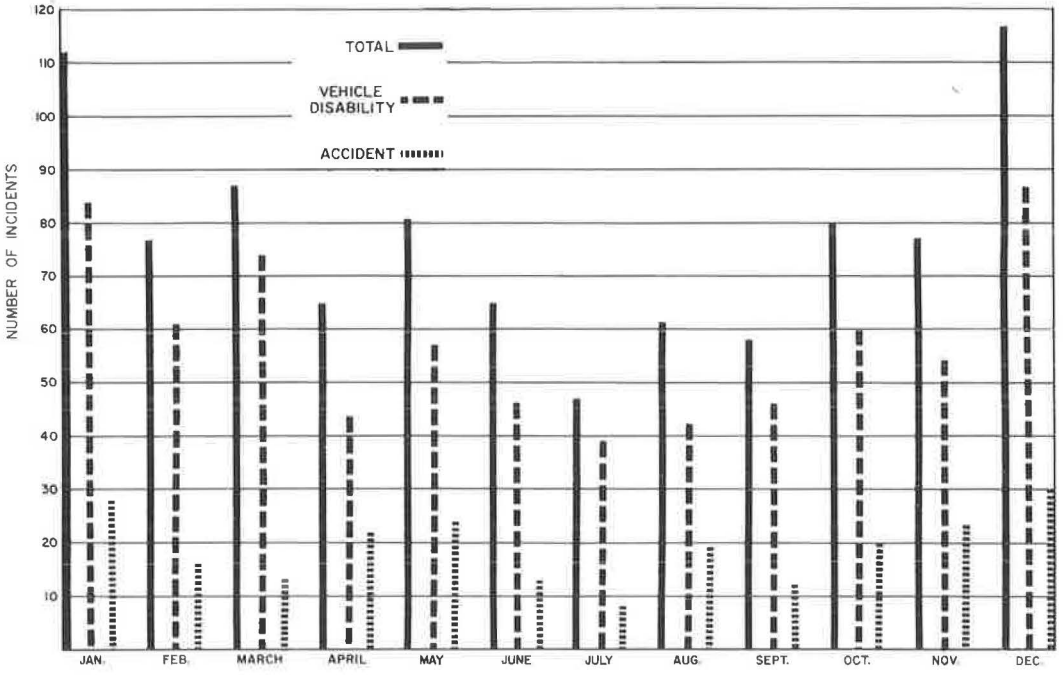


Figure 5. Incidents by month.

gives the comparison of total incidents by climatic conditions. Table 4 shows that the potential frequency of incidents is much greater during rain or snow, slushy and wet pavement conditions, as well as during colder temperature.

Table 5 gives the frequency of accidents under various conditions of pavement, weather, and temperature.

Table 6 gives the comparison of vehicle disabilities by climatic conditions. Vehicle disabilities include stalls, flats, spin-outs, etc.

In the tables, for purposes of comparison only, a rate of incidents per hour and per day was calculated for the entire study section and then determined for 1 mi of study section. As these incidents covered both directions of the freeway, the total length applicable to these incidents was 6.4 mi, thus considering these incidents as occurring on two roadways of 3.2 mi each.

The tables reveal the obvious effect of snow, wet and/or slushy pavement, and low temperatures by an increased frequency of stalled vehicles and accidents. These increases were all statistically significant. It was determined, however, that the frequency of flat tires was not affected significantly by climatic conditions.

TABLE 3

TOTAL TIME OF CLIMATIC CONDITIONS

Condition	Hours	14-Hr Days
Pavement:		
Dry	3,150 hours	225.000
Wet	373 hours	26.643
Slushy	47 hours	3.357
Weather:		
Clear or cloudy	3,306 hours	226.143
Rain	183 hours	13.071
Snow	81 hours	5.786
Temperature:		
Low (below 30)	672 hours	48.000
Medium (30-70)	2,366 hours	169.000
High (above 70)	532 hours	38.000

Duration of Incidents

Figure 6 shows the duration of the 927 incidents, based on an accumulated percentile, for the study year. From this data, average durations were determined to be 6.14 min for accidents, 4.94 min for vehicle disabilities; over-all average of 5.24 min. Median value of all incidents was 3 min. The duration of 50 percent of

