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March 11, 1982

IN REPLY PLEASE REFER TO FILE NO. 23-7-19

Memorandum to: Mr. W. S. Ferguson

From : N. J. Garber and C. W. Lynn

Subject: A Case Study of Experimental Passing Zones on Route 8 in Patrick County

BACKGROUND

This memorandum addresses a unique situation involving pavement markings on a four-mile section of Route 8 in Patrick County. The history of this situation began in 1976, when engineers of the Virginia Department of Highways and Transportation reviewed sight distances on two-lane roads in Patrick County to determine whether passing zones were marked in accordance with the Department's prevailing standards. At the time, many of the roads in the area were specially marked with a single broken yellow centerline that was referred to as "mountain pavement marking" and that permitted passing in each direction when the motorist considered it safe. The mountain markings were employed on many of these roads because the very restrictive geometrics and low traffic speeds would provide few, if any, passing zones under normal Departmental standards. Thus, it has been Department policy to allow passing in mountainous areas to facilitate traffic flow which might otherwise come to a virtual standstill when slow-moving vehicles were present.

The results of the review of sight distances on the section of Route 8 in question indicated that since this section did not exhibit the grade and horizontal and vertical alignment characteristic of most roads in mountainous areas, it should not have been marked with mountain pavement markings in the first place. However, when normal Departmental standards for non-mountainous areas were applied, there was insufficient sight distance to allow for regular passing zones and the section was re-marked for no passing.

This change prompted reactions from several sources. First, several complaints were received from motorists in the area, who requested that the Department reestablish passing zones. (Indeed, in a later motorist survey conducted at the study site, 89% of the respondents felt that the provision of passing zones was both important and necessary.) Concurrently, some discussion arose among the Department's engineers concerning the state's normal passing zone standards, which were more rigorous than those recommended in the national Manual on Uniform Traffic Control Devices (MUTCD), as noted in Table 1. There was some concern that application of the stricter Virginia standards, which were based upon the posted speed limit rather than the actual speed as used in the MUTCD, would result in fewer passing zones, which in turn could increase the probability of frustrated motorists passing illegally. In order to assess this problem, the Department asked the Research Council to study this section of Route 8 to determine if safe and acceptable passing distances less than the normal Department standards could be developed.

Table 1

Minimum Passing Sight Distances

85th Percentile. Speed, mph	MUTCD Minimum Passing Sight Distances, ft.	Posted Speed, mph	VDH&T Minimum Passing Sight Distance, ft.
30	500	30	1,000
40	600	40	1,200
50	800	50	1,600

It is again noted that this memorandum describes a case study of the unique situation on Route 8; it does not purport to present an overall evaluation of Departmental policies on pavement marking standards. Therefore, the conclusions drawn apply only to the situation on Route 8. A study dealing explicitly with the practice of mountain pavement markings is in progress at the Research Council at this writing.

METHOD

The study site consists of a four-mile section of Route 8 between Routes 57 and 58 in Patrick County (see Figure 1). This section has a roadway width of 20 feet, carries about 2,380 vehicles per day, and is posted at 55 mph. The vertical alignment is generally flat, but there are some horizontal curves.

Data collection was divided into two phases. During the "before" period, the site was marked for no passing throughout its four-mile length, and data were collected on 1,954 vehicles travelling the test site during November 1978. For the "after" phase, four experimental passing zones were installed based upon the 85th percentile speed and site distances recorded in November 1978 when passing was not permitted. As seen in Figure 2, each passing zone was between 600 and 925 feet long, and allowed for 800 feet of sight distance. It should be noted that the sight distance allowed for these passing zones was somewhat more stringent than that under MUTCD standards, but somewhat less strict than the Department's standards. Under the new conditions, experimental data were collected on 2,755 vehicles travelling the test section between April and June of 1979. It was recognized that comparing traffic data for late fall with data for spring and early summer might introduce a seasonal variation; however, it was felt that this variation would not invalidate the findings.

Both before and after data were collected using various data acquisition systems. Information on traffic volumes, vehicle mix, speeds, and queues was collected both before and after the new passing zones were installed. Self-reported information on motorists' passing behavior under no-passing conditions was collected at the study site during the before phase, and passing maneuvers at the experimental zones during the after phase were recorded on 8-mm film. Available accident data were obtained for both phases.

RESULTS

The main focus of the analysis was on a comparison of the traffic and safety characteristics at the study site before and after the installation of the passing zones, because in order to recommend that passing zones remain at the study site, they must result in improved operational characteristics without significant degradation of safety.

