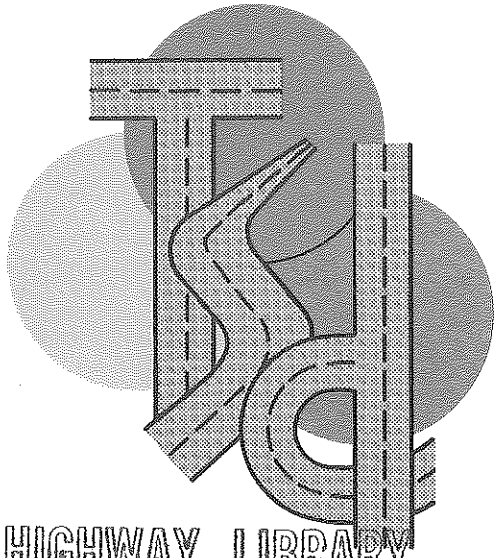
FINAL REPORT

COLOR CODING STUDY FOR FREEWAY MARKINGS
MEDIAN DELINEATION PHASE

Report TSD-231-73



TRAFFIC and SAFETY DIVISION

DEPARTMENT OF STATE HIGHWAYS
STATE OF MICHIGAN

FINAL REPORT

COLOR CODING STUDY FOR FREEWAY MARKINGS MEDIAN DELINEATION PHASE

Report TSD-231-73

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February 1974

STUDY CONDUCTED BY THE

Michigan Department of State Highways and Transportation
Traffic and Safety Division

in cooperation with

U.S. Department of Transportation
Federal Highway Administration

The opinions, findings and conclusions expressed in this publication are those of the author and not necessarily those of the Federal Highway Administration.

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FOREWORD

In late 1971 the decision by the Federal Highway Administration and the National Joint Committee on Uniform Traffic Control Devices to edgeline all freeways (left and right sides) with white lines prefaced a decision to study this approach to delineation. We added a variation that was believed would provide a clearer path ahead to the driver. It was proposed to study freeway vehicle operations on curves with no edgelines but with clear post-mounted delineation, followed with the addition of white edgelines, and finally to change the color of the median edgeline and post-mounted delineators to yellow on these same curves.

Subsequently the Federal Highway Administration disallowed experimental use of median yellow delineators and the study was concluded, after placement of the white edgelines on both sides of the freeway through the curves.

In 1972 another pavement marking change was made in national policy namely to paint all median edgelines yellow, retaining white on the right edge and a white skip for lane lines. If corresponding yellow delineators were used on the median edge (particularly right curves) of freeways, added clarity to these curves would be provided during inclement weather and for the night-time driver. With yellow delineators on the median side and white delineators on the right side the random pattern presently seen that uses all white delineators would be changed to a defined path between a left side yellow reflective scheme and a white reflective right side.

The portion of the study completed showed that edgelines definitely affect vehicle travel on freeway curves and should aid safety on the highways through better vehicle positioning in the driving lanes.

CONCLUSION:

Few prior studies have shown a benefit from pavement edgelines in terms of effect on the driver. The only response from drivers was that they seemed to "like it". This study shows some advantageous effects from edgemarkings on curves, some of which would also be applicable to tangent sections.

It was found that speeds are significantly reduced in a curve more with edgelines than without.

Centerline straddling was substantially reduced, thereby placing more vehicles fully in one lane or the other. In right hand curves studied, the usage of the right lane through the curve seems more consistent than the left. On left hand curves the shifting to the left lane appears independent of edgelines, but rather dictated by the desire to drive on the superelevation-induced, spiral path.

The fact that drivers aligned themselves more positively in the lane on curves suggests that it may be one of the benefits of tangent edgelines, particularly on two-way roadways. A reduction in the number of vehicles running off the edge of the pavement on two-lane, two-way roadways with edgemarkings would result in less shoulder rutting and should provide less accident potential.

RECOMMENDATIONS:

The results of this study show improved vehicle operation on freeway curves with edgelining added. We recommend this practice be continued.

Further areas of study should be investigated: 1) when median edgelines are repainted in yellow by Official Ruling M-14, Oct. 1973; 2) place yellow post delineators on the median side of the two right curves rather than clear presently used. Right side clear delineators would be removed through these right curves but retained as at present on the left curves. This would test a Pennsylvania study conclusion that clarity of delineation is improved.

Arizona's delineation studies showed no difference in using post delineators compared to painted edgelines on tangent sections. They chose post delineation on the basis of economics. Economics eventually could dictate this approach for Michigan. If only curves were paint edgelined and post delineated, horizontal alignment changes would be dramatized for the driver. Tangent sections would only be post delineated if this approach were used.