TABLE 4

VEHICULAR INCIDENTS[a]
BY CLIMATIC CONDITIONS—TOTALS

Climatic Condition	Total Incidents	Total Time of Condition		Study Section Incidents			
		Hours	Days (14 hr)	Per Hour	Per Day (14 hr)	Per Hour per Mile	Per Day per Mile
Pavement:							
Dry	704	3,150	225.00	0.22	3.13	0.03	0.49
Wet	177	373	26.64	0.47	6.64	0.07	1.04
Slushy	46	47	3.36	0.98	13.70	0.15	2.14
Weather:							
Clear	720	3,306	236.14	0.22	3.05	0.03	0.48
Rain	106	183	13.07	0.58	8.11	0.09	1.27
Snow	101	81	5.79	1.25	17.46	0.19	2.73
Temperature:							
Below 30	253	672	48.00	0.38	5.27	0.06	0.82
30 to 70	561	2,366	169.00	0.24	3.32	0.04	0.52
Above 70	113	532	38.00	0.21	2.97	0.03	0.46

[a]For both directions—6.4 mi, total study area length.

TABLE 5

VEHICULAR INCIDENTS[a]
BY CLIMATIC CONDITIONS—ACCIDENTS

Climatic Condition	Total Accidents	Total Time of Condition		Study Section Accidents			
		Hours	Days (14 hr)	Per Hour	Per Day (14 hr)	Per Hour per Mile	Per Day per Mile
Pavement:							
Dry	165	3,150	225.00	0.05	0.73	0.01	0.11
Wet	53	373	26.64	0.14	1.99	0.02	0.31
Slushy	11	47	3.36	0.23	3.28	0.04	0.51
Weather:							
Clear	173	3,306	236.14	0.05	0.73	0.01	0.11
Rain	31	183	13.07	0.17	2.37	0.03	0.37
Snow	25	81	5.79	0.31	4.32	0.05	0.68
Temperature:							
Below 30	67	672	48.00	0.10	1.40	0.02	0.22
30 to 70	141	2,366	169.00	0.06	0.83	0.01	0.13
Above 70	21	532	38.00	0.04	0.55	0.01	0.09

[a]For both directions—6.4 mi, total study area length.

TABLE 6

VEHICULAR INCIDENTS[a]
BY CLIMATIC CONDITIONS—VEHICLE DISABILITIES

Climatic Condition	Total Vehicle Disabilities	Total Time of Condition		Study Section Vehicle Disabilities			
		Hours	Days (14 hr)	Per Hour	Per Day (14 hr)	Per Hour per Mile	Per Day per Mile
Pavement:							
Dry	539	3,150	225.00	0.17	2.40	0.03	0.37
Wet	124	373	26.64	0.33	4.65	0.05	0.73
Slushy	35	47	3.36	0.74	10.43	0.12	1.63
Weather:							
Clear	547	3,306	236.14	0.17	2.32	0.03	0.36
Rain	75	183	13.07	0.41	5.74	0.06	0.90
Snow	76	81	5.79	0.94	13.14	0.15	2.05
Temperature:							
Below 30	186	672	48.00	0.28	3.88	0.04	0.61
30 to 70	420	2,366	169.00	0.18	2.49	0.03	0.39
Above 70	92	532	38.00	0.17	2.42	0.03	0.38

[a]For both directions—6.4 mi, total study area length.

all incidents was 3 min or less and 12 percent lasted for 10 min or more. About 90 percent of the vehicle disabilities and 86 percent of the accidents were on the freeway for 10 min or less. The recorded duration of the incident was terminated when the