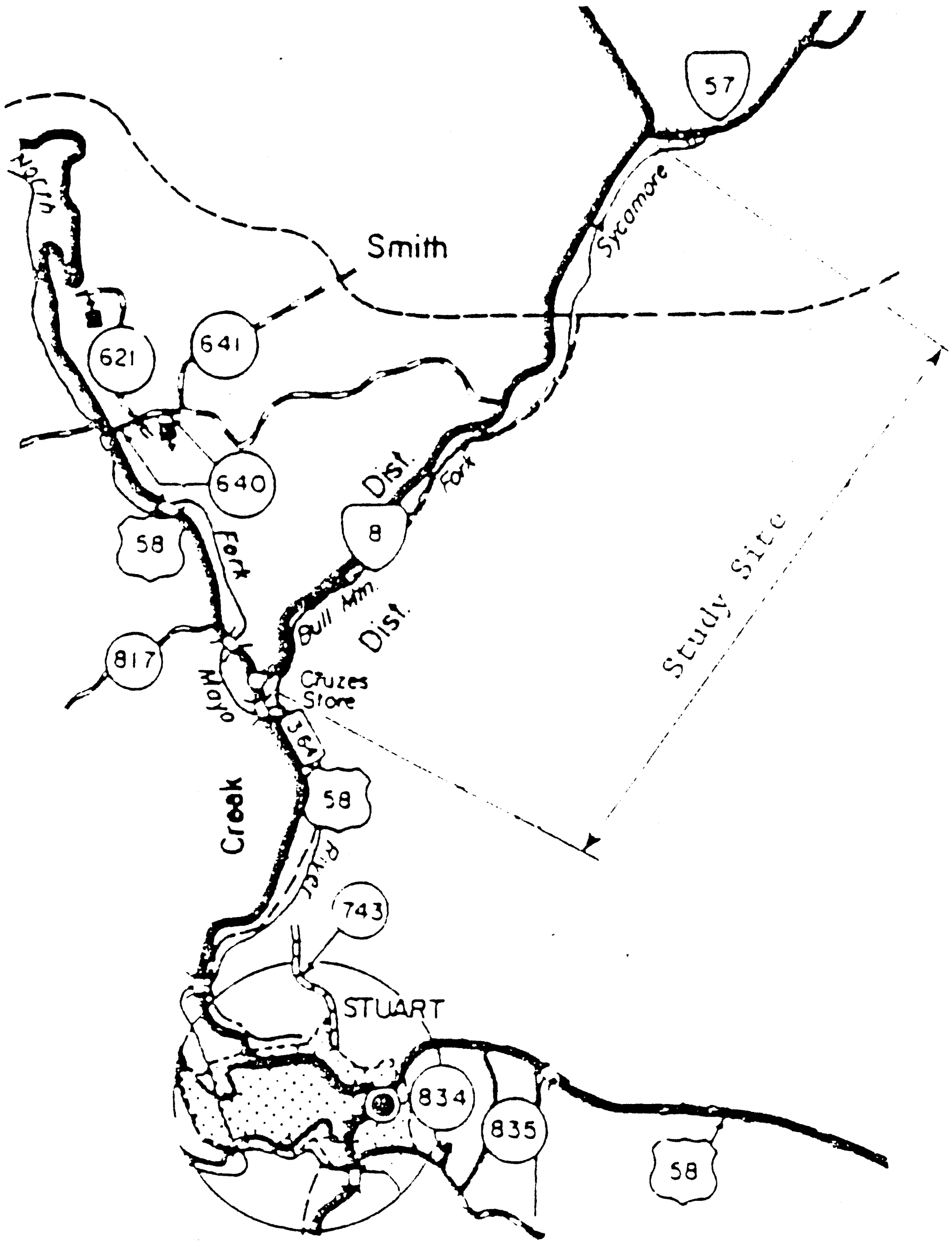

Figure 1. Location of study site.

