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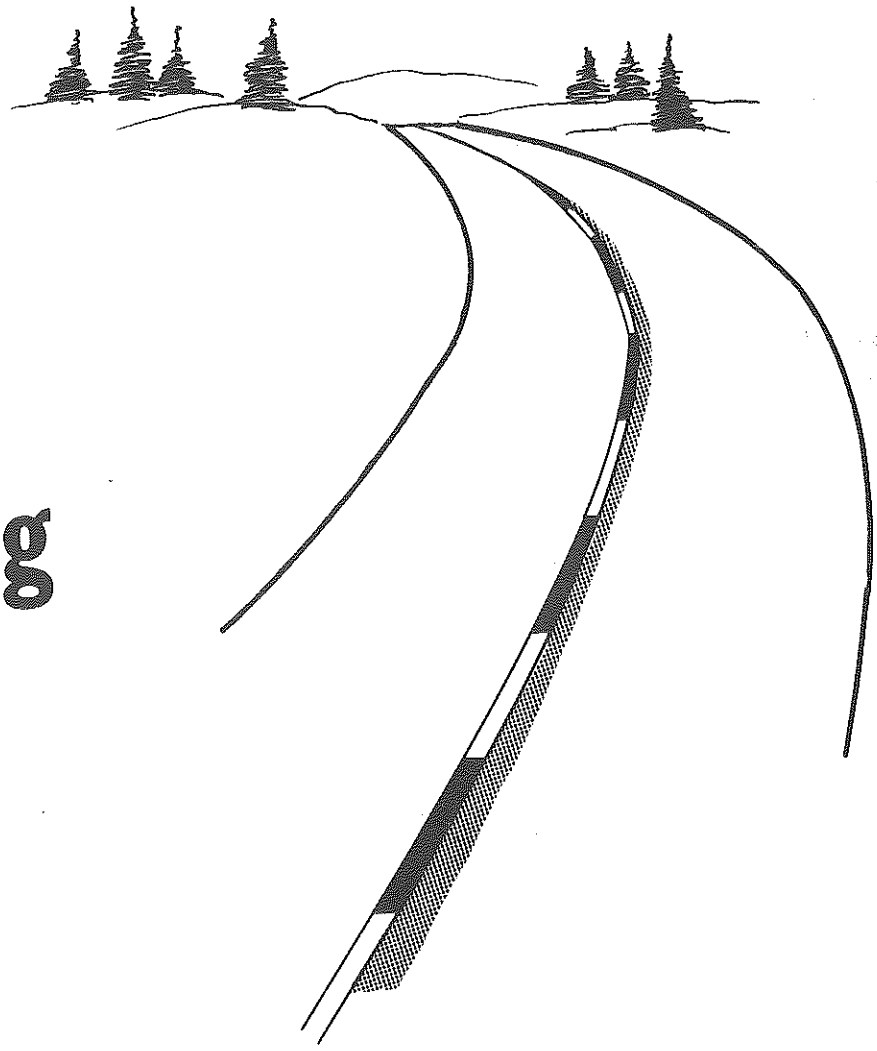
A review of the Criteria for marking no-passing zones



TRAFFIC DIVISION - MAY 1963

Michigan State Highway Department
John C. Mackie - Commissioner

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MICHIGAN STATE HIGHWAY DEPARTMENT

JOHN C. MACKIE, COMMISSIONER

Traffic Division

A REVIEW OF THE CRITERIA FOR MARKING NO-PASSING ZONES

Conducted in cooperation with

THE BUREAU OF PUBLIC ROADS

U. S. Department of Commerce

May 1963

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TABLES AND ILLUSTRATIONS

PREFACE

A great deal of discussion recently has centered on the impact of late-model cars on the operation of Michigan highways. In particular, some questions are asked about the effect of the general lowering of the height of the newer cars. In recent years, most new American automobiles have been lower in height than comparable models in previous years. In addition, the increasing number of compact and sports model cars, both foreign and domestic, has tended to decrease the average height of autos on the highways.

In view of this change, some of the questions most asked have concerned the Michigan criteria for establishing no-passing zones on its highways. Specifically the questions are these: Is the assumed driver-eye height of $4\frac{1}{2}$ feet too high? Is the required maximum sight distance of 1000 feet for marking no-passing zones too short? If the answer to either of these questions is positive, then what values should be substituted for the present ones? Providing the answers to these questions is the purpose of this study.

SYNOPSIS

The purpose of this report is the evaluation of the Michigan criteria for marking no-passing zones. The first chapter contains a review of the criteria from an academic standpoint; that is, the effect of changes in vehicle design and speeds. The second chapter contains a review of the effect in the field of various changes in the criteria, and the third chapter contains the conclusions and recommendations for the report.

Recommended for use in Michigan is conformance to national standards, with slight modifications. Also recommended is a repeat in 1967 of the academic investigation and an attempt to develop a workable method of locating no-passing zones in the field. The repeat investigation can re-evaluate the subsequent effect of the downward trend in vehicle heights and the upward trend in vehicle speeds, while the development of an improved field method will benefit both the motoring public and the persons responsible for establishing the zones.

CHAPTER I

Criteria Review

A. Driver Eye Height

1. Present Criterion

The Michigan criteria for establishing no-passing zones presently prescribes an assumed driver eye height of $4\frac{1}{2}$ feet.[1] This height was determined in 1939-40 and substantiated in 1954.

2. Vehicle and Eye Height

The overall height of new automobiles has, in general, been decreasing since at least 1927.[2] Since the end of World War II the periods of greatest decline in auto height have been 1946-49 and 1956-60. Since 1960, the rate of this decline has lessened but the decline continues. This is shown in Table I.[3]

TABLE I

Overall Height of New Autos, 1959-62

Year	Average Low	Average	Average High
1959	55.3 in.	55.8 in.	57.0 in.
1960	54.6 in.	55.6 in.	55.7 in.
1961	54.5 in.	55.2 in.	55.6 in.
1962	54.2 in.	55.0 in.	55.3 in.

These heights are based upon a car carrying a load of 750 pounds.

According to K. A. Stonex of the General Motors Proving Grounds, the decline in vehicle height will probably continue until an ultimate low of 53, or possibly 52 inches is reached. Mr. D. W. Loutzenheiser and Mr. E. R. Harle, Jr., of the Bureau of Public Roads, accept the 52-inch minimum and also estimate that it will not be reached until between 1972 and 1977.(4.

Expansion of the data in Table I indicates that the 52-inch minimum will be reached by 1971. Although this expansion is based upon limited data, it seems to confirm the 1972-77 prediction.

Stonex has also calculated the difference between overall vehicle height and driver eye height.(2. He did this by relating the overall vehicle height to an accumulation of four elements comprising the driver eye height: ground clearance of the car, car floor structure, seat height under the driver's weight, and the seated stature of the eye. The difference in overall vehicle height and driver eye height he found to be a very nearly constant 10 inches. If this 10-inch difference is accepted, the average driver eye height for 1959 cars is 45.8 inches, for 1960 is 45.6 inches, for 1961 is 45.2 inches, and for 1962 is 45.0 inches.

Professor Clyde E. Lee, of the University of Texas, used photographs to determine driver eye heights.(5. From 761 side view photographs of different passenger cars, he concluded that the eye height of 85 per cent of all drivers is greater than 3.95 feet, or 47.4 inches. Because

this study was conducted in 1959 and was based on 1933-59 vehicles, and because the average age of passenger vehicles in this country is six years,(6. this figure of 47.4 is probably the most indicative of the average driver eye height today.

Table I does not include any data for foreign cars used in this country. Stonex has noted, however, that many of the foreign cars are actually higher than the highest of the domestic cars.(7. A check of the 1959 foreign cars, for instance, reveals an overall average loaded height of 55.5 inches, which compares quite favorably with the 55.8 inch average height found for American cars that year. This indicates that no special treatment need be made for considering the effect of foreign vehicles on driver eye height.

3. Conclusion

An eye height of four feet will satisfy requirements for present day automobiles and future automobiles for years to come. This figure approximates the value found by Professor Lee and also conforms to the eye height standard now recommended nationally.

The rate of the decline in average overall height and the resulting average eye height is decreasing and as this condition prevails, the predicted ultimate low eye height may not be reached even by 1972-1975. It, however, is sound traffic engineering principle to review standards and criteria periodically and thus a re-evaluation should be performed around 1967.

B. Sight Distance

1. Present Criteria

The Michigan criteria for establishing no-passing zones prescribes use of the following sight distances:(1.

TABLE II

Required Sight Distances
for Marking No-Passing Zones

Average Speed (miles per hour)	Sight Distance (feet)
50 or greater	1000
45	900
40	800
35	700
30	600
25	500

Where the sight distance is less than the appropriate figure in Table II, a passing restriction will be required.

2. Basis for Present Criteria

The sight distances for marking no-passing zones listed in Table II are founded on the results of field studies made in 1945. No-passing zones based upon a $4\frac{1}{2}$ foot eye and object height and upon five different sight distances were established on several Michigan highways. The distances between adjacent zones thus established were then measured to determine which sight distance gave the best balance between safety and restrictiveness.

The five sight distances to be tested were chosen on the basis of data contained in the Traffic Engineering Handbook[8-9.] and upon speed and accident studies for the area involved. The 1000-foot sight distance seemed to result in zones that were of the most reasonable length. This was then adopted as the minimum sight distance for marking no-passing zones required on two and three-lane highways where the average speed is 50 miles per hour or greater. The other values shown in Table II are based upon data contained in a 1940 AASHO Manual.[10.]

3. Discussion

The most important factors affecting sight distance on a highway are its grade and alignment, the eye height of motorists driving on it, and the speeds of vehicles using it. The grade and alignment of a highway normally remain static, but the other factors can and do vary considerably. Since adoption of the values shown in Table II, driver eye heights have been decreasing as shown in the preceding section and vehicle speeds have been increasing.[11.] Thus, a review of these values seems in order.