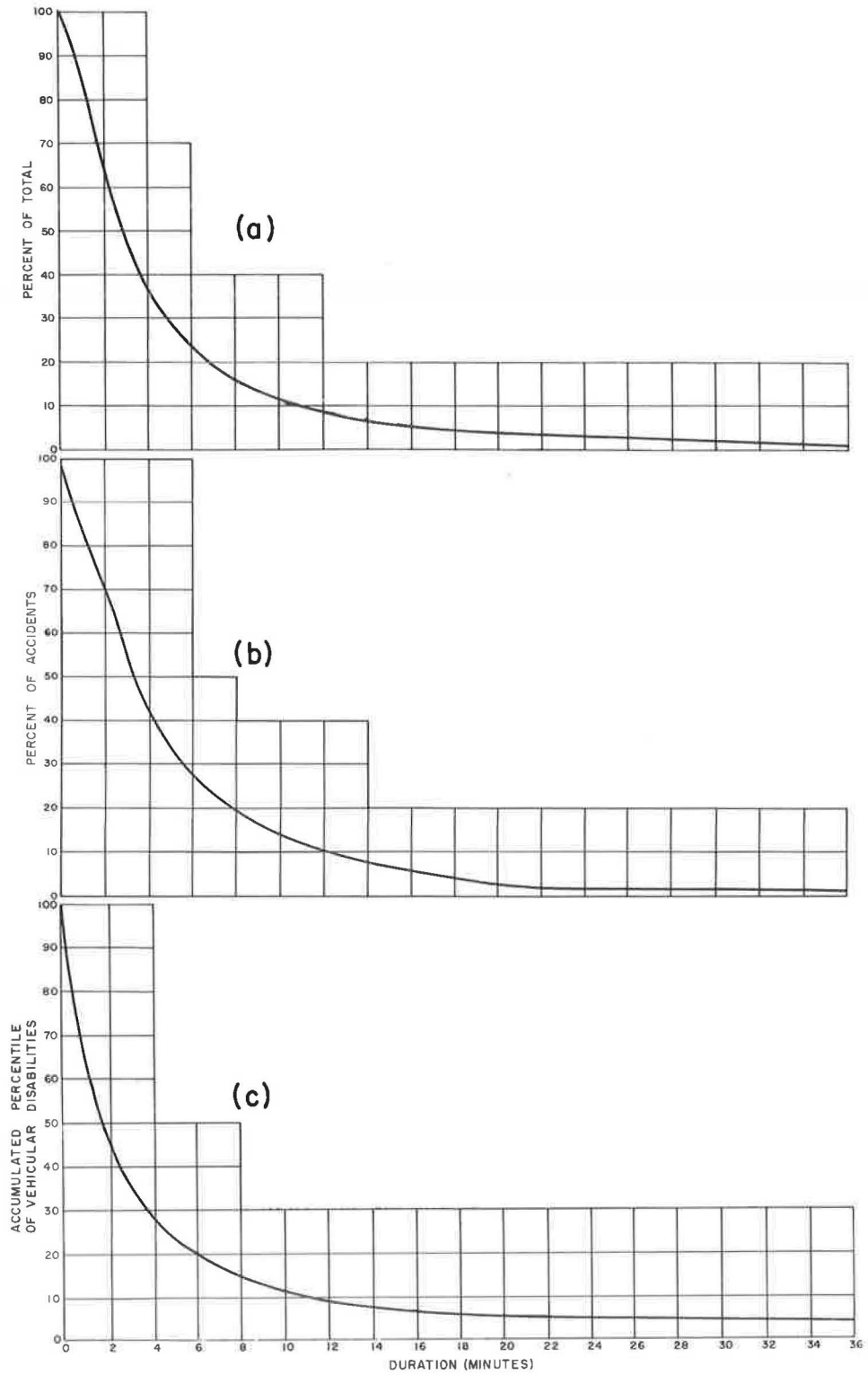


Figure 6. Duration of (a) incidents, (b) accidents, and (c) vehicular disabilities.

TABLE 7

TOTAL VEHICULAR INCIDENTS
BY TYPE OF AID RECEIVED

Type of Aid	Accidents		Veh. Disabilities		Total Incidents	
	No.	% of Total	No.	% of Total	No.	% of Total
Self to shoulder	108	46	113	16	221	24
Self to freeway	13	6	187	27	200	22
Pushed or pulled to shoulder	52	23	227	33	279	30
Pushed or pulled on freeway	2	1	126	18	128	13
Self to shoulder with official aid	54	24	45	6	99	11
Total	229	100	698	100	927	100

incident (vehicle) was removed to the shoulder or when the freeway traffic resumed movement.

Figure 6 also shows duration of accidents and vehicle disabilities. Similarity in the curves is apparent.

Vehicle Incidents and Type of Aid

From the general log, the freeway incidents were correlated by type of aid and by lane of occurrence. The "aid" was classified as follows:

1. Self to shoulder—motorist assisted self and moved vehicle to shoulder;
2. Self to freeway—motorist assisted self and continued on freeway;
3. Pushed or pulled to shoulder—vehicle disabled to the extent that it was necessary to be pushed or pulled to the shoulder;
4. Pushed or pulled on freeway—motorist, unable to repair disabled vehicle, received aid and was pushed or pulled on freeway; and
5. Self to shoulder with official aid—although the motorist was able to move vehicle, he waited for official aid to arrive before driving vehicle to the shoulder.

Table 7 gives the vehicular incidents for the total study section by types of aid.