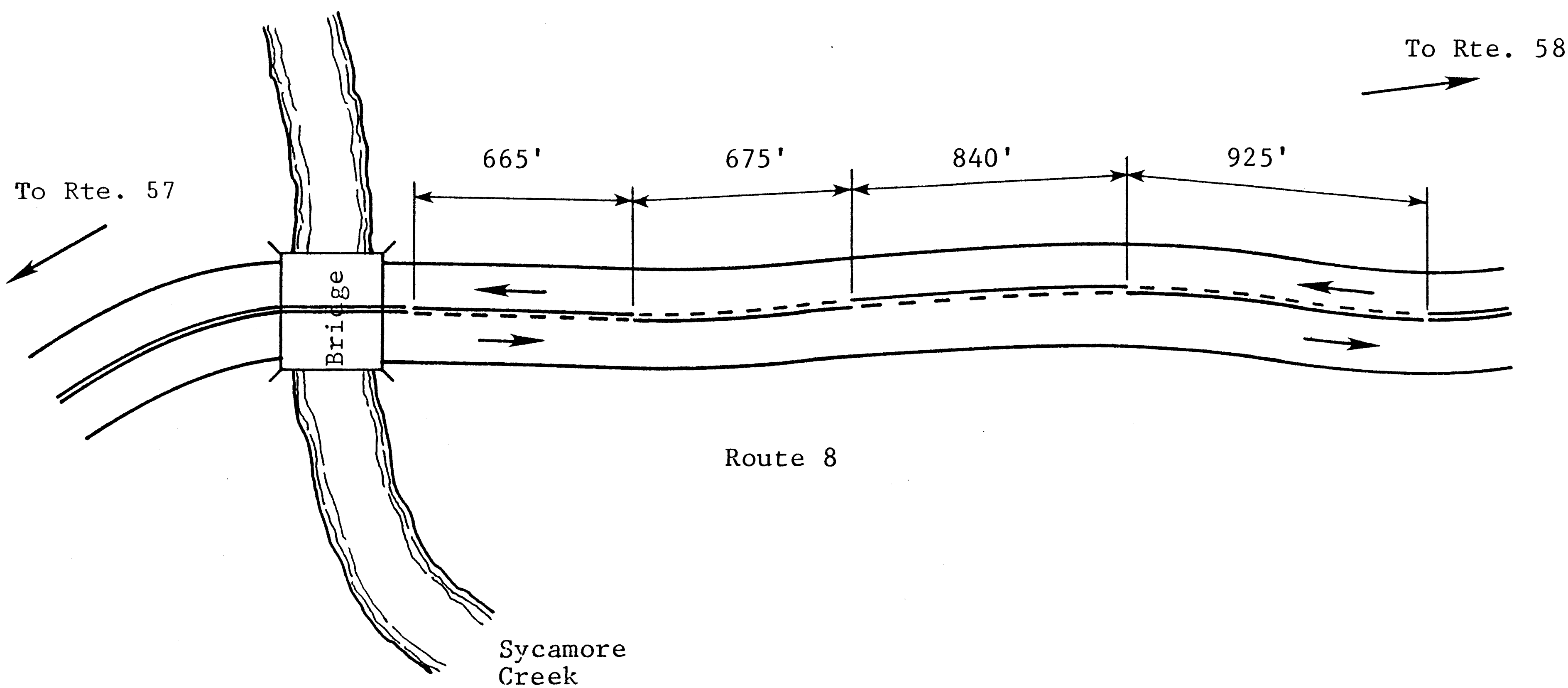

Figure 2. Schematic of the four experimental passing zones.

The following roadway characteristics were examined: (1) traffic volumes and composition, (2) vehicle speed, (3) passing maneuvers, (4) traffic queuing, and (5) accident frequency and probability of future risk.

Traffic Volumes and Composition

As seen in Tables 2 and 3, no significant differences were noted in overall traffic volumes, peak-hour volumes, and traffic composition between the data collection phases. In both cases, volumes averaged between 111 and 118 vehicles per hour, with maximum hourly volumes being recorded between 1530 and 1630. Additionally, passenger cars accounted for 90% of the traffic. There was, however, a slight difference in the ratio of regular trucks to tractor-trailers, especially in the southbound lane, with fewer trucks and more tractor-trailers using the roadway after the installation of passing zones. It is speculated that once such zones were provided, professional drivers were more likely to use the roadway than previously. In any case, changes noted in other traffic variables after installation of the passing zones were not a result of changes in volume at the site.

Table 2

Average Number of Vehicles Per Hour

	Before		After	
Time	Northbound	Southbound	Northbound	Southbound
0830-1000	39	54	34	53
1000-1400	58	52	52	53
1400-1530	78	53	61	52
1530-1630	103	78	100	70
Overall Average	62	56	56	55

Table 3

Percentage Distribution of Vehicle Types

	Before		After	
	Northbound	Southbound	Northbound	Southbound
Cars	90.7	90.0	90.4	90.3
Trucks	5.5	7.3	5.8	5.3
Tractor-Trailers	3.3	2.7	3.8	4.4

Vehicle Speed

If the passing zones on Route 8 were effective in improving traffic flow, the mean speeds of vehicles over the test section should have increased. As seen in Table 4, this was the case. Mean speeds increased from 48.9 mph during the no-passing phase to 50.8 mph during the passing phase, while 85th percentile speeds increased from 55.1 mph to 58.4 mph. These changes were significant at the 95% level of confidence.