Some of these possibilities should be investigated for utility and cost effectiveness in Michigan as involved with tangent freeway sections and the newer curvilinear designs.

INTRODUCTION:

It had been proposed in most recent National Joint Committee and Federal Highway Administration actions that all freeways with wide medians be delineated on the median side with white edgelines in addition to that on the right hand side.

In terms of providing the best guidance to the motorist with the greatest clarity of meaning, it was determined that this proposal would be researched to determined if in fact the addition would provide better path delineation than some other marking arrangement.

OBJECTIVE:

The plan was to determine if gains in driver guidance can be made with the use of white left edgelines and delineation, or if additional driver benefits can be attained using another left edge color than white, which is standard for the right hand edge.

NOTE: As was mentioned earlier it was not possible to follow the original stated objective due to a decision change by the Federal Highway Administration which disallowed experimental use of yellow delineators on medians. This study was therefore reduced to investigate only the effects of centerline marking and clear delineators on both sides, compared to this same scheme with left and right white edgelines added.

BENEFITS:

The benefits to the driver on a freeway curve are several. If a dual color arrangement (yellow left - white right) provides a more definitive path to the motorist, then it should leave fewer uncertainties in the driver's mind. The benefits may be reflected in more steady operating speeds, less lane changing and reduced driver tension.

Usage of colors to denote a difference in action or intent or even left to right side indication has been practiced for years, as in walk-wait signal colors and navigation and aircraft lighting. It follows that if a different color usage than the through roadway is beneficial at ramps, then it should be useful on left edges to differentiate the left from the right side of the roadway, particularly through curving alignments.

The analysis of data from the Interchange Ramp Color Marking and Delineation Study showed that edge lines and delineators were noticed more than anything else in the driving view, particularly in interchange areas. (From MDSH report TSD-TR-120-69 of September 1969 final report).

LOCATION:

The study areas were established on US-127 south of Lansing. Sites 1 and 2 were chosen on southbound and northbound curves two miles south of I-96 near a rest area and Sites 3 and 4 at a second set of curves on US-127 five miles to the south at its interchange with M-36 (Figure 1).

PHASES OF STUDY:

Phase I Study Conditions as follows:

New centerlines were painted on the route and right side white-reflecting delineators were in place, as well as left side white ones at right curves. The pavement is Portland Cement Concrete.

Phase II Study Conditions:

Centerline painting and delineator arrangement was the same as Phase I. (4") white edgelines were painted along the right and left edges of the pavement.

STUDY AREA DESCRIPTIONS:

Study Site #1 - Northbound (Figures 1 and 2)

This study area lies within a 2^{o} 15' curve to the left.

Vehicles enter the area on a 1.8% downgrade to 0% grade within the study area.

Speed recording and observation points 2100' apart, at beginning and end of areas.

Median woods at grade on the left and a Rest Area on the right, open and above grade. The median averages 180 feet wide.

Study Site #2 - Southbound (Figures 1 & 2)

The study area is on a 2° 15' curve to the right.

Vehicles enter area from 1.84% downgrade to 0% in study area.

Speed recording and observation points 2400' apart.

open below grade median and woods on the right, then woods both sides toward end of study area.

Study Site #3 - Northbound (Figures 1 & 3)

The study area is on a 2° curve to the left.

Vehicles enter area from 2% downgrade to .4% downgrade in study area.

Speed recording and observation points 1200' apart.

Clear, shallow median is 70 feet wide.

Vehicles enter the area on a tangent approach under two structures (M-36).

Study Site #4 - Southbound (Figures 1 & 3)

The study area is on a 2° curve to the right.

Vehicles enter on .4% upgrade that continues through study area.

Speed recording and observation points 1100' apart.

Vehicles enter on a curve approach under a structure 700 feet advance of area, plus two structures within area (M-36).