The average speed of all traffic on rural Michigan highways was about 44 miles per hour in 1945. Adoption of the 1000-foot sight distance based on a 50-mile-per-hour average speed then served as an added safety factor. In 1949, however, the average speed of traffic was 52 miles per hour. In the following two years, it dipped below 50 miles per hour, but in every year but one since then has been over 50. As shown in Figure 1, the trend of

AVERAGE SPEEDS ON 2 LANE STATE TRUNKLINE HIGHWAYS IN MICHIGAN

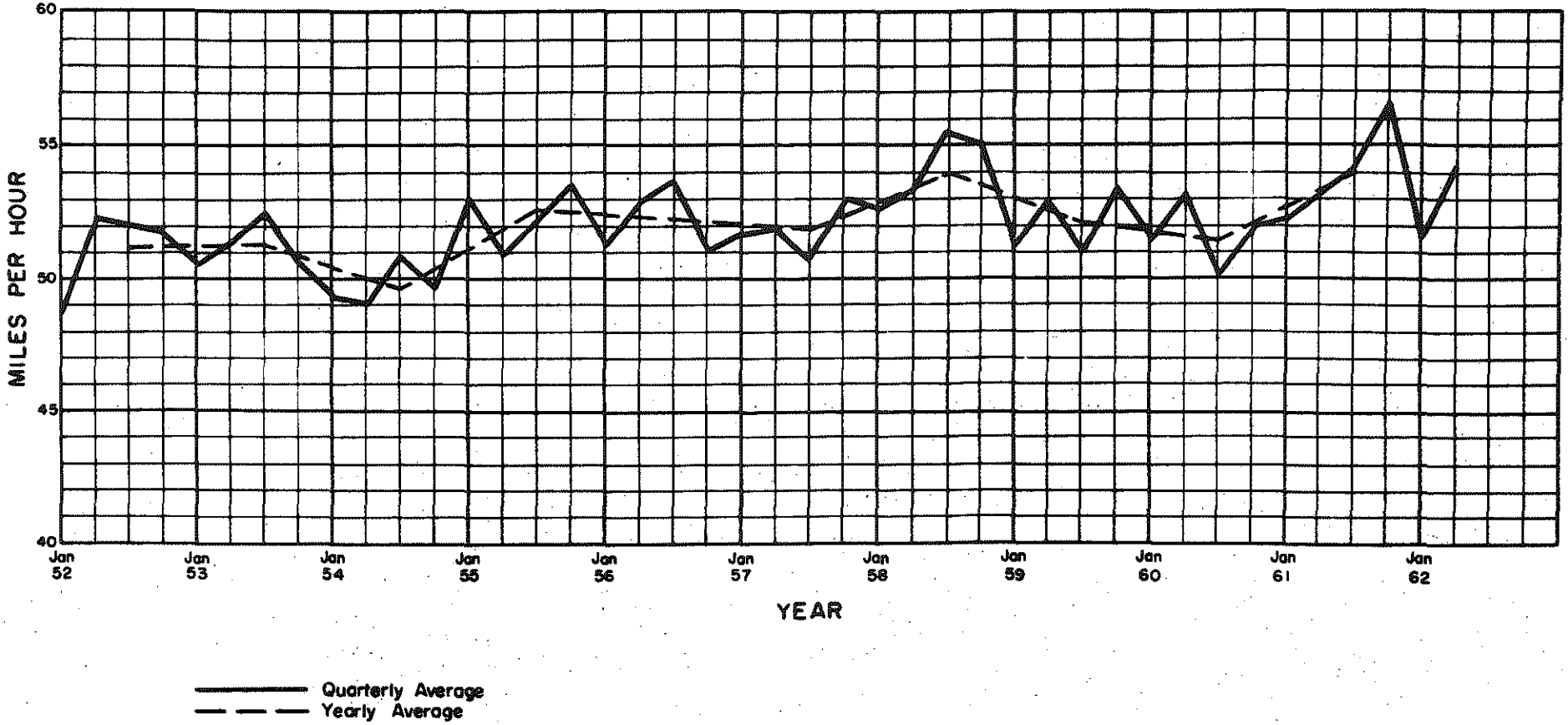
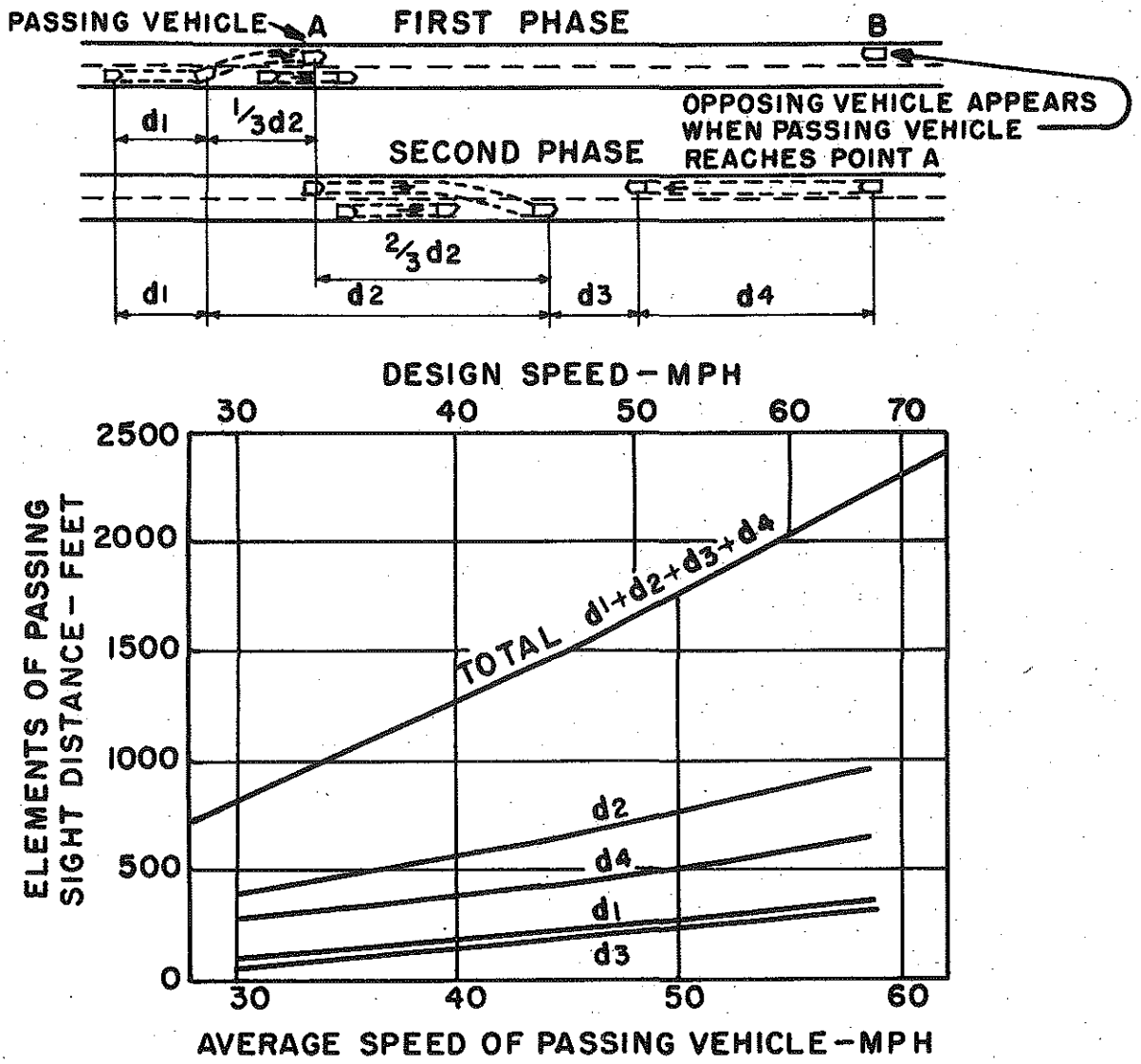


FIGURE I



ELEMENTS OF AND TOTAL PASSING SIGHT DISTANCE

2 - LANE HIGHWAYS

AASHO POLICY

FIGURE II

SOURCE: "A POLICY ON GEOMETRIC DESIGN OF RURAL HIGHWAYS" AASHO-1954 PAGE 437

this average speed has been slowly, but steadily, upward since 1952. Although the 50-mile-per-hour standard could probably be safely retained, assumption of an average speed of 55 miles per hour should be safe for many years to come.

Figure II shows the relationships between speeds and sight distance requirements on two-lane roadways.[12] It is based to a large extent upon the results of a field study by C. W. Prisk of passing maneuvers made from 1938 to 1941.[13] From a study of some 3500 simple passings (one car passing one car) Prisk drew the following conclusions:

1. The average passing driver wants to travel approximately 10 mph faster than the vehicle he passes and about 6 mph faster than the average speed of all traffic.

2. The passing vehicle, on the average, slows down before passing to within 5 mph of the speed of the vehicle to be passed.

3. The normal or desired speeds of the passed and passing vehicles are approximately the same as their average speeds during the passing.

4. There is no appreciable change in the speed of the passed vehicle during the passing.

5. The average maximum speed attained by the passing vehicle during the maneuver is 3 to 4 mph above its normal driving speed and about 10 mph higher than the average for all traffic on the highway.

Two additional assumptions were made to derive Figure II. The first held that the average pass is begun with a delayed start and completed with a hurried return

to the right lane. The other assumption was that an opposing vehicle, which appears in view as the passing vehicle pulls abreast of the one to be passed, will be traveling at the same speed as the passing vehicle.

The upper part of Figure II illustrates the four elements of a passing maneuver. The first element, d1, includes the distance traveled during the perception and reaction times and during the acceleration to the point of encroaching on the left lane. The second element, d2, is the distance traveled while the passing vehicle is in the left lane. The third element, d3, is the clearance length, or the distance between an opposing vehicle and the passing vehicle at the end of its maneuver. The fourth element, d4, is the distance traveled by the opposing vehicle during the passing maneuver.

For highway design purposes, the minimum passing sight distance must provide for all four elements of the passing maneuver. For restricting passing on a highway, however, distances d1 and d2 should not be included in the required sight distance for marking no-passing zones.(10. Until a vehicle is ready to complete its pass, it can, in the face of an opposing vehicle, still return to the right lane behind the vehicle to be passed. For marking no-passing zones, then, only the sum of d3 and d4 is required for sight distance.

The lower part of Figure II relates design and passing speed to passing sight distance requirements for all four parts of the passing maneuver. The upper abscissa represents the design speed; the lower abscissa the average speed of a passing vehicle; the ordinate, the sight distance.

Adopting an expected average speed of 55 miles per hour and adding six miles per hour (from Prisk's observations), the average speed of a passing vehicle on a two-lane Michigan highway will be 61 miles per hour. The required sight distances d3 and d4 are then 325 feet and 700 feet respectively. The total required sight distance for marking is, by this standard, 1025 feet.

Use of the design speed in Figure II gives considerably different results. The design speed for two-lane Michigan trunklines is 60 miles per hour.(14. The corresponding distances d3 and d4 are 275 feet and 592 feet respectively. The total of 867 feet is 158 feet less than that required by the average passing speed.

The actual speeds near a no-passing zone may be more nearly reflected by the design speed of a highway than by the average speed of vehicles using it. The speed checks used for determining average speeds on Michigan trunklines are taken on tangent stretches of roadway with no significant change in horizontal or vertical alignment for 1300 feet in either direction. This means that, in the areas studied, no actual limit is placed on the speed a driver can attain if he has unrestricted freedom of movement. The speeds checked, then, probably match the highest attained anywhere on the roads under consideration.

The design speed of a highway, however, reflects the highest speed which may be driven continuously if a driver is to pursue his course comfortably and safely. In all probability, the only places where he must drive as slow as the design speed are those where no-passing zones are required. Assuming that a majority of drivers not only must, but do slow their vehicles when approaching a hill or curve calling for a no-passing zone, the design speed is probably more indicative than the overall average speed of the speeds driven near no-passing zones.

To actually determine the speeds traveled by passing vehicles near no-passing zones would require a repeat of Prisk's observations, which is a project obviously beyond the scope of this study.

Splitting the difference between the sight distance required by the average passing speed and by the design speed results in a total of 946 feet. Rounding all three totals gives results of 900, 950, and 1000 feet. This seems to indicate that the required sight distance could safely be reduced, but that no change in Table II is really necessary.

4. Conclusion

For all speeds of today, the required sight distance of 1000 feet for marking no-passing zones is more than adequate and, based upon a prediction of future trends, retention of the 1000-foot sight distance is justified.