Table 4

Speed Characteristics

	Before Phase	After Phase
Number of vehicles sampled	1,954	2,755
Mean speed, mph	48.9	50.8
85th percentile speed, mph	55.1	58.4
Standard deviation, mph	6.8	6.5

It should also be noted that while the change was not significant, the standard deviation decreased somewhat in the after phase. This could indicate that more vehicles were travelling at roughly the same speeds during the after period, which generally would be interpreted as indicative of a safer roadway environment. These speed distributions will be dealt with in greater detail in the accident characteristics section of this memorandum.

Traffic Queues

Another passing related operational characteristic expected to change as a result of improved traffic flow is vehicle queuing. For the purposes of this study, a queue was defined as two or more vehicles travelling in the same direction with a maximum headway of six seconds between any two consecutive vehicles. If the introduction of passing lanes improved traffic flow, queuing occurrence and queue size should be reduced while queue speeds should increase. As shown in Table 5, all three characteristics changed significantly as expected. In both the northbound and southbound lanes, the number of queues and the number per hour decreased significantly. Numbers of vehicles per queue also decreased, while the speed at which the queues travelled increased significantly. All of these factors would indicate that the operational characteristics of the roadway improved after installation of passing zones.

Table 5

Queue Characteristics by Direction

	Northbound		Southbound	
	Before	After	Before	After
Number of queues per hour	11.8	8.1	8.8	5.5
Number of vehicles per queue	2.8	2.5	2.3	2.2
Speed per queue, mph	47.8	50.5	46.3	47.3
Total number of queues	94	65	70	44

Passing Maneuvers

A number of characteristics of passing maneuvers were examined during the analysis. Unfortunately, no individual passing measure was taken both before and after installation of the passing zones, and thus no changes in passing characteristics can be related to the introduction of the passing zones. However, two pieces of information can be used to augment the results already noted with regard to the operational improvements provided by the passing zones.

First, during the survey of motorists conducted prior to installation of the zones, it was found that 77% of the respondents admitted to having passed illegally at the study site during the time that passing zones were not available (see Table 6). Since motorists traditionally tend to underestimate the frequency of their illegal behavior, it can be assumed that this figure may be somewhat higher than reported. About 15% admitted to having passed illegally daily or several times a week.

Table 6

Frequency of Illegal Passes

	Percent of Drivers
Daily	4.3
Several times a week	11.2
Rarely	61.4
Never	22.7
No response	0.4

Clearly, this is a very high rate of violations. As a rule, such large violation rates indicate that there is something amiss with the situation that causes motorists to rationalize illegal actions.

The second factor that further illuminates the problem has to do with passing distances as calculated from the 30 passing maneuvers filmed during the after period. As seen in Table 7, there was considerable variation in the length of roadway needed to complete a passing maneuver.

Table 7

Passing Distances for all Vehicles, in feet

Maximum	1,113
Minimum	520
Mean	803
85th percentile	975
Percentage of vehicles completing pass within the 900-foot zone	79

Of all passes filmed, 85% were completed within a distance of 975 feet, but only 79% were completed within the 900 feet allowed for passing in the experimental zones. This would indicate that the experimental passing zones were slightly shorter than they ought to be, given that it is desirable to have at least 85% of all maneuvers completed within the passing zone.

Accident Frequency

As was noted earlier, it was not anticipated that an analysis of accident data would provide much insight into the change, if any, induced in the safety environment on Route 8 since few accidents occurred there. Nevertheless, accident data were obtained for the entire four-mile study site and are shown in Table 8.

Table 8

Summary of Accident Data

Year	Fatal	Injury Accidents	Persons Injured	Property Damage Only Accidents	Total Accidents	ADT
1978	0	4	4	1	5	2,210
1979	0	2	2	3	5	2,165
1980	0	4	5	3	7	2,105

As can be seen from the data, while the ADT dropped slightly over the three-year period, total accidents increased modestly from five to seven. Obviously, these data provide too small a sample to use in attempting to draw any meaningful conclusions.

However, some indication of the accident potential can be derived from an examination of speed distributions. According to Soloman, the more variance exhibited in speeds within a given traffic population, the more likely are accidents.(1) Conversely, the less variance in the distribution, the less likely are accidents. This phenomenon has been noted in numerous studies of speeds and accidents.(2,3,4) While speed variance is directly related to accident occurrence, absolute speeds are related to accident severity, in that once an accident has occurred, crashes occurring at higher speeds have more serious consequences.(5,6,7,8,9,10) Thus, by examining changes in mean speed and speed distributions concurrent with different roadway markings, some predictions concerning the accident environment can be made.