US-127 STUDY SITE LOCATIONS

Ingham County, Michigan

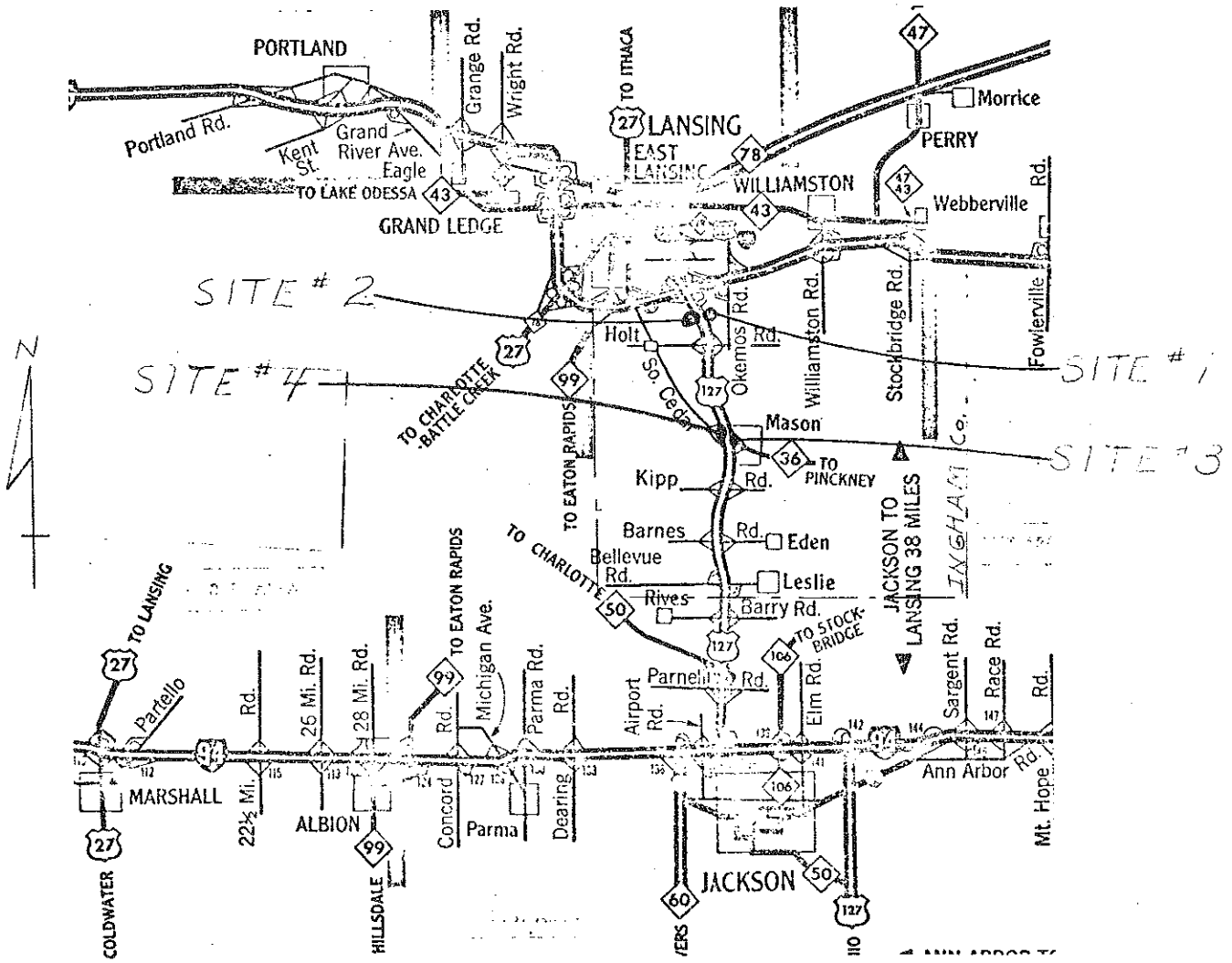