The determination of speed control on Michigan highways is based on the principle of the 85th percentile. It has

been substantiated that this is a proper basis for establishing speed control. This would provide a more realistic basis for speed determination at no-passing zones as well. Therefore, if other than 1000-foot sight distance for marking no-passing zones is deemed necessary, the selection of these respective sight distances should not be based on average speeds or design speeds but rather on eighty-five percentile speeds. It is necessary to repeat, however, that the 1000-foot sight distance is completely adequate and even more so for all conditions of safety and efficiency and does not result in undue restriction on traffic movement.

The ultimate answer to this question and that of what eye height to choose apparently lies in a repeat of the 1945 field experiments. This has been done and the results are summarized in the next chapter.

C. Target Height

1. Present Criteria

The beginning of a no-passing zone is located at that point at which an observer sighting forward through a $4\frac{1}{2}$ foot target just loses sight of another $4\frac{1}{2}$ foot target a specified distance away. The end of a zone is located at that point at which an observer sighting from the crest of the curve downward through a $4\frac{1}{2}$ foot target just regains sight of a $2\frac{1}{2}$ foot target. As a precaution for a dip in the curve, the end of a zone may be extended, if necessary, to the point where, by sighting through a $4\frac{1}{2}$ foot target at the end of the zone, a $2\frac{1}{2}$ foot target is visible any place throughout the curve.(1.

2. Discussion

Use of a $2\frac{1}{2}$ foot high target in setting the end of a no-passing zone is a safety factor. It is based on an assumed height of vehicle headlights of $2\frac{1}{2}$ feet. The stipulation that the $2\frac{1}{2}$ foot target must be seen throughout a dip in a vertical curve is simply an additional safety factor.

The need for these safety factors cannot be readily proved or disproved on paper. A check on the policies of 17 other states throughout the United States reveals that Michigan is unique in use of the $2\frac{1}{2}$ foot target height (although some states go much lower, they combine the lower height with a much shorter sight distance). The majority of states checked conform to the national standard[15] which is based on the following premise:[16]

> "While the headlights of a vehicle are only about 2 feet above the pavement, a reduction in the value of the assumed height of object is not necessary. In the case of sight distance for safe passing at night, the beams of the headlights of an opposing vehicle generally are seen sometime before the headlights come into view and even before the top of a vehicle can be seen at the same location in the daytime."

Apparently, as with sight distance, the answer to this question of need for a lower object height lies in what its use produces in the field.

D. Summary: Conclusions

Through a review of vehicle speeds and heights, an attempt has been made to evaluate the existing criteria for marking no-passing zones on Michigan highways. From this review, the following conclusions may be made:

1. The assumed driver eye height of $4\frac{1}{2}$ feet should be lowered presumably to 4 feet.
2. The required sight distance of 1000 feet for marking no-passing zones for higher speed highways should be entirely adequate for many years to come. This 1000 feet satisfies all conditions of safety, and the selection of sight distance for marking no-passing zones from speed determinations, either average or 85th percentile, is not required.
3. The need for use of a lower object height when setting the end of a no-passing zone can neither be justified nor denied without considering its actual effect in the field.

Ultimately, the recommendations to be made from these conclusions depend upon the results of field studies made using the various criteria.

CHAPTER II

No-Passing Zone Field Study

A. Introduction

Chapter I established the need for revised criteria for marking no-passing zones on Michigan highways. Alternatives for a revised eye-height and sight distance were offered, but no definite choice of value was made in either case. Instead, the ultimate choice was left to be made on the basis of the results of a field study testing the various criteria. This chapter concerns the conduct and results of that field study. It should be noted that sight distance as used in this chapter refers to that required for marking no-passing zones and not that required to make a passing maneuver.

B. Description of Study

1. Locations Studied

Some 130 pairs of existing no-passing zones were chosen at random in the field for testing in this study. Each zone was to be a simple vertical curve (normally, driver eye height does not affect the marking of zones on horizontal curves) on a two-lane state trunkline in a rural area.

After collection of the field data, a number of the zones had to be eliminated. Either they included some horizontal curvature or they included a double crest,

producing grossly distorted results. A total of 86 pairs of zones were left. Appendix A lists the location of these zones.

2. Procedure

Six or eight no-passing zones were established at each existing zone studied. One new zone was based on Michigan criteria; the others were based on varying criteria, as shown in Table III. Methods 1-2 and 2-4 were not originally among the tested criteria, but were tried on 35 pair of zones as a result of the conclusions contained in Chapter I.

TABLE III

No-Passing Zone Method Key

Sight Distance	Method	Target Heights	
		Beginning of Zone	End of Zone
900 Feet	1-2	4' to 4'	4' to 4'
	1-4	$3\frac{1}{2}$' to $3\frac{1}{2}$'	$3\frac{1}{2}$' to $3\frac{1}{2}$'
	1-5	$3\frac{1}{2}$' to $3\frac{1}{2}$'	$3\frac{1}{2}$' to $2\frac{1}{2}$'
1000 Feet	2-1 *	$4\frac{1}{2}$' to $4\frac{1}{2}$'	$4\frac{1}{2}$' to $2\frac{1}{2}$'
	2-2	4' to 4'	4' to 4'
	2-3	4' to 4'	4' to $2\frac{1}{2}$'
	2-4	$3\frac{1}{2}$' to $3\frac{1}{2}$'	$3\frac{1}{2}$' to $3\frac{1}{2}$'
1100 Feet	3-3	4' to 4'	4' to $2\frac{1}{2}$'

* Present Michigan Criteria.

After each new zone was established, its beginning and ending points were measured in relation to the limits

of the existing zone. By measuring the total length of each existing zone, the length of each new zone could also be computed.

The field work for this study was performed by a crew that generally consisted of three men equipped with measuring wheels, sighting targets, and two-way radios (walkie-talkies). The field method employed is described in the following paragraphs.

3. Field Method

The prescribed Michigan field method for marking no-passing zones on vertical curves involves two men equipped with a chalkline and sighting targets.(1. The chalkline is made as long as the required sight distance for markings; the height of each target is initially set at 4½ feet. The two men begin the operation by walking toward the crest of the curve while keeping the chalkline taut between them. The beginning of the no-passing zone is set where the man in the rear, sighting through his target, first loses sight of the target held by the man in front. The man in front then drops his end of the chalkline and walks toward the other man, who has lowered his target to a height of 2½ feet. The end of the zone for the opposite direction is set where the forward man, sighting through his target (still at a height of 4½ feet), just regains sight of the other target. If there is a dip in the roadway between the two men, the end of the zone is extended - if necessary - to the point where, by sighting through the 4½-foot target, the 2½-foot target is visible any place in the dip. This entire process is then repeated to set the zone limits on the down grade of the curve.

The field method used to establish the zones for this study was essentially the same as the one just described. Measuring wheels and two-way radios (walkie-talkies) were substituted for the chalkline, however, because the chalkline proved to be too cumbersome and difficult to keep at the right length.

Use of the measuring wheels, graduated in feet, and the walkie-talkies overcame these deficiencies. Two men, each with a wheel, positioned themselves the required distance apart in advance of each vertical curve. Then, by setting the dials of both wheels at zero and using the radios every 50 feet, they could hold the required distance between them as they walked up the hill. The sighting targets, which were covered by a luninescent material for easier sighting, were mounted on rods attached to the measuring wheels. When a third man was present on the crew, he took notes and acted as party chief.

C. Results of Study

1. General

Table IV summarizes the results of this study. Appendices B, C, and D show the results in detail.

The results indicate that a change of one foot in the assumed driver eye height and of 100 feet in the required sight distance have about the same effect on the length of a no-passing zone. Both changes will result in an average difference of approximately 100 feet in the length of a zone.

Where the two changes differ in effect is in determining the limits of a zone. Generally, with a lower eye height the only change in criteria, a zone will be lengthened about the same at its beginning as at its end. When only the sight distance is changed, however, the average change in length of zone is at least 10 times as great at the beginning as at the end.

The least effect is caused by using a different object height when setting the end of a zone. For each one-half foot this height is raised, the end of a zone is shortened by an average of only 12 feet.

2. Relation to Existing Zones

Of all the criteria tested in this study, only one resulted in an average zone length longer than that of the existing zones. This was criteria 3-3, which involves an 1100-foot sight distance.

One of the largest differences found was that between existing zones and those based on the Michigan criteria. On the average, the existing zones studied are 112 feet longer than actually required. Eighty-three feet, or 74 percent, of this excess was found at the beginning; 29 feet, or 26 percent, at the end. Ten zones studied are either not required at all (sight was never lost), or are required for so short a distance (200 feet or less)(1. that they should be eliminated.

One or more of several causes seem accountable for these discrepancies. These would include the human differences, such as eyesight, involved in establishing the zones; differences accumulated through maintenance operations;

TABLE IV

NO-PASSING ZONE STUDY

Comparison of Length and Location of Zones by Various Criteria

Comparisons	Average Difference in Location and Length		
	Beginning	End	Total Length
Existing vs. Mich.	+ 83	+ 29	+ 112
1-2 vs. Mich.	- 84	- 31	- 115
1-4 vs. Mich.	- 32	+ 18	- 14
1-5 vs. Mich.	- 32	+ 44	+ 12
2-2 vs. Mich.	+ 35	- 17	+ 18
2-3 vs. Mich.	+ 35	+ 24	+ 59
2-4 vs. Mich.	+ 56	+ 19	+ 75
3-3 vs. Mich.	+ 129	+ 25	+ 154

\+ Longer than Michigan Method

\- Shorter than Michigan Method

arbitrary placement or lengthening of the zones for "safety" purposes, and the non-use of the prescribed field method because of its limitations.

Although further discussion of this problem is beyond the scope of this study, these results strongly suggest the need for developing a more workable, scientific and accurate field method for establishing no-passing zones.

3. Relation to Michigan Criteria Zones

a. Method 1-2

This method combines a 900-foot sight distance with a 4-foot eye and object height. Originally, it was not among the criteria tested because it was believed it would produce zones that were entirely too short. Because its eye height and sight distance conform to the minimum values found necessary in Chapter I of this report, however, it was tested on a limited number of zones after the original field study was completed.

The results of the field study made using these criterions seem to bear out the original contention. This method produced an average zone length 115 feet shorter than that for Michigan criteria zones and 227 feet shorter than that for existing zones. Of the 70 zones tested, 16 would be eliminated by this method. These results seem to conclusively reject any possibility of adopting this set of criteria.

b. Method 1-4

This method combines a 900-foot sight distance with a $3\frac{1}{2}$-foot eye and object height. Of the six methods first tested for this study, it produced the shortest of all zones, yet, its average total length differed by only 14 feet from that for the Michigan criteria zones.

Location of the beginning point of method 1-4 zones was, on the average, 32 feet shorter (up the hill) than that for Michigan criteria zones. Part of this difference was made up at the end of the average zone, where method 1-4 extended the zone by 18 feet.

One of the most surprising results of this field study involves this method on vertical curves where the Michigan criteria indicated the need for no zone. Because in about 60 percent of the zones studied, 1-4 zones were shorter than 2-1 (Michigan) zones, it might be expected that on some or all of these "no-zone" curves, 1-4 would also show that a zone is not needed. Yet, in no case was this true. Generally, on these particular curves, 1-4 zones were considerably shorter than the existing zones, but in every case the resultant zone was over 250 feet long. This result seems to be the exception to the rule that changing the sight distance has a greater effect on the length of a zone than does changing the eye height.

c. Method 1-5

This method combines a 900-foot sight distance with a $3\frac{1}{2}$-foot eye height and a $2\frac{1}{2}$-foot object height. The zone beginnings for these criteria are identical to those for method 1-4. Because of the lower object height, though, the average zone end for method 1-5 is extended 26 feet beyond that for method 1-4.