Speed distributions for the period during which no passing was in effect and for the after period are shown in Figure 3. It can be noted from this figure (and from Table 4) that while mean speeds increased significantly during the after period, the standard deviation decreased slightly, but not significantly. This would indicate that since the variance in speeds was essentially unchanged, the number of accidents would remain unchanged. However, since the mean speeds were higher during the after phase, crashes occurring then would be expected to be somewhat more serious. Since there were few accidents occurring at the study site and since this number is not expected to increase as a result of the change in pavement markings, the main safety consideration in deciding whether to use the less stringent passing zone standard revolves around whether the somewhat more serious consequences of these few accidents are an acceptable trade-off against improved operational characteristics.

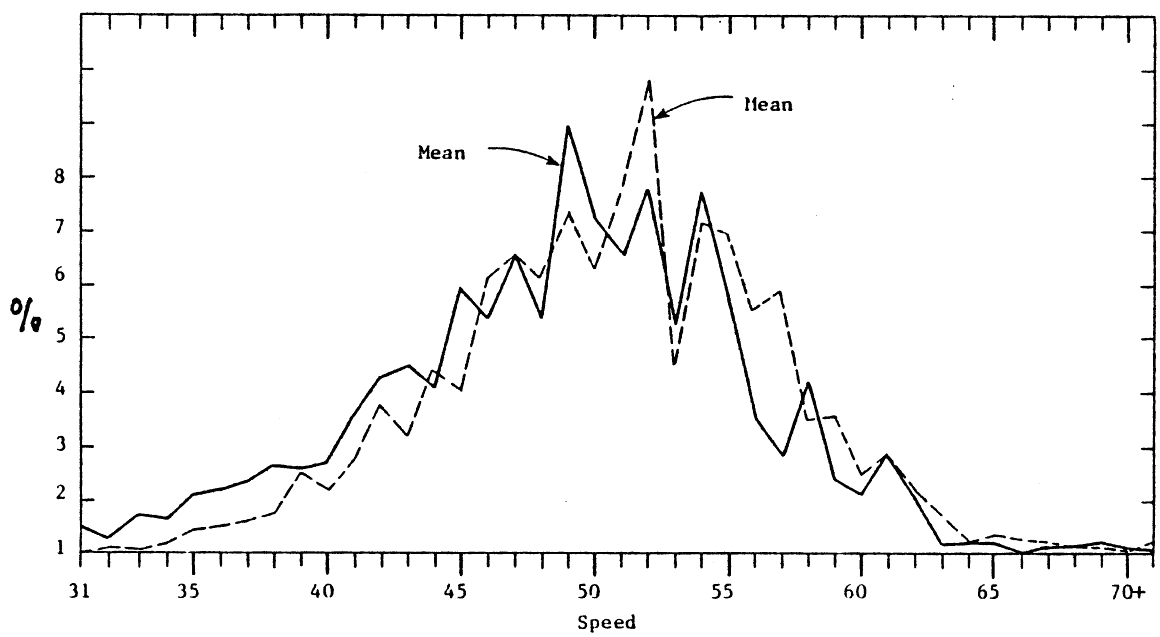

Figure 3. Speed Distributions

CONCLUSIONS AND RECOMMENDATIONS

It can be concluded from this examination that the operational characteristics of the four-mile test section of Route 8 between Routes 57 and 58 were significantly improved after provision of the experimental passing zones. Average and 85th percentile speeds both increased significantly, indicating an improved traffic flow and level of service. The numbers of queues and sizes of queues both decreased, indicating that delay time was reduced, while the speed at which the queue travelled increased, again indicating improved operational characteristics. Also, although motorists' opinions were not obtained after installation of the passing zones, it is assumed that since the public was in favor of such an action, the public opinion was satisfied and the numbers of illegal passing maneuvers reduced.

The improvements in mean speeds, queues, travel time, and overall traffic flow do not appear to have been achieved at the expense of traffic safety although the few accidents that occurred in the test section during the after period were, as could be expected, somewhat more severe than those in the before period. More data are needed to determine the extent of the impact of this change in pavement markings on the safety environment at Route 8.

While the uniqueness of conditions prevailing at Route 8 when this study began may preclude any general application of the results of the study, several recommendations concerning Route 8 itself may be made. It is recommended that passing zones at the study site be marked with sight distances equal to at least 800 feet and a passing zone of at least 975 feet. The current markings do not reflect this requirement. It is also recommended that accident experience be monitored at the site to see if accident rates continue to be as low as they were during the study period. Finally, it is recommended that changes to the general policy regarding the provision of mountain pavement markings await the results of the Research Council's study of mountain marking that is in progress.

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