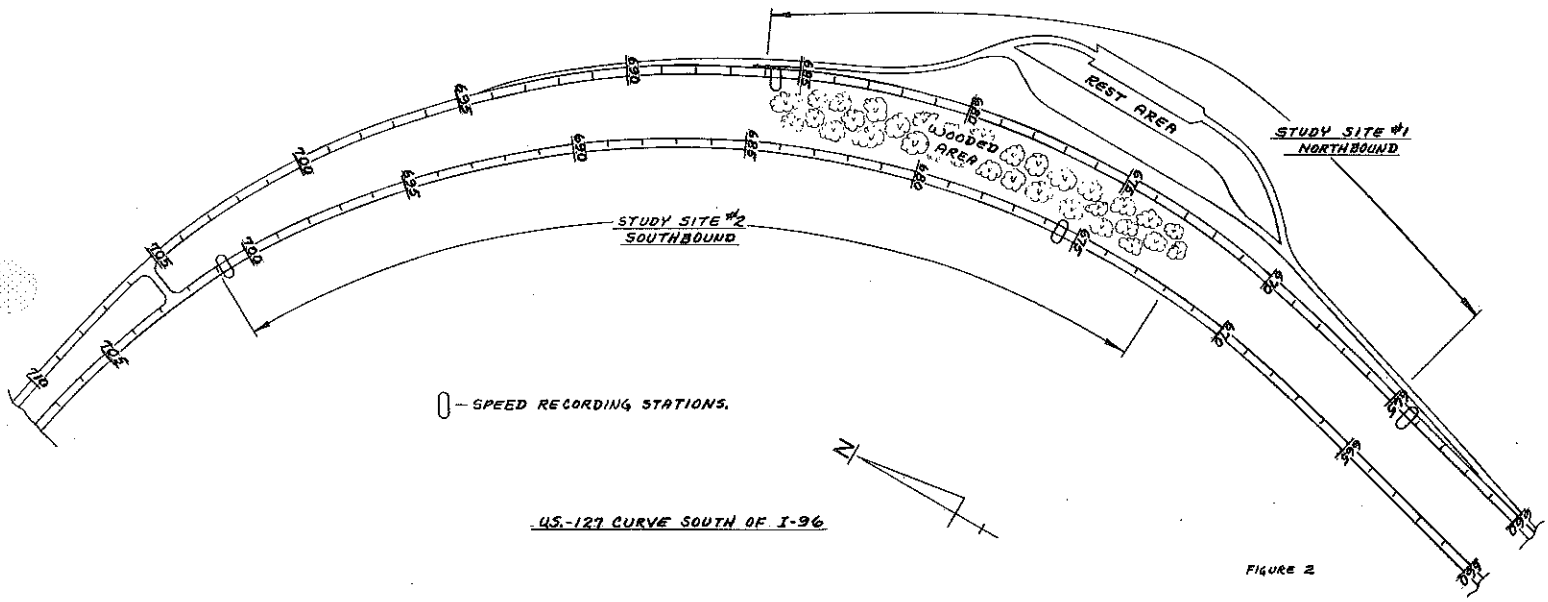
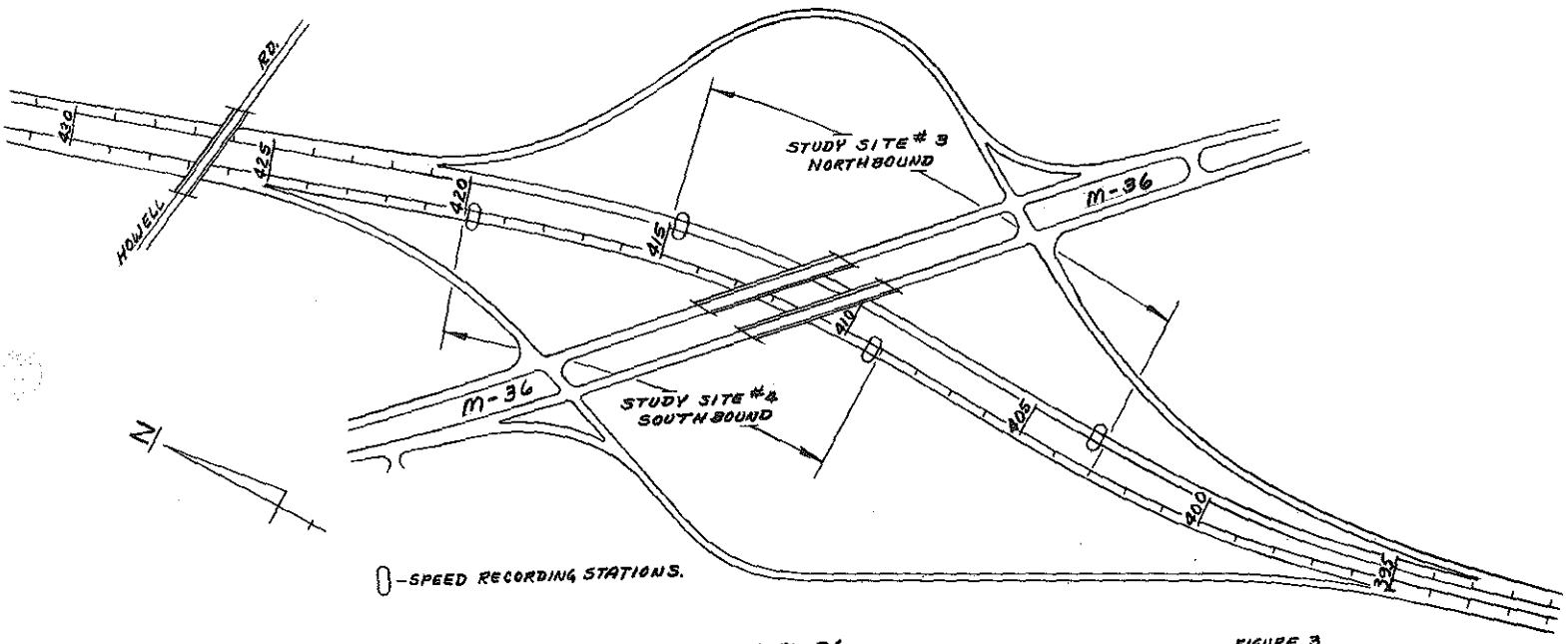