Compared to the Michigan criteria zones, then, 1-5 zones have an average of 32 feet shorter beginnings and of 44 feet longer endings, or an average of only 12 feet longer total lengths. No other method produced results which compared so favorably, in total length, to those for the Michigan criteria.

If the assumption is accepted that the Michigan criteria, although in need of revision, still produces no-passing zones of "reasonable" length, then it must be conceded that method 1-5 also produces reasonable zones. Yet, this method has one great drawback: the $2\frac{1}{2}$-foot object height. The extra time, effort, and expense involved in using the lower height hardly seems to be justified by an extension (over method 1-4 zones) of 26 feet. At 60 miles per hour, this represents about $\frac{1}{3}$-second of driving time.

d. Method 2-2

These criteria consist of a 1000-foot sight distance and a 4-foot eye and object height. Compared to the Michigan criteria, the average beginning point for this method is 35 feet longer and the average ending point is 17 feet shorter. This means that the average zone based on method 2-2 is only 18 feet longer than the average zone based on Michigan criteria.

Again, if the Michigan criteria is accepted as "reasonable", though in need of revision, zones based on method 2-2 must also be accepted as reasonable. Only 1-4 and 1-5 zones conformed more closely in total length to that of Michigan criteria zones, and even 1-5 zones differed more at the extremities. Method 2-2 also has the advantage of being an easy one to apply. Thus, method 2-2 must be one of those strongly considered for replacing the Michigan criteria.

e. Method 2-3

Method 2-3 combines a 1000-foot sight distance with a 4-foot eye height and a 2½-foot object height. The beginning points for this method are identical to those for method 2-2. Whereas 2-2 zones are 17 feet shorter than Michigan criteria zones at the end points, 2-3 zones are 24 feet longer than Michigan criteria

at the end points. Method 2-3 zones are, therefore, on the average, 59 feet greater in total length than Michigan criteria zones.

Although this method also produces "reasonable" zones, three other methods produce more "reasonable" zones. This method also has the disadvantage of the $2\frac{1}{2}$-foot object height which, in this case, increases the end of the zone 41 feet (over 2-2) -- or the equivalent of 0.46 second driving time at 60 miles per hour.

f. Method 2-4

This method combines a 1000-foot sight distance with a $3\frac{1}{2}$-foot eye and object height. Originally, it was not among the criteria tested because it was believed it would produce zones that were entirely too long. Because its eye height and sight distance conform to the maximum values found necessary in Chapter I of this report, however, it was tested on a limited number of zones after the original field study was completed.

The resulting zones were long, but not unreasonably so. In comparison to Michigan criteria zones, the average 2-4 zone was 56 feet longer at the beginning and only 19 feet longer at the end. The total increase in length (75 feet),

however, seems too great for this method to be seriously considered as a substitute for the Michigan criteria.

g. Method 3-3

This method combines an 1100-foot sight distance with a 4-foot eye height and a $2\frac{1}{2}$-foot object height. It was among the first six sets of criteria tried only to test the effect of an additional increase in sight distance.

As expected, it produced zones that were much too long. Compared to the average Michigan criteria zone, the average 3-3 zone was 154 feet longer -- 129 at the beginning; 25 feet at the end. All three of these figures seem to confirm the predicted effect of changing sight distance and eye height. Following the figures cited on page 18 of this report, the respective difference should be 150, 110, and 40 feet--very close, indeed, to the values actually found.

D. Summary: Conclusions

The present Michigan criteria for marking no-passing zones was based, to a large extent, on expediency. The $4\frac{1}{2}$-foot eye height was chosen from the appropriate data then available, thus the 1000-foot sight distance was chosen for its "reasonableness" and the $2\frac{1}{2}$-foot object height was adopted as a 'safety factor." Combined, these criteria

produced no-passing zones of "reasonable" length--not overly restrictive, but enough so.

Nothing uncovered in this field study has shown that zones based on these criteria are unreasonable. The presently prescribed field method can be attacked; the criteria themselves can be attacked, but the results they produce cannot. Therefore, any new criteria adopted should result in no-passing zones which conform fairly closely to those based on the present criteria.

Accepting this premise, then, only three of the new sets of criteria tested in this study seem worthy of further consideration. These are methods 1-4, 1-5, and 2-2. Method 1-4 consists of a 900-foot sight distance coupled with a $3\frac{1}{2}$-foot eye height; method 1-5 consists of a 900-foot sight distance coupled with a $3\frac{1}{2}$-foot eye height and $2\frac{1}{2}$-foot object height, and method 2-2 consists of a 1000-foot sight distance coupled with a 4-foot eye height. On the average and in comparison to the average Michigan criteria zone, method 1-4 will shorten a zone by 14 feet (-32, beginning; +18, end), and method 2-2 will lengthen it by 18 feet (+35, beginning; -17, end).

Actually, because method 1-5 achieves its extra proximity through the lower object height which has been shown unnecessary, it too can be dismissed from further discussion. This leaves only methods 1-4 and 2-2 for consideration.

One other conclusion must be drawn from the results of this field study, and that is that the prescribed field

method for establishing no-passing zones is in need of almost complete revision. The awkwardness, time consumption, inaccuracies, and lack of safety inherent in this field method all show this to be true. The field method used for this study is a step in the right direction, but only a step.

Chapter III

Conclusions and Recommendations

A. Conclusions

The purpose of this report is the evaluation of the Michigan criteria for marking no-passing zones. The first chapter concerns a review of the criteria from an academic standpoint; that is, the effect of changes in vehicle design and speeds. The second chapter concerns the effect of the various criteria in the field: what type and length of zones would result.

The first chapter contains these conclusions:

1. The presently assumed driver eye-height should be lowered to 4 feet.
2. The presently required maximum sight distance of 1000 feet for marking no-passing zones is certainly adequate for today's needs and should be so for some time to come.
3. The requirement that a $2\frac{1}{2}$-foot target be used in setting the end of a no-passing zone seems unnecessary.

Chapter I also contained a discussion of the selection of sight distance for marking no-passing zones based upon various average speeds and design speed of the highway. It was pointed out in this chapter that the selection of 1000 feet of sight distance for marking no-passing zones will be recommended for use on Michigan highways rather than selecting a sight distance based upon respective average,

design, or 85th percentile speeds. This affords simplicity in field application, is proper for highway speeds on all Michigan highways, and is more than adequate for safety requirements, and does not restrict movement of traffic unduly. For these reasons, it is concluded that no speed determination, whether it be based upon average, design, or 85th percentile speeds, is necessary. Any advantage, benefit, or accuracy acquired from speed determination for each no-passing zone will not justify the time, expense, and complexity resulting. Thus, in Michigan, the sight distance criteria for marking no-passing zones for all cases will be 1000 feet.

It is understandable that other agencies may desire to select the sight distance criteria for this purpose based upon speed determination. If this is so, then it is recommended that the selection of this sight distance be based upon the 85th percentile speed in accordance with the National Manual of Uniform Traffic Control Devices. The sight distance requirements for this method are presented in Table V below.

TABLE V

National Standard
Required Sight Distance for Marking
No-Passing Zones (17.

Speed (85th Percentile) MPH	Sight Distance Feet
30	500
40	600
50	800
60	1000
70	1200

From the second chapter of the report, the conclusion was made that, of the criteria tested in the field, only two sets gave satisfactory results. These combined a 1000-foot sight distance with a 4-foot eye height and a 900-foot sight distance with a $3\frac{1}{2}$-foot eye height. Of the two sets, the one based on the 1000-foot sight distance generally resulted in a longer zone, but both sets differed in average lengths by less than 20 feet from the average length of zone based on Michigan criteria.

Two additional conclusions were drawn in the second chapter: One, that the use of a lower target height in setting the end of a zone is not justified by the extra length of zone thus acquired; and two, that the prescribed field method for marking no-passing zones is in need of drastic revision.

The two sets of criteria under consideration are methods 1-4 and 2-2. A review of the field study outlined in Chapter II shows there is little difference in application of the two methods. Both are simple and easy to work with. Both produce no-passing zones of reasonable length: 2-2 zones are longer at the beginning; 1-4 at the end; but the differences are generally insignificant.

Selection of one method over the other on the basis of sight distance is also difficult. The 1000-foot sight distance (of method 2-2) allows for the trend toward higher speeds which is prevalent today, but the 900-foot sight distance (of method 1-4) corresponds to the Michigan design

speed of 60 miles per hour. This speed normally remains static and may be more nearly indicative than prevailing speeds of actual speeds driven near no-passing zones.

Two factors, however, favor method 2-2. These are the eye height and a desire for uniformity. The four-foot eye height is certainly adequate for today's needs and probably should be so for the near future.

The advantages of uniformity, the other factor favoring method 2-2, have been strongly stated elsewhere--many times--and need not be repeated here. Suffice to say, however, that little argument can be made against uniformity as long as the recommended standard seems reasonable and proper. Method 2-2, which corresponds to national recommendations as revised in 1961,[17.] is such a standard. The results of this study clearly show this to be so. Therefore, the preference for method 2-2 becomes quite apparent.

Regardless of which method might be chosen, it would stand in need of modification. Although a lower target height for setting the end of a zone is not necessary, the provision that the target be seen throughout a dip in the curve is necessary. Almost 50 percent of the zones established for this study were lengthened, often appreciably, by this provision. It should, therefore, remain an integral part of the procedure for marking no-passing zones on vertical curves. Also, there seems to be no reason for having any differential in sight distance based on a difference in speeds. There may be a few isolated locations where a shorter sight distance, based on a lower speed, would not

require a zone. Although a longer sight distance would, these locations are probably so small in number that no extra provision need be made for them. Instead, in the interest of both safety and simplicity, the one definite standard for sight distance should suffice.

B. Recommendations

Based on the results of this study, the following recommendations are made concerning the procedure for establishing no-passing zones on Michigan highways.

1. Require that the beginning of a no-passing zone be established where an observer sighting through a 4-foot target just loses sight of a second 4-foot target 1000 feet away.
2. Require that the end of the same zone be established where the two targets, still 1000 feet apart, are again visible to one another. Each zone should be checked to determine if a dip exists between the 1000-foot sight distance within which a vehicle can be lost from view. If this condition exists, the end of the zone shall be extended to the point where by sighting through the target, the other target is visible throughout the dip. The target for these provisions shall also be at four feet elevation.
3. This study should be repeated in 1967. The effect of the downward trend in vehicle height and of the upward trend in vehicle speeds can then be re-analyzed.

4. As soon as possible, development of an improved, more scientific field method for establishing no-passing zones should be undertaken. This is not only in the interest of the motoring public, but also for the safety of the personnel responsible for this field work.