Of the 927 total incidents, 46 percent of the motorists were able to move their vehicles to the shoulder or continue on the freeway, 43 percent needed assistance, and 11 percent waited for official aid before driving their vehicles to the shoulder. The total of 698 vehicle disabilities included 593 stalled vehicles. Forty-one percent of the motorists were able to restart their vehicles, 55 percent received aid from another motorist, and only 4 percent waited for official aid.

The record of accidents does not list the total vehicles involved but only the total number of accidents. Fifty-two percent of the accident vehicles were self-removed from the freeway, 24 percent needed a tow or push, and 24 percent waited for official assistance. Analysis of total incident data, to relate type of aid to the lane in which the incident occurred, has not been completed. Preliminary data reveal that 14 percent of the motorists, waiting for official aid, were involved in median lane (1) incidents as compared to 3 percent of the motorists stranded in the shoulder lane. Also, 32 percent

of the accident vehicles in the median lane were movable but motorists waited for official aid. As expected, the need for assistance increased as the incidents occurred in lanes farther from the refuge shoulder.

SUMMARY

Incidents by Location

A comparison of incidents in the 4- and 3-lane sections reveals greater frequency, reflected in daily averages, in the 4-lane section, as follows:

1. 4-lane section = 0.69 incidents per mile = 0.16 accidents and 0.53 vehicle disabilities.
   3-lane section = 0.51 incidents per mile = 0.13 accidents and 0.38 vehicle disabilities.
2. 4-lane section = 11.9 total incidents per million vehicle-miles = 2.8 accidents and 9.1 vehicle disabilities.
   3-lane section = 8.7 total incidents per million vehicle-miles = 2.2 accidents and 6.5 vehicle disabilities.

Comparison of total incidents, by lane, revealed that 45.7 percent occurred in the median lane—more than twice those in lane 2 and lane 3; 47 percent of the accidents occurred in the median lane; and 44 percent of the vehicle disabilities occurred in the median lane.

Incidents by Time of Day, Direction of Travel, and Day of Week

As expected, the frequency of incidents was greater during the time of day when the heavy volumes occurred and the greatest number of incidents occurred during the periods when maximum density of the freeway was exceeded. More analysis of the volume and density relationship to incidents is planned for the future.

Neither the direction of travel nor the day of the week had any significant influence on vehicular incidents.

Vehicular Incidents Related to Climatic Conditions

The greatest number of incidents occurred during the months when driving conditions were made more hazardous by low temperatures or sudden changes in the weather.

Compared to dry conditions, there were twice as many incidents per day per mile when the pavement was wet and four times as many when the pavement was slushy. There were three times as many incidents per day per mile when it was raining and almost six times as many when it was snowing.

Comparison by temperature indicated the frequency of total incidents at below 30° was 60 percent more than above 30°. As compared to dry pavement, the number of vehicle disabilities occurring on wet pavement was almost doubled and on slushy pavement was 4 ½ times as frequent. Judging solely on weather conditions, the frequency of vehicle disabilities almost tripled during rainy weather and increased by almost 6 times when it was snowing. During temperatures below 30°, the vehicle disabilities were almost 1.6 times that above 30°.

The frequency of accidents when the pavement was wet was about 3 times greater than when it was dry and during slushy conditions it was almost 5 times as much.

There were more than three times as many accidents in rain and six times as many in snow as there were in clear weather. For below 30F the frequency of accidents was almost double that for above 30F.

Duration of Incidents

The average duration for the total 927 incidents was 5.24 min; the median value was 3 min. Thirty-eight percent of the total incidents had a duration of 3 to 10 min; 12 percent had a duration of 10 min or more.

The average duration of 229 accidents was 6.14 min; 86 percent of the accidents had a duration of less than 10 min.

The average duration of vehicle disabilities was 4.94 min; and 90 percent of the vehicle disabilities had a duration of less than 10 min.

Vehicle Incidents and Type of Aid

Examination of the type of assistance needed by the motorists involved in incidents showed that 46 percent of the motorists moved their vehicles to the shoulder by themselves or continued on the freeway, 43 percent needed a tow or push, and 11 percent waited in the lane for official aid even though their vehicles were in a condition to be moved. There was a gradual increase of motorists in the last category as the incident occurred farther from the shoulder (3 percent in the shoulder lane and 14 percent in the median lane).