Figure 1



US.-127 CURVE SOUTH OF I-96

FIGURE 2



U.S.-127 CURVE AT M-36

FIGURE 3

STUDY RESULTS:

Tables I through IV list lane usage as a percent and the entering and leaving speeds at each study site as well as the percent of change. The percent of the traffic stream that travels on the centerline is shown as well as those that make passing maneuvers. The tables also show the data by phase, and the percent of trucks in each phase. Phase I data was taken without edgelines in place and Phase II data was taken after 4 inch white edgelines were painted on both edges. Figures 4 and 5 graphically depict the phase relationships of speeds and percentages of volumes in the right lane at ends of each study site.

Specifically two elements of the study showed strong evidence of association to the addition of white edgelines through the study areas. These are speed changes and lane usage patterns.

SPEED STUDIES ANALYSIS

At Sites 1, 2 and 3 (See Tables I, II and III) the speed reductions within the study areas were greater following the edgelines application. Net speed changes at these sites, Phase II to Phase I, varied from .38 M.P.H. to 1.45 M.P.H. These reductions occurred even though at two of the three sites the entering speeds were higher for Phase II than Phase I. The vehicles speeds at the end of each study site during Phase II was also the slowest speed recorded. These speed reductions are graphically displayed in Figure 5. Presumably then, the improved definition of the curved road

TABLE I

Study Site #1 NBd. by Rest Area

Phase		Vehicles in Right Lanes (Percent	Speeds (MPH)	Vehicles Traveling on Centerline (Percent)	Vehicles Passing (Percent)	Trucks (Percent)
I	Enter	83.1	68.94	28.6	10.7	3.9
	Leave	83.7	68.40	12.9		
Zone Change		+0.6	-.54			
II	Enter	83.3	69.59	12.6	11.5	6.6
	Leave	74.4	67.88	8.3		
Zone Change		-8.9	-1.71			
Phase II to I Net Change		-9.5	-1.17	-20.6	+0.8	

TABLE II

Study Site #2 SBd. by Rest Area

Phase		Vehicles in Right Lanes (Percent)	Speeds (MPH)	Vehicles Traveling on Centerline (Percent)	Vehicles Passing (Percent)	Truck (Percent)
I	Enter	94.2	64.61	13.4	11.5	6.7
	Leave	89.5	63.31	1.3		
Zone Change		-4.7	-1.30			
II	Enter	86.7	65.96	4.2	10.8	8.5
	Leave	86.9	63.21	0.0		
Zone Change		+0.2	-2.75			
Phase II to I Net Change		+4.9	-1.45	-10.5	-0.7	

TABLE III

Study Site #3 NBd. @ M-36

Phase		Vehicles in Right Lanes (Percent)	Speeds (MPH)	Vehicles Traveling on Centerline (Percent)	Vehicles Passing (Percent)	Trucks (Percent)
I	Enter	95.0	68.70	59.2	6.9	13.7
	Leave	75.7	67.44	18.3		
Zone Change		-19.3	-1.26			
II	Enter	91.8	68.46	26.1	0.0	15.3
	Leave	75.5	66.82	13.0		
Zone Change		-16.3	-1.64			
Phase II to I Net Change		+3.0	-0.38	-38.4	-6.9	

TABLE IV

Study Site #4 SBd. @ M-36

Phase		Vehicles in Right Lanes (Percent)	Speeds (MPH)	Vehicles Traveling on Centerline (Percent)	Vehicles Passing (Percent)	Trucks (Percent)
I	Enter	96.6	67.27	1.7	4.0	13.0
	Leave	93.2	64.69			
Zone Change		-3.4	-2.58			
II	Enter	95.1	66.35	1.6	1.1	17.3
	Leave	95.1	66.43			
Zone Change		0.0	+0.08			
Phase II to I Net Change		+3.4	+2.66	-.1	-2.9	