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APPENDICES:

TABLE OF CONTENTS

APPENDIX A

ZONE NUMBERS AND LOCATION

ZONE NUMBER		LOCATION
1		M-61 West of Harrison at N. Harding Avenue
2		M-61 West of Harrison at 0.4 miles West of N. Harding
3		M-61 West of Harrison at 0.8 miles West of N. Harding
4		M-61 West of Harrison at 1.6 miles West of N. Harding
5		M-61 West of Harrison at 0.6 miles West of N. Bringold
6		M-61 West of Harrison at N. Hemlock Avenue
7		M-61 West of Harrison at 0.4 miles West of McKinley Avenue
8	*	US-27 North of Clare at Tobacco River
9		US-27 North of Clare at 0.5 miles North of Tobacco River
10		US-27 North of Clare at 1.5 miles North of Tobacco River
11		US-27 North of Clare at 1.9 miles North of Tobacco River
12		US-27 North of Clare at 0.5 miles North of Surrey Road
13		US-27 North of Clare at Beaverton Road
14		US-27 North of Clare at 0.4 miles North of Beaverton Road
15		US-27 North of Clare at 0.9 miles North of Beaverton Road
16		US-27 North of Clare at 0.6 miles North of Adams Road
17		US-27 North of Clare at 0.4 miles North of State Park
18		US-27 North of Clare at 0.7 miles North of State Park
19		US-27 North of Clare at 0.9 miles North of Lincoln Park
20	*	US-27 North of Clare just South of Mansiding Road
21		M-66 North of Ionia at Session Road
22		M-66 North of Sheridan at Holland Lake Road
23		M-66 North of Ionia at 0.6 miles South of Paackes Road

* Zones 8-20 are on old US-27, which was abandoned by the State in September, 1962.

ZONE NUMBER		LOCATION
24		M-66 North of Ionia at South of Sidney Road
25		M-66 North of Ionia at South City Limits of Stanton
26		M-66 North of Ionia at South of North City Limits of Stanton
27		M-66 North of Ionia at South of Briggs Road
28		M-66 North of Ionia at Coral Road
29		M-66 North of Ionia at Church Road
30		M-66 North of Ionia at first curve N. of W. Junction of M-46
31		M-66 North of Ionia at second curve N. of W. Junction of M-46
32		M-66 North of Ionia at 2.3 miles North of Black Creek
33	*	US-27 South of Gaylord 0.5 miles North of Waters
34		US-27 South of Gaylord 1.1 miles N. of W. Otsego Lake Drive
35		US-27 South of Gaylord 0.5 miles N. of State Park
36		US-27 South of Gaylord just South of Wah Wah Soo Drive
37		US-27 South of Gaylord 0.5 miles N. of Wah Wah Soo Drive
38		US-27 N. of Gaylord 0.5 miles N. of Gaylord City Limits at TB San.
39	*	US-27 North of Gaylord 0.5 miles N. of Allis Road
40		US-27 North of Gaylord 1.7 miles N. of State Roadside Park
41		US-27 North of Olivet south of Stine Road
42		M-50 Northwest of Tompkins Center
43		M-50 Southeast of Tompkins Center at Bennet Road
44		M-36 West of Gregory
45		M-99 South of Lansing just South of Bishop Road
46		M-78 South of Charlotte at South City Limits

* Zones 33-39 are on old US-27, which was abandoned by the State in September, 1962.

ZONE NUMBER	LOCATION
47	M-78 South of Charlotte just North of Roadside Park
48	M-99 South of Lansing at Dimondale Highway
49	M-99 South of Lansing just North of Bridge over Grand River
50	M-99 South of Lansing at Bailey Road
51	M-99 South of Lansing at Skinner Road
52	M-78 Northeast of M-47 Southwest of Morrice Road
53	M-78 Northeast of M-47 at Church Road
54	M-47 North of M-78 just North of Intersection
55	M-47 North of M-78 just South of Winegar Road
56	M-66 North of Ionia 0.7 miles North of City Limits
57	M-66 North of Ionia at Dildine Road
58	M-66 North of Ionia 0.6 miles North of Dildine Road
59	M-66 North of Ionia at Hall Road
60	M-66 North of Ionia 0.6 miles North of Hall Road
61	M-66 North of Ionia at Hubbel Road
62	M-66 North of Ionia at Tingley Road
63	M-66 North of Ionia just South of Bricker Road
64	M-66 North of Ionia just South of Snows Lake Road
65	M-66 North of Ionia just South of Dick Road
66	M-66 North of Ionia just South of Fenwick Road
67	M-66 North of Ionia at Boyer Road South
68	M-66 North of Ionia at Boyer Road North
69	M-66 North of Ionia just South of M-57
70	M-66 North of Ionia just North of M-57
71	US-12 in Lenawee County at Hogan Highway
72	US-12 in Lenawee County at Van Tyle Road

ZONE NUMBER	LOCATION
73	US-12 in Lenawee County 0.4 miles West of Hudson Road
74	US-12 in Lenawee County 0.8 miles West of Hudson Road
75	US-12 in Lenawee County just West of Wisner Highway
76	US-12 in Lenawee County at Ely Road
77	US-12 in Lenawee County at Egan Highway
78	US-12 in Lenawee County just East of Cambridge Junction
79	US-12 in Lenawee County just West of Cambridge Junction
80	US-12 in Lenawee County at Brooklyn Highway
81	US-12 in Lenawee County 0.4 miles West of Brooklyn Highway
82	US-12 in Lenawee County 0.3 miles West of Round Lake Highway
83	US-12 in Lenawee County 0.8 miles West of Round Lake Highway
84	US-12 in Lenawee County 0.4 miles West of Silver Lake Highway
85	US-12 in Lenawee County at Wheaton Road
86	US-12 in Lenawee County just East of US-127

APPENDIX B

EXISTING ZONES AND VARIOUS CRITERIA COMPARED TO MICHIGAN CRITERIA

Zone No. and Direction		Existing Zones			1 - 2			1 - 4			1 - 5			2 - 2			2 - 3			2 - 4			3 - 3		
		Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total
1	W	+ 74	+ 22	+ 96				- 65	+ 16	- 49	- 65	+ 34	- 31	+ 15	- 12	+ 3	+ 15	+ 16	+ 31				+120	+ 16	+136
	E	+246	+ 32	+278				- 54	+ 22	- 32	- 54	+ 25	- 29	+ 21	+ 2	+ 23	+ 21	+ 11	+ 32				+137	+ 11	+148
2	W	+155	+ 48	+203				- 20	+ 32	+ 12	- 20	+ 51	+ 31	+ 40	- 24	+ 16	+ 40	+ 19	+ 59				+140	- 1	+139
	E	+164	+ 25	+189				- 6	+ 1	- 5	- 6	+ 40	+ 34	+ 39	- 39	0	+ 39	+ 25	+ 64				+119	+ 33	+152
3	W	+164	+ 73	+237	-177	+ 5	-172	- 50	+ 5	- 45	- 50	+ 30	- 20	+ 20	- 19	+ 1	+ 20	+ 16	+ 36	- 56	+ 23	- 33	+110	+ 16	+126
	E	+207	+ 41	+248	- 75	- 36	-111	- 61	+ 8	- 53	- 61	+ 30	- 31	+ 14	- 21	- 7	+ 14	+ 15	+ 29	- 71	- 17	- 88	+110	+ 15	+125
4	W	+144	+ 70	+214				- 70	+ 7	- 63	- 70	+ 12	- 58	+ 15	0	+ 15	+ 15	+ 10	+ 25				+115	+ 70	+185
	E	+118	+ 45	+163				- 82	+ 3	- 79	- 82	+ 19	- 63	+ 10	- 28	- 18	+ 10	+ 6	+ 16				+116	+ 6	+122
5	W	+205	+ 35	+240				- 77	+ 17	- 60	- 77	+ 24	- 53	+ 15	+ 3	+ 18	+ 15	+ 12	+ 27				+110	+ 12	+122
	E	+182	+ 5	+187				- 58	+ 11	- 47	- 58	+ 18	- 40	+ 17	+ 4	+ 21	+ 17	+ 7	+ 24				+107	+ 5	+112
6	W	+120	+ 30	+150				- 40	+ 21	- 19	- 40	+ 37	- 3	+ 25	- 8	+ 17	+ 25	+ 12	+ 37				+105	+ 12	+117
	E	+266	+ 27	+293				- 31	+ 13	- 18	- 31	+ 42	+ 11	+ 25	- 27	- 2	+ 25	+ 19	+ 44				+105	+ 19	+124
7	W	+298	+ 66	+364	- 70	- 39	-109	- 45	- 13	- 58	- 45	+ 39	- 6	+ 25	- 83	- 58	+ 25	+ 15	+ 40	+ 61	+ 17	+ 78	+125	+ 15	+140
	E	+430	+ 52	+482	0	- 3	- 3	+ 30	+ 25	+ 55	+ 30	+ 34	+ 64	+ 45	- 5	+ 40	+ 45	+ 16	+ 61	+114	+ 27	+141	+100	+ 22	+122
8	N	+125	+ 77	+202	- 63	- 29	- 92	- 35	+ 19	- 16	- 35	+ 36	+ 1	+ 30	- 7	+ 23	+ 30	+ 16	+ 46	+ 33	+ 28	+ 61	+110	+ 26	+136
	S	+122	- 9	+113	- 95	- 16	-111	- 44	+ 9	- 35	- 44	+ 38	- 6	+ 34	- 26	+ 8	+ 34	+ 18	+ 52	+ 46	- 3	+ 43	+138	+ 18	+156
9	N	+ 65	+ 31	+ 96				- 60	+ 13	- 47	- 60	+ 28	- 32	+ 20	- 11	+ 9	+ 20	+ 12	+ 32				+120	+ 12	+132
	S	+113	+ 34	+147				- 67	+ 13	- 54	- 67	+ 27	- 40	+ 14	- 10	+ 4	+ 14	+ 10	+ 24				+110	+ 10	+120
10	N	0	+ 89	+ 89				- 60	+ 12	- 48	- 60	+ 22	- 38	+ 10	+ 2	+ 12	+ 10	+ 13	+ 23				+110	+ 29	+139
	S	+ 92	+ 4	+ 96				- 76	+ 10	- 66	- 76	+ 23	- 53	+ 16	- 9	+ 7	+ 16	+ 8	+ 24				+127	+ 8	+135
11	N	+150	+747	+897	+ 5	- 23	- 18	+ 33	+704	+737	+ 33	+846	+879	+ 38	+629	+667	+ 38	+812	+850	+ 88	+ 40	+128	+ 98	+737	+835
	S	+809	+ 20	+829	-150	- 21	-171	+622	+ 57	+679	+622	+113	+735	+657	- 18	+639	+657	+ 82	+739	+101	+ 41	+142	+622	+ 82	+704
12	N	+ 85	+108	+193				- 25	+ 5	- 20	- 25	+ 31	+ 6	+ 25	- 9	+ 16	+ 25	+ 28	+ 53				+125	+ 38	+163
	S	+171	+ 15	+186				- 82	+ 20	- 62	- 82	+ 42	- 40	+ 35	- 32	+ 3	+ 35	+ 18	+ 53				+154	+ 4	+158
13	N	+100	+ 18	+118				- 25	+ 18	- 7	- 25	+ 46	+ 21	+ 25	- 32	- 7	+ 25	+ 6	+ 31				+125	- 10	+115
	S	+ 89	+ 6	+ 95				- 10	+ 12	+ 2	- 10	+ 45	+ 35	+ 40	- 37	+ 3	+ 40	+ 20	+ 60				+124	+ 20	+144
14	N	+ 70	+ 37	+107	- 76	+ 4	- 72	- 45	+ 5	- 40	- 45	+ 28	- 17	+ 15	- 22	- 7	+ 15	+ 10	+ 25	+ 32	+ 29	+ 61	+115	+ 10	+125
	S	+101	0	+101	- 72	0	- 72	- 46	+ 13	- 33	- 46	+ 35	- 11	+ 25	- 12	+ 13	+ 25	+ 18	+ 43	+ 58	+ 18	+ 76	+119	+ 18	+137
15	N	+200	+238	+438				+ 55	+ 9	+ 64	+ 55	+ 26	+ 81	+ 55	- 9	+ 46	+ 55	+ 12	+ 67				+125	+ 12	+137
	S	+ 36	+ 47	+ 83				- 40	- 2	- 42	- 40	+ 38	- 2	+ 20	-104	- 84	+ 20	+ 18	+ 38				+105	+ 42	+147