The 698 vehicle disabilities included 593 stalled vehicles. Of these 593, 41 percent of the motorists were able to restart their vehicles and either continue on the freeway or move to the shoulder, 55 percent received aid from another motorist or wrecker, and only 4 percent waited for official aid before driving to the shoulder.

Out of a total of 229 accidents, 52 percent of the situations were resolved by assistance provided by the involved motorists, 24 percent needed a tow or push, and 24 percent waited for officials to arrive even though they were able to move the vehicles to the shoulder under their own power. Again, a high percentage of accidents occurring in the median lane were movable, but motorists waited for official aid. The relationship of lane of incident location and type of assistance required and received will be studied further to supplement this paper.

ACKNOWLEDGMENT

The author wishes to express his appreciation to Gordon Paesani of the Michigan State Highway Department, John C. Lodge Freeway Surveillance Project, for permitting use of data from a project study, entitled "Vehicular Incidents on an Urban Freeway," and for his generous cooperation and assistance in the preparation of this paper.

Appendix

MICHIGAN STATE HIGHWAY DEPARTMENT
OFFICE OF ENGINEERING-TRAFFIC DIVISION

T. V. SURVEILLANCE DAILY LOG

PAGE 3 OF 4 Form 1578 B (Rev. 4/63)

DATE January 11 19 63 OPERATOR No. 3 Keryeski OBSERVER J. Taube

Incident Number	Time Start	Time End	Cause	Location Camera	Location Lane	Lanes Affected	Assistance Non Official	Assistance Official	Assistance Time Notified	Assistance Time Arrived	Assistance Action Taken	Pav'L. Surface	Weather	Remarks
25	1413	1414	O	2o	2	S	S					4	2	Single axle—unknown
26	1550	1551	St	10o	2	All	PM			1551	SP	4	2	Standard—Stalled
26	1551	1551	Aid	10o	2	All						4	2	Standard—Pushed stalled veh.
27	1608	1606	St	5o	3	2 & 3	S				SS	2	2	Standard—Momentary stall
28	1627	1633	V	13i	2	S						2	2	Standard—Received ticket
28	1627	1633	V	13i	2	S						2	2	Police car—Issued ticket
29	1659	1701	St	12o	1	All	S				SS	5	4	Standard—Stalled
30	1701	1702	O	9o	2	S						5	4	Standard—unknown
31	1717	1810	St	11o	1	All		W/P	1717	1722	P	5	4	Standard—On shoulder at 1723
31	1722	1810	Aid	11o	1	All						5	4	Wrecker—On shoulder at 1723 Gave push to standard veh.
31	1722	1725	Aid	11o	2	S						5	4	Police car—Gave aid
32	1739	1846	St	14o	R	Ramp		W		1801	P	5	4	Standard—On shoulder at 1826
32	1801	1846	Aid	14o	R	Ramp						5	4	Wrecker—Pushed standard veh. On shoulder at 1826
33	1846	1848	O	7i	2	S						5	4	Standard—unknown
34	1905	1938	A	1o	1	All		W/P		1905	P	5	4	Standard—On shoulder at 1917
34	1905	1935	A	1o	1	All		W/P		1905		5	4	Standard—On shoulder at 1906
34	1905	1931	A	1o	1	All		W/P		1905		5	4	Standard—On shoulder at 1906
34	1905	1906	Aid	1o	1	All						5	4	Police car—On scene
34	1913	1938	Aid	1o	1	All						5	4	Wrecker—On shoulder at 1917 Pushed veh. shoulder

CODING FOR OBSERVER'S LOG

CAUSE
A - Accident
B - Vehicular breakdown
flat tire
motor trouble
C - Congestion
ST - Stall
V - Violation
W - Inclement weather
O - Other

PAVEMENT
1 - Dry
2 - Wet
3 - Icy
4 - Snowy
5 - Slushy

LOCATION
USE CAMERA NUMBER AND DIRECTION OF TRAVEL
0 - Outbound
1 - Inbound

ASSISTANCE
BY NON-OFFICIAL
S - Self help
M - Passing motorist
BY OFFICIAL
P - Police dept.
W - Wrecker
F - Fire dept.

LANES
1 - Median
2 - Center
3 - Right
4 - Extra right
M - Median
S - Shoulder
R - Ramp

ACTION TAKEN
P - Moved to shoulder
T - Moved off freeway
SP - Started (by push)
SS - Started (by self)
C - Changed tire

WEATHER
1 - Clear
2 - Overcast
3 - Rain
4 - Snow
5 - Fog
6 - Sleet
7 - Hail