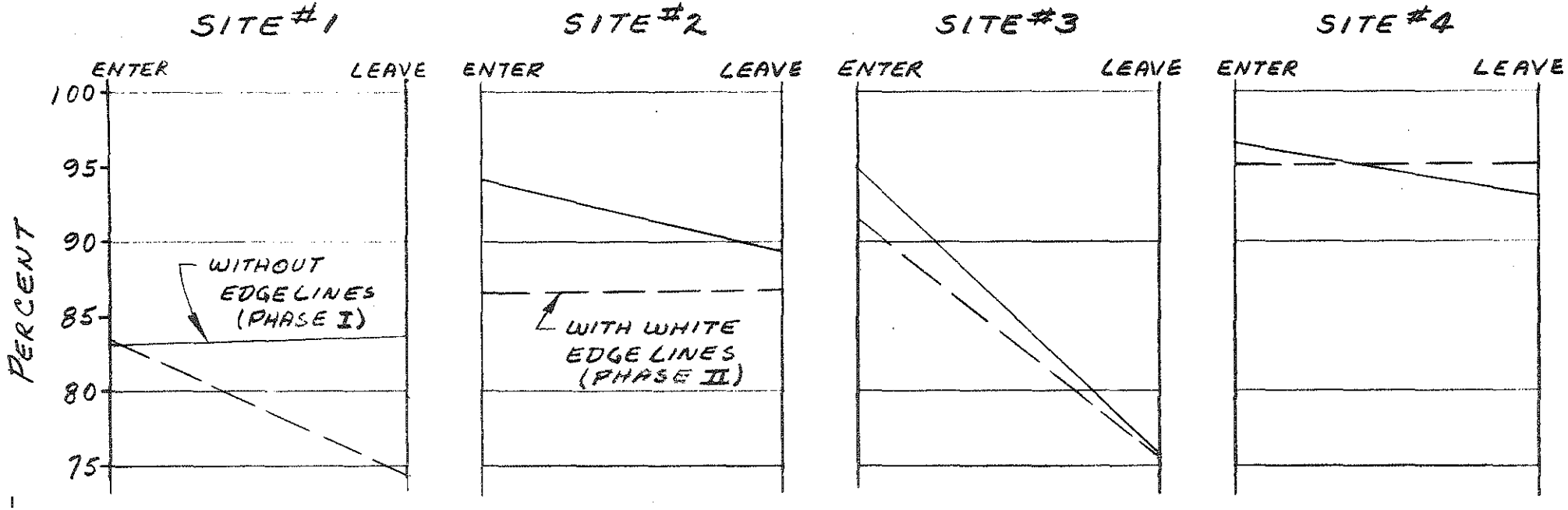


FIGURE 4 - PERCENTAGE OF VEHICLES IN RIGHT LANE AT ENDS OF STUDY SITES.

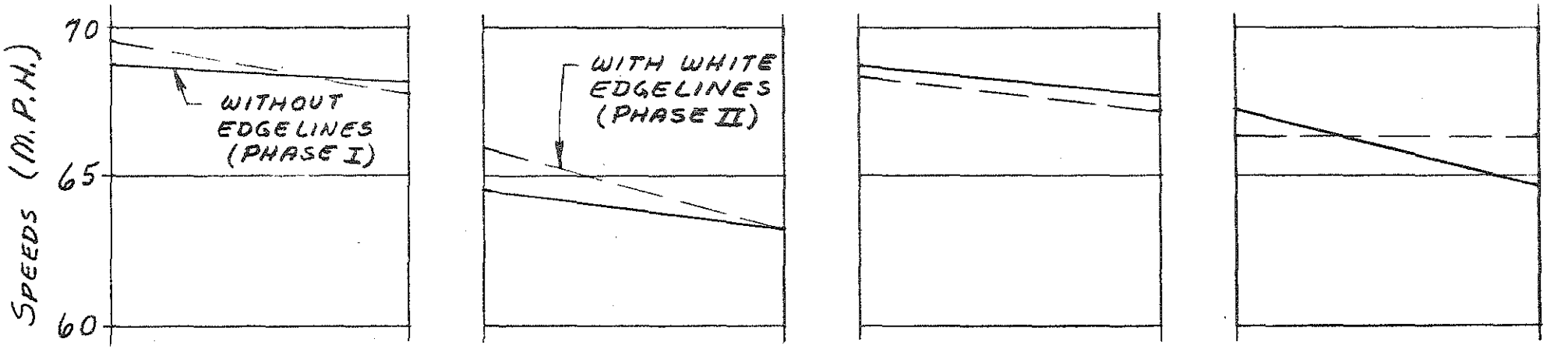


FIGURE 5 - SPEEDS OF VEHICLES AT ENDS OF STUDY SITES.

ahead as provided by the edgelining, caused drivers to decelerate more than they did without this definition provided. The relative views ahead at nite are shown in Figures 6, 7, and 8.

Drivers at Site #4, (Table IV) reacted differently, perhaps due to the unique characteristics of the site. (Figure 9). The Phase I speed here dropped 2.58 M.P.H. within the curve. The alignment at this site is a right curve under the dual structures of M-36. (Figure 9). This appearance of discontinuance under the structures apparently caused the above speed drop. After the edgelines were placed the speeds through the whole study zone were nearly unchanged, (+.08). They were however, 1.74 M.P.H. higher than the zone end speeds before edgemarking.