Existing Zones and Various Criteria Compared to Michigan Criteria

Zone No. and Direction		Existing Zones Beg.	End	Total	1 - 2 Beg.	End	Total	1 - 4 Beg.	End	Total	1 - 5 Beg.	End	Total	2 - 2 Beg.	End	Total	2 - 3 Beg.	End	Total	2 - 4 Beg.	End	Total	3 - 3 Beg.	End	Total
		Existing Zones and Various Criteria Compared to Michigan Criteria																							
16	N			+416			0			+279			+330			+356			+356			+434			+466
	S			+424			0			+282			+322			+261			+319			+369			+358
17	N	+ 90	+ 16	+106				- 50	+ 26	- 24	- 50	+ 49	- 1	+ 20	- 10	+ 10	+ 20	+ 24	+ 44				+140	+ 22	+162
	S	+151	+ 21	+172				- 31	+ 2	- 29	- 31	+ 26	- 5	+ 35	- 29	+ 6	+ 35	+ 17	+ 52				+135	+ 25	+160
18	N	+ 75	+ 12	+ 87				- 50	+ 11	- 39	- 50	+ 29	- 21	+ 20	- 10	+ 10	+ 20	+ 14	+ 34				+120	+ 14	+134
	S	+110	+ 3	+113				- 57	+ 11	- 46	- 57	+ 32	- 25	+ 21	- 11	+ 10	+ 21	+ 14	+ 35				+110	+ 11	+121
19	N	- 7	+ 74	+ 67				- 60	+ 13	- 47	- 60	+ 40	- 20	+ 25	- 31	- 6	+ 25	+ 18	+ 43				+125	+ 18	+143
	S	+ 88	+ 5	+ 93				- 5	+ 5	0	- 5	+ 26	+ 21	+ 31	- 12	+ 19	+ 31	+ 20	+ 51				+136	+ 18	+154
20	N	+ 75	+ 39	+114	- 60	- 3	- 63	- 30	+ 22	- 8	- 30	+ 42	+ 12	+ 20	- 8	+ 12	+ 20	+ 16	+ 36	+ 41	+ 26	+ 67	+ 90	+ 22	+112
	S	+154	- 10	+144	- 65	- 26	- 91	- 42	+ 4	- 38	- 42	+ 39	- 3	+ 30	- 28	+ 2	+ 30	+ 20	+ 50	+ 65	+ 2	+ 67	+134	+ 20	+154
21	N	+138	+ 19	+157				- 40	+ 22	- 18	- 40	+ 47	+ 7	+ 26	- 9	+ 17	+ 26	+ 22	+ 48				+105	+ 22	+127
	S	- 50	+ 16	- 34				- 37	+ 6	- 31	- 37	+ 29	- 8	+ 31	- 26	+ 5	+ 31	+ 11	+ 42				+122	+ 11	+133
22	N	+144	+ 9	+153				- 65	+ 13	- 52	- 65	+ 28	- 37	+ 16	- 11	+ 5	+ 16	+ 13	+ 29				+123	+ 13	+136
	S	+ 53	+ 3	+ 56				- 58	+ 7	- 51	- 58	+ 25	- 23	+ 20	- 18	+ 2	+ 20	+ 12	+ 32				+111	+ 12	+123
23	N	+ 75	-720	-645				- 73	+ 15	- 58	- 73	+ 35	- 38	+ 13	- 16	- 3	+ 13	+ 22	+ 35				+108	+ 22	+130
	S	-644	+ 22	-622				- 9	+ 8	- 1	- 9	+ 24	+ 15	+ 51	- 8	+ 43	+ 51	+ 8	+ 59				+151	+ 8	+159
24	N	+ 44	- 9	+ 35	- 78	+ 8	- 70	- 72	+ 22	- 50	- 72	+ 32	- 40	+ 12	- 4	+ 8	+ 12	+ 10	+ 22	+ 27	+ 21	+ 48	+113	+ 5	+118
	S	+ 30	- 13	+ 17	- 93	+ 4	- 89	- 56	+ 10	- 46	- 56	+ 27	- 29	+ 20	- 9	+ 11	+ 20	+ 11	+ 31	+ 27	+ 29	+ 56	+119	+ 11	+130
25	N	+ 4	+136	+140				- 60	+ 6	- 54	- 60	+ 24	- 36	+ 21	- 17	+ 4	+ 21	+ 9	+ 30				+127	+ 9	+136
	S	+ 2	+ 41	+ 43				- 39	+ 21	- 18	- 39	+ 29	- 10	+ 25	- 1	+ 24	+ 25	+ 14	+ 39				+116	+ 18	+134
26	N	+271	+108	+379				- 25	+ 18	- 7	- 25	+ 58	+ 23	+ 40	- 18	+ 22	+ 40	+ 58	+ 98				+ 75	+ 90	+165
	S	+213	- 55	+158				+ 4	- 13	- 9	+ 4	+ 52	+ 56	+ 72	- 49	+ 23	+ 72	+ 23	+ 95				+227	+ 9	+236
27	N	+ 58	+ 12	+ 70				- 45	+ 24	- 21	- 45	+ 51	+ 6	+ 20	- 27	- 7	+ 20	+ 19	+ 39				+118	+ 9	+127
	S	- 7	+ 18	+ 11				- 7	+ 21	+ 14	- 7	+ 55	+ 48	+ 46	- 14	+ 32	+ 46	+ 29	+ 75				+151	+ 25	+176
28	N	- 66	+149	+ 83				- 5	+ 10	+ 5	- 5	+ 33	+ 28	+ 40	- 33	+ 7	+ 40	+ 16	+ 56				+155	+ 16	+171
	S	- 1	+ 9	+ 8				- 19	+ 19	0	- 19	+ 53	+ 34	+ 46	- 38	+ 8	+ 46	+ 31	+ 77				+131	+ 29	+160
29	N	+186	+ 14	+200	- 59	- 78	-137	- 3	+ 19	+ 16	- 3	+ 65	+ 62	+ 62	- 26	+ 36	+ 62	+ 29	+ 91	+122	+ 12	+134	+193	+ 25	+218
	S	+129	+ 23	+152	- 98	- 51	-149	0	0	0	0	+ 48	+ 48	+ 52	- 36	+ 16	+ 52	+ 29	+ 81	+ 92	+ 29	+121	+155	+ 54	+209
30	N	+ 40	+ 20	+ 60				- 30	+ 11	- 19	- 30	+ 33	+ 3	+ 31	- 19	+ 12	+ 31	+ 17	+ 48				+130	+ 17	+147
	S	+101	+ 25	+126				- 32	+ 4	- 28	- 32	+ 29	- 3	+ 26	- 38	- 12	+ 26	+ 14	+ 40				+111	+ 14	+125

Zone No. and Direction		Existing Zones			Existing Zones and Various Criteria Compared to Michigan Criteria																	
					1 - 2			1 - 4			1 - 5			2 - 2			2 - 3			2 - 4			3 - 3		
		Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total
31	N	- 82	+ 11	- 71				- 50	+ 14	- 36	- 50	+ 21	- 29	+ 25	- 3	+ 22	+ 25	+ 9	+ 34				+117	+ 9	+126
	S	-105	- 18	-123				- 30	+ 13	- 17	- 30	+ 27	- 3	+ 30	- 5	+ 25	+ 30	+ 15	+ 45				+121	+ 15	+136
32	N	+282	- 27	+255				- 35	+ 13	- 22	- 35	+ 47	+ 12	+ 30	- 21	+ 9	+ 30	+ 20	+ 50				+125	+ 20	+145
	S	+ 99	+ 19	+118				- 27	- 6	- 33	- 27	+ 17	- 10	+ 18	- 51	- 33	+ 18	+ 4	+ 22				+130	+ 4	+134
33	N	+ 95	+ 28	+123				- 5	+ 20	+ 15	- 5	+ 53	+ 48	+ 20	- 55	- 35	+ 20	+ 26	+ 46				+115	+ 58	+173
	S	+208	-131	+ 77				+ 25	+ 4	+ 29	+ 25	+ 41	+ 66	+ 50	- 45	+ 5	+ 50	+ 13	+ 63				+220	+ 13	+233
34	N	-145	+ 20	-125				- 55	+ 11	- 44	- 55	+ 25	- 30	+ 20	- 11	+ 9	+ 20	+ 13	+ 33				+ 95	+ 13	+108
	S	- 77	+ 1	- 76				- 67	+ 10	- 57	- 67	+ 30	- 37	+ 20	- 11	+ 9	+ 20	+ 12	+ 32				+112	+ 12	+124
35	N	+ 95	+ 39	+134				- 20	+ 13	- 7	- 20	+ 31	+ 11	+ 40	- 8	+ 32	+ 40	+ 19	+ 59				+135	+ 27	+162
	S	+ 96	- 25	+ 71				- 28	+ 14	- 14	- 28	+ 49	+ 21	+ 55	- 36	+ 19	+ 55	+ 22	+ 77				+160	+ 22	+182
36	N			+630			0			+252			+275			+192			+242			+434			+306
	S			+511			0			+328			+377			+255			+402			+418			+516
37	N	- 35	+ 23	- 12	- 59	+ 9	- 50	- 45	+ 11	- 34	- 45	+ 27	- 18	+ 25	- 7	+ 18	+ 25	+ 13	+ 38	+ 64	- 6	+ 58	+115	+ 13	+128
	S	-115	- 12	-127	- 78	- 41	-119	- 65	+ 9	- 56	- 65	+ 28	- 37	+ 18	- 23	- 5	+ 18	+ 13	+ 31	- 22	- 12	- 34	+112	+ 13	+125
38	N	- 66	- 20	- 86	- 92	- 4	- 96	- 62	+ 38	- 24	- 62	+ 54	- 8	+ 38	- 3	+ 35	+ 38	+ 28	+ 66	+ 89	+ 16	+105	+227	+ 16	+243
	S	-128	+ 39	- 89	- 71	- 98	-169	- 38	- 42	- 80	- 38	+ 9	- 29	+ 25	- 42	- 17	+ 25	+ 53	+ 78	+ 52	+ 24	+ 76	+152	+ 39	+191
39	N	-157	+ 2	-155	- 85	+ 12	- 73	- 55	+ 7	- 48	- 55	+ 25	- 30	+ 15	- 15	0	+ 15	+ 11	+ 26	- 57	+ 37	- 20	+100	+ 11	+111
	S	+ 17	+ 2	+ 19	+ 7	-120	-113	- 57	+ 7	- 50	- 57	+ 29	- 28	+ 19	- 21	- 2	+ 19	+ 14	+ 33	+ 17	- 11	+ 6	+101	+ 14	+115
40	N	0	+ 46	+ 46				+ 10	- 7	+ 3	+ 10	+ 18	+ 28	+ 40	- 18	+ 22	+ 40	+ 38	+ 78				+120	+100	+220
	S	+ 29	- 42	- 13				- 58	- 1	- 59	- 58	+ 61	+ 3	+ 29	- 71	- 42	+ 29	+ 24	+ 53				+154	- 23	+131
41	N	+104	- 16	+ 88				- 36	+ 16	- 20	- 36	+ 58	+ 22	+ 11	- 12	- 1	+ 11	+ 35	+ 46				+168	+ 35	+203
	S	+ 7	+ 2	+ 9				- 22	+ 3	- 19	- 22	+ 38	+ 16	+ 55	+ 11	+ 66	+ 55	+ 30	+ 85				+176	+ 67	+243
42	N	+262	- 58	+204	- 88	- 27	-115	- 10	+ 23	+ 13	- 10	+ 50	+ 40	+ 45	- 13	+ 32	+ 45	+ 29	+ 74	+ 52	+ 15	+ 67	+135	+ 40	+175
	S	+ 46	- 11	+ 35	-156	- 66	-222	- 33	+ 13	- 20	- 33	+ 47	+ 14	+ 25	- 30	- 5	+ 25	+ 26	+ 51	+ 53	- 11	+ 42	+148	- 7	+141
43	N	+150	- 1	+149	- 35	-306	-341	- 20	0	- 20	- 20	+ 81	+ 61	+ 31	- 60	- 29	+ 31	+ 45	+ 76	+ 65	- 27	+ 38	+100	- 3	+ 97
	S	+118	+ 70	+188	-347	+ 37	-310	+ 1	+ 12	+ 13	+ 1	+ 71	+ 72	+ 39	- 34	+ 5	+ 39	+ 25	+ 64	+ 72	+ 55	+127	+120	+ 25	+145
44	W	+209	+119	+328	- 79	- 46	-125	- 82	+ 6	- 76	- 82	+ 11	- 71	+ 4	- 7	- 3	+ 4	+ 2	+ 6	+ 39	- 24	+ 15	+108	+ 2	+110
	E	+113	+ 24	+137	- 89	+ 35	- 54	- 78	+ 15	- 63	- 78	+ 19	- 59	+ 5	- 1	+ 4	+ 5	+ 11	+ 16	+ 39	+ 47	+ 86	+ 99	+ 6	+105
45	N	-100	+282	+182	-143	- 25	-168	-223	- 4	-227	-223	+ 24	-199	+ 42	+ 22	+ 64	+ 42	+ 51	+ 93	+ 46	+ 50	+ 96	- 60	+ 2	- 58
	S	- 36	+ 18	- 18	+ 7	- 15	- 8	- 47	+ 18	- 29	- 47	+ 46	- 1	+ 97	- 23	+ 74	+ 97	+ 5	+102	+135	+ 6	+141	+126	+ 16	+142

Zone No. and Direction		Existing Zones			Existing Zones and Various Criteria Compared to Michigan Criteria																				
					1 - 2			1 - 4			1 - 5			2 - 2			2 - 3			2 - 4			3 - 3		
		Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total
46	N	+ 28	+ 29	+ 57				- 35	+ 20	- 15	- 35	+ 42	+ 7	+ 30	- 12	+ 18	+ 30	+ 24	+ 54				+112	+ 31	+143
	S	+116	+ 46	+162				- 14	+ 34	+ 20	- 14	+ 48	+ 34	+ 53	- 3	+ 50	+ 53	+ 21	+ 74				+168	+ 15	+183
47	N	+ 30	+406	+436				- 41	+ 16	- 25	- 41	+ 35	- 6	+ 9	- 17	- 8	+ 9	+ 16	+ 25				+ 97	+ 16	+113
	S	- 10	+ 14	+ 4				- 41	+ 36	- 5	- 41	+ 46	+ 5	+ 21	- 15	+ 6	+ 21	+ 19	+ 40				+113	- 2	+111
48	N	+ 57	+ 95	+152	- 69	- 38	-107	- 19	+ 26	+ 7	- 19	+ 42	+ 23	+ 26	+ 1	+ 27	+ 26	+ 29	+ 55	+ 60	+ 27	+ 87	+ 99	+ 29	+128
	S	+ 58	+ 27	+ 85	- 78	- 13	- 91	- 26	+ 27	+ 1	- 26	+ 59	+ 33	+ 51	- 28	+ 23	+ 51	+ 17	+ 68	+ 87	+ 10	+ 97	+137	- 17	+120
49	N	+ 50	+ 83	+133	- 74	- 48	-122	- 31	+ 16	- 15	- 31	+ 41	+ 10	+ 21	- 21	0	+ 21	+ 28	+ 49	+ 76	+ 22	+ 98	+120	+ 42	+162
	S	+ 40	+ 20	+ 60	- 98	- 41	-139	- 31	+ 8	- 23	- 31	+ 42	+ 11	+ 37	- 42	- 5	+ 37	+ 17	+ 54	+ 87	+ 8	+ 95	+158	- 3	+155
50	N	- 23	+ 22	- 1	- 67	- 35	-102	- 4	+ 29	+ 25	- 4	+ 68	+ 64	+ 41	- 16	+ 25	+ 41	+ 25	+ 66	+ 57	+ 32	+ 89	+125	+ 29	+154
	S	+183	+ 54	+237	-131	- 13	-144	- 21	+ 43	+ 22	- 21	+ 58	+ 37	+ 36	- 12	+ 24	+ 36	+ 10	+ 46	+ 45	+ 13	+ 58	+151	+ 10	+161
51	N	+ 55	+ 40	+ 95	- 81	- 11	- 92	- 35	+ 24	- 11	- 35	+ 37	+ 2	+ 26	- 12	+ 14	+ 26	+ 21	+ 47	+ 69	+ 40	+109	+136	+ 14	+150
	S	+ 32	+ 35	+ 67	- 85	- 13	- 98	- 31	+ 24	- 7	- 31	+ 35	+ 4	+ 36	- 16	+ 20	+ 36	+ 20	+ 56	+ 63	+ 28	+ 91	+133	+ 15	+148
52	N	+ 58	+ 21	+ 79				- 24	+ 36	+ 12	- 24	+ 56	+ 32	+ 31	- 6	+ 25	+ 31	+ 20	+ 51				+117	+ 33	+150
	S	+ 55	+ 21	+ 76				- 42	+ 31	- 11	- 42	+ 44	+ 2	+ 20	- 15	+ 5	+ 20	+ 19	+ 39				+109	+ 8	+117
53	N	+ 72	+ 53	+125				- 5	- 9	- 14	- 5	+ 48	+ 43	+ 40	- 34	+ 6	+ 40	+ 26	+ 66				+138	+ 28	+166
	S	+128	+ 3	+131				- 36	+ 22	- 14	- 36	+ 49	+ 13	+ 40	- 33	+ 7	+ 40	+ 27	+ 67				+139	+ 25	+164
54	N	+179	+ 42	+221				- 9	+ 25	+ 16	- 9	+ 44	+ 35	+ 42	- 29	+ 13	+ 42	+ 21	+ 63				+107	+ 21	+128
	S	+140	+100	+240				- 10	+ 27	+ 17	- 10	+ 67	+ 57	+ 21	- 26	- 5	+ 21	+ 8	+ 29				+ 71	+ 40	+111
55	N	+ 86	+ 7	+ 93				- 36	+ 9	- 27	- 36	+ 26	- 10	+ 30	- 8	+ 22	+ 30	+ 16	+ 46				+105	+ 29	+134
	S	+ 56	+ 60	+116				- 66	+ 29	- 37	- 66	+ 53	- 13	+ 26	- 9	+ 17	+ 26	+ 18	+ 44				+149	- 5	+144
56	N	+147	+ 47	+194				- 54	+ 17	- 37	- 54	+ 32	- 22	+ 31	+ 7	+ 38	+ 31	+ 18	+ 49				+133	+ 27	+160
	S	+ 74	+ 32	+106				- 66	+ 22	- 44	- 66	+ 30	- 36	+ 25	+ 7	+ 32	+ 25	+ 15	+ 40				+125	+ 13	+138
57	N	+289	+152	+441	- 96	- 72	-168	+ 10	+ 23	+ 33	+ 10	+ 46	+ 56	+ 30	- 18	+ 12	+ 30	+ 30	+ 60	+104	+ 27	+131	**+140**	+ 38	+178
	S	+400	+ 8	+408	-104	- 92	-196	- 10	+ 18	+ 8	- 10	+ 63	+ 53	+ 51	- 62	- 11	+ 51	+ 35	+ 86	+ 96	+ 8	+104	+162	+ 16	+178
58	N	+275	+249	+524	- 39	- 12	- 51	+ 48	- 1	+ 47	+ 48	+ 13	+ 61	+ 72	- 1	+ 71	+ 72	+ 39	+111	+111	+130	+241	+159	+160	+319
	S	+374	+ 18	+392	- 85	-109	-194	- 62	- 10	- 72	- 62	+ 60	- 2	+ 40	- 86	- 46	+ 40	+ 25	+ 65	+ 65	- 59	+ 6	+200	- 8	+192
59	N	+166	+ 71	+237	- 39	- 23	- 62	- 23	+ 14	- 9	- 23	+ 50	+ 27	+ 31	- 33	- 2	+ 31	+ 20	+ 51	+ 86	+ 32	+118	+106	- 2	+104
	S	+349	+ 56	+405	- 40	+ 6	- 34	- 30	+ 28	- 2	- 30	+ 50	+ 20	+ 25	- 17	+ 8	+ 25	+ 16	+ 41	+ 90	+ 33	+123	+115	- 4	+111
60	N	+156	+ 62	+218				0	+ 9	+ 9	0	+ 37	+ 37	+ 40	- 19	+ 21	+ 40	+ 27	+ 67				+156	+ 37	+193
	S	+312	+ 33	+345				- 25	+ 20	- 5	- 25	+ 49	+ 24	+ 51	- 40	+ 11	+ 51	+ 21	+ 72				+166	+ 17	+183