LANE USAGE ANALYSIS

An analysis of the percentages of vehicles in the lanes entering and leaving appear to be independent at each site with no apparent correlation between sites, Tables I through IV. The right lane percentages of vehicles in Phase I varied from 83.1% to 96.6% entering the study areas and 75.7% to 93.2% leaving those zones. Phase II lane percentages also varied greatly; 83.3% to 95.1% entering; and 74.4% to 95.1% of vehicles in the right lane leaving the study areas. Figure 4 shows a graph of these lane percentages in each phase.

The most notable lane usage changes are shown by the percents of vehicles traveling on centerline through the curves (Tables I, II and III). The left curve sites (1 and 3) exhibit high rates of

traveling on centerline, 41.5% and 77.5% respectively. Under Phase II conditions these dropped to 20.9% and 39.1%. These sites as well as site 2 show a marked improvement in alignment of vehicles fully on one lane or the other. From an operational and safety standpoint this should represent a real improvement.

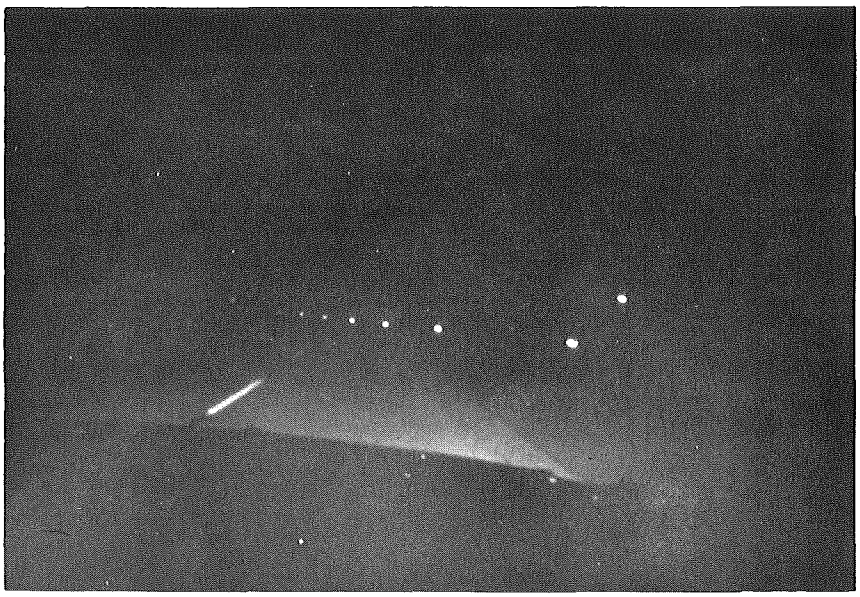
The tendency of drivers to drive the easier path in left curves is very evident from these observations of centerline encroachment at left and right hand curves. The inside lane at curves drives easier due to the superelevation of the pavement which results in a steeper cross section slope on the inside lane. The outside lane which has a flatter slope requires more conscious steering effort to negotiate the curve.

If we analyze the average percentage of right lane vehicles for both phases at each site, we see that the right hand curves (Sites 2 and 4) average 89.3% and 95% of the vehicles in the right lane. This compares to 81.1% and 84.5% at the two left curves (Sites 1 and 3).

The centerline travel at Site 4 was minimal in Phase I and remained so in Phase II where entering and leaving lane volumes also stayed constant. The 8 to 12% higher right lane entering volumes at Site #3 over the other left hand curve at Site #1 is apparently due to vehicles at Site #3 just emerging from a right curve which characterizes higher right lane usage (Figure 3). The tangent approach to Site #1 should represent an average tangent lane usage percentage on this route. (Figure 2).

The passing percentages by phase did not appreciably change at the sites except Site #3 where 6.9% make passing maneuvers in Phase I and none were observed in Phase II. It could be hypothesized that the high centerline encroachment in Phase II (39.1%) may have reduced the amount of passing, however the 6.9% passed in Phase I under 77.5% centerline encroachment.

Individual site differences between the four sites all have factors affecting the traffic stream such as those evidenced by lane usage differences. The "Before" and "After" photographs in Figures 6 through 9 depict the relative views to the driver with and without edgelining. The value of edgelines in defining the path ahead is readily apparent even utilizing the same delineator pattern. A different vehicle with a high hood has somewhat changed the view appearance at the bottom of each "Before" photo but the difference in path definition was indeed radically improved with edgelines. The reflectorized bridge markings are also very evident in Figures 8 and 9.



SITE #1 BEFORE EDGELINING - Left curve

SITE #1 AFTER EDGELINING - Left curve

Figure 6

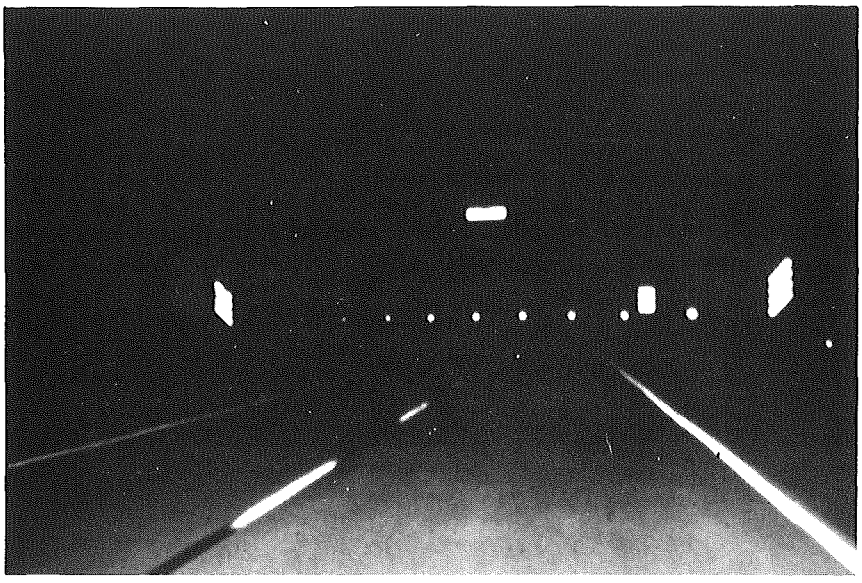
SITE #2 BEFORE EDGELINING - Right curve

SITE #2 AFTER EDGELINING - Right curve

Figure 7

SITE #3 BEFORE EDGELINING

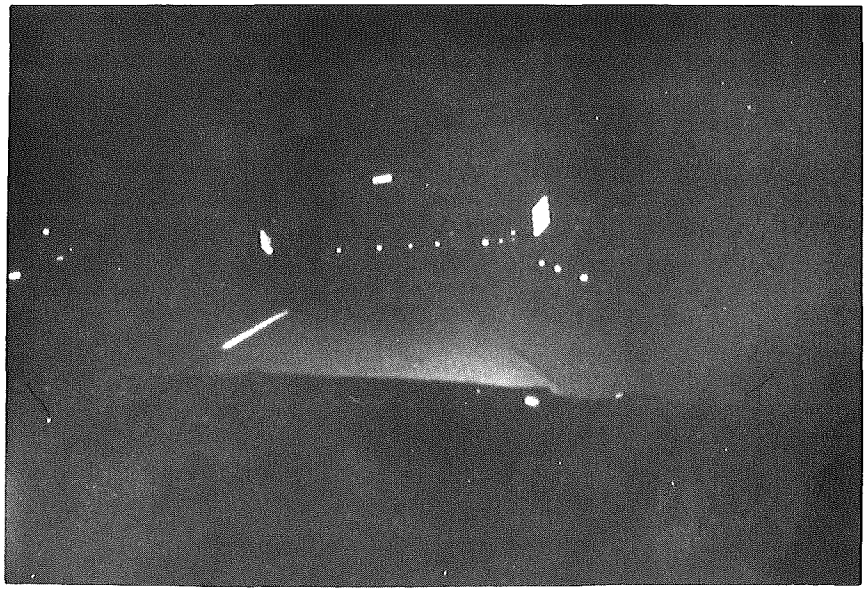
View ahead under M-36



SITE #3 AFTER EDGELINING

View ahead under M-36

Figure 8



SITE #4 BEFORE EDGELINING

Right curve toward M-36

SITE #4 AFTER EDGELINING

Right curve toward M-36

Figure 9

STUDY PROCEDURE

Four sites by direction were established for the study in two general areas. (See Figures 2 & 3). Sites 1 & 2 are on the curve south of College Road near the rest area, Site #1 on the northbound lanes, Site #2 on the southbound side. Two other sites are under the M-36 interchange overpass five miles south of Sites 1 & 2. Site #3 is on the northbound lanes and Site #4 on the southbound. Approximately 200 free-speed samples were obtained at two points at each of these sites, or eight speed locations, plus lane volumes. The speeds were obtained by placing a flat counter tape at each end of the study sections. Long wire leads were laid to a vehicle off the freeway where the impulses were recorded. The lane volumes, lane usage patterns or other behaviors were recorded manually by observers placed at strategic locations. All studies were taken during hours of darkness. Drive through films were made through each area to record the views at each site for record and initial evaluation.

Following the first series of studies (Phase I), study areas were then edgemarked both sides with 4" white paint in accordance with present standards. Studies were then repeated as above at all locations for Phase II. The speed characteristics and lane usage patterns will be compared with and without white edgemarking.

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