Zone No. and Direction		Existing Zones			1 - 2			1 - 4			1 - 5			2 - 2			2 - 3			2 - 4			3 - 3		
		Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total
61	N	+192	+ 69	+261				- 45	+ 28	- 17	- 45	+ 52	+ 7	+ 21	- 23	- 2	+ 21	+ 11	+ 32				+121	- 11	+110
	S	+244	+ 33	+277				- 16	+ 21	+ 5	- 16	+ 38	+ 22	+ 35	- 14	+ 21	+ 35	+ 17	+ 52				+105	+ 11	+116
62	N	+232	+221	+453			-199	+ 9	+ 28	+ 37	+ 9	+ 74	+ 83	+ 59	- 8	+ 51	+ 59	+ 64	+123	+169	+ 86	+255	+222	+100	+322
	S	+302	+ 56	+358			-193	+ 34	- 1	+ 33	+ 34	+ 56	+ 90	+100	- 51	+ 49	+100	+ 39	+139	+225	+ 51	+276	+230	+ 60	+290
63	N	+171	+ 30	+201				- 36	+ 13	- 23	- 36	+ 28	- 8	+ 26	- 15	+ 11	+ 26	+ 10	+ 36				+121	+ 10	+131
	S	+123	+ 47	+170				- 45	+ 32	- 13	- 45	+ 39	- 6	+ 20	- 4	+ 16	+ 20	+ 24	+ 44				+105	+ 24	+129
64	N	+189	+ 33	+222				- 31	+ 4	- 27	- 31	+ 31	0	+ 32	- 26	+ 6	+ 32	+ 6	+ 38				+ 87	+ 6	+ 93
	S	+ 64	+ 15	+ 79				- 49	+ 6	- 43	- 49	+ 32	- 17	+ 16	- 25	- 9	+ 16	+ 14	+ 30				+106	+ 14	+120
65	N	+ 60	+ 30	+ 90	- 46	- 17	- 63	- 30	+ 14	- 16	- 30	+ 43	+ 13	+ 26	- 36	- 10	+ 26	+ 18	+ 44	+ 53	+ 1	+ 54	+126	+ 18	+144
	S	+141	+ 19	+160	- 44	- 13	- 57	- 30	+ 15	- 15	- 30	+ 46	+ 16	+ 20	- 31	- 11	+ 20	+ 9	+ 29	+ 73	+ 9	+ 82	+100	- 10	+ 90
66	N	+154	+ 40	+194				- 5	+ 11	+ 6	- 5	+ 49	+ 44	+ 30	- 36	- 6	+ 30	+ 21	+ 51				+129	+ 21	+150
	S	+203	+ 54	+257				- 4	- 3	- 7	- 4	+ 65	+ 61	+ 26	- 67	- 41	+ 26	+ 28	+ 54				+106	+ 8	+114
67	N	+ 76	+ 42	+118				- 51	+ 8	- 43	- 51	+ 35	- 16	+ 25	- 18	+ 7	+ 25	+ 18	+ 43				+113	+ 18	+131
	S	+130	+ 3	+133				- 41	+ 27	- 14	- 41	+ 37	- 4	+ 20	+ 3	+ 23	+ 20	+ 13	+ 33				+ 97	+ 11	+108
68	N	+ 17	+ 23	+ 40				- 67	+ 12	- 55	- 67	+ 28	- 39	+ 15	- 12	+ 3	+ 15	+ 13	+ 28				+109	+ 13	+122
	S	+ 12	- 5	+ 7				- 57	+ 16	- 41	- 57	+ 29	- 28	+ 21	- 6	+ 15	+ 21	+ 13	+ 34				+111	+ 13	+124
69	N	+ 76	+ 30	+106				- 30	+ 20	- 10	- 30	+ 32	+ 2	+ 41	- 11	+ 30	+ 41	+ 12	+ 53				+140	+ 9	+149
	S	- 3	+ 32	+ 29				- 45	+ 15	- 30	- 45	+ 33	- 12	+ 25	- 17	+ 8	+ 25	+ 20	+ 45				+126	+ 20	+146
70	N	+ 82	0	+ 82	- 46	0	- 46	- 42	+ 16	- 26	- 42	+ 30	- 12	+ 19	- 8	+ 11	+ 19	+ 11	+ 30	+ 53	+ 29	+ 82	+ 93	+ 9	+102
	S	+ 56	+ 14	+ 70	- 64	- 9	- 73	- 55	+ 10	- 45	- 55	+ 37	- 18	+ 20	- 21	- 1	+ 20	+ 14	+ 34	+ 65	+ 14	+ 79	+119	+ 14	+133
71	W			+683			0			+257			+296			+237			+292			+398			+389
	E			+448			0			+265			+351			+246			+388			+418			+463
72	W	-359	+ 6	-353	-132	- 30	-162	- 65	+ 13	- 52	- 65	+ 29	- 36	+ 15	- 8	+ 7	+ 15	+ 16	+ 31	+ 13	- 7	+ 6	+125	+ 16	+141
	E	- 9	- 11	- 20	- 75	- 24	- 99	- 35	+ 16	- 19	- 35	+ 26	- 9	+ 26	- 3	+ 23	+ 26	+ 14	+ 40	+ 22	+ 19	+ 41	+104	+ 27	+131
73	W	+ 10	+ 16	+ 26				+ 10	+ 17	+ 27	+ 10	+ 47	+ 57	+ 50	- 23	+ 27	+ 50	+ 21	+ 71				+160	+ 9	+169
	E	+179	- 10	+ 169				+ 20	+ 17	+ 37	+ 20	+ 57	+ 77	+ 81	- 42	+ 39	+ 81	+ 29	+110				+180	+ 5	+185
74	W	0	+ 1	+ 1				- 65	0	- 65	- 65	+ 9	- 56	+ 20	- 5	+ 15	+ 20	+ 3	+ 23				+120	+ 6	+126
	E	- 20	- 11	- 31				- 81	+ 8	- 73	- 81	+ 27	- 54	+ 15	- 7	+ 8	+ 15	+ 10	+ 25				+120	+ 10	+130
75	W	- 35	0	- 35	-170	- 12	-182	- 50	+ 12	- 38	- 50	+ 38	- 12	+ 20	- 24	- 4	+ 20	+ 19	+ 39	- 65	+ 30	- 35	+115	+ 19	+134
	E	- 37	+ 3	- 34	-104	- 35	-139	- 29	+ 18	- 11	- 29	+ 37	+ 8	+ 25	- 12	+ 13	+ 25	+ 10	+ 35	- 3	+ 28	+ 25	+ 95	- 3	+ 92

Existing Zones and Various Criteria Compared to Michigan Criteria

Zone No. and Direction		Existing Zones			Existing Zones and Various Criteria Compared to Michigan Criteria																				
					1 - 2			1 - 4			1 - 5			2 - 2			2 - 3			2 - 4			3 - 3		
		Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total	Beg.	End	Total
76	W	- 15	- 31	- 46				- 85	- 2	- 87	- 85	+ 54	- 31	+ 40	- 86	- 46	+ 40	+ 21	+ 61				+165	+ 21	+186
	E	+183	- 6	+177				+ 31	+ 9	+ 40	+ 31	+ 35	+ 66	+ 58	- 6	+ 52	+ 58	+ 29	+ 87				+122	+ 50	+172
77	W	-119	- 20	-139				- 45	+ 12	- 33	- 45	+ 36	- 9	+ 20	- 29	- 9	+ 20	+ 19	+ 39				+130	+ 19	+149
	E	-135	- 6	-141				- 25	+ 26	+ 1	- 25	+ 34	+ 9	+ 21	- 10	+ 11	+ 21	- 16	+ 37				+ 75	+ 5	+ 80
78	W	+ 20	- 11	+ 9	- 80	- 34	-114	- 5	+ 12	+ 7	- 5	+ 35	+ 30	+ 30	- 22	+ 8	+ 30	+ 17	+ 47	+ 30	- 13	+ 17	+110	+ 17	+127
	E	- 25	- 10	- 35	-101	- 26	-127	- 26	+ 16	- 10	- 26	+ 41	+ 15	+ 30	- 12	+ 18	+ 30	+ 18	+ 48	+ 22	+ 7	+ 29	+109	+ 18	+127
79	W	- 44	+ 13	- 31				- 60	+ 26	- 34	- 60	+ 34	- 26	+ 20	- 1	+ 19	+ 20	+ 14	+ 34				+125	+ 13	+138
	E	-136	- 23	-159				- 64	+ 19	- 45	- 64	+ 28	- 36	+ 14	- 1	+ 13	+ 14	+ 14	+ 28				+104	+ 22	+126
80	W	-112	- 51	-163	-120	- 74	-194	- 50	- 18	- 68	- 50	+ 34	- 16	+ 30	- 55	- 25	+ 30	+ 17	+ 47	- 15	- 51	- 66	+ 8	+ 15	+ 23
	E	- 43	- 10	- 53	- 45	+ 26	- 19	- 34	+ 11	- 23	- 34	+ 35	+ 1	+ 26	- 9	+ 17	+ 26	+ 23	+ 49	+ 79	+ 61	+140	+ 92	+ 49	+141
81	W	+150	0	+150				- 60	+ 24	- 36	- 60	+ 47	- 13	+ 20	- 11	+ 9	+ 20	+ 24	+ 44				+ 65	+ 13	+ 78
	E	+ 21	- 78	- 57				- 34	+ 14	- 20	- 34	+ 57	+ 23	+ 30	- 38	- 8	+ 30	+ 29	+ 59				+127	+ 29	+156
82	W	+ 70	- 12	+ 58				- 40	+ 23	- 17	- 40	+ 53	+ 13	+ 35	- 33	+ 2	+ 35	+ 14	+ 49				+150	- 20	+130
	E	+129	- 13	+116				+ 5	+ 15	+ 20	+ 5	+ 35	+ 40	+ 50	- 10	+ 40	+ 50	+ 21	+ 71				+131	+ 25	+156
83	W	-133	- 4	-137				- 65	+ 10	- 55	- 65	+ 17	- 48	+ 15	- 10	+ 5	+ 15	+ 2	+ 17				+105	+ 16	+121
	E	- 77	- 52	-129				- 65	+ 13	- 52	- 65	+ 28	- 37	+ 15	- 5	+ 10	+ 15	+ 14	+ 29				+126	+ 14	+140
84	W	- 85	- 31	-116				- 45	+ 5	- 40	- 45	+ 29	- 16	+ 20	- 19	+ 1	+ 20	+ 11	+ 31				+105	+ 11	+116
	E	- 32	- 33	- 65				- 40	+ 18	- 22	- 40	+ 32	- 8	+ 26	- 11	+ 15	+ 26	+ 14	+ 40				+110	+ 14	+124
85	W	-150	+ 85	- 65	-108	- 74	-182	- 40	+ 25	- 15	- 40	+ 52	+ 12	+ 40	- 21	+ 19	+ 40	+ 39	+ 79	+ 12	+ 27	+ 39	+125	+ 56	+181
	E	+115	+ 8	+123	-113	- 24	-137	+ 16	+ 10	+ 26	+ 16	+ 31	+ 47	+ 70	- 17	+ 53	+ 70	+ 12	+ 82	+ 87	+ 8	+ 95	+205	+ 12	+217
86	W	0	- 22	- 22				- 30	+ 16	- 14	- 30	+ 36	+ 6	+ 30	- 15	+ 15	+ 30	+ 21	+ 51				+130	+ 34	+164
	E	+387	- 55	+332				- 30	+ 5	- 25	- 30	+ 42	+ 12	+ 40	- 35	+ 5	+ 40	+ 18	+ 58				+149	+ 7	+156

APPENDIX C

ZONE LENGTHS

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
1	W	794	698		649	667	701	729		834
	E	919	641		609	612	664	673		789
2	W	745	542		554	573	558	601		691
	E	745	556		551	590	556	620		708
3	W	1074	837	665	792	817	838	873	804	963
	E	1008	760	649	707	729	753	789	672	885
4	W	949	735		672	677	750	760		920
	E	942	779		694	716	761	795		901
5	W	1015	775		715	722	793	802		897
	E	944	757		710	717	778	781		869
6	W	975	825		806	822	842	862		942
	E	1152	859		841	870	857	903		983
7	W	908	544	435	486	538	486	584	626	684
	E	825	343	340	398	407	383	404	484	465
8	N	815	613	521	597	614	636	659	656	749
	S	820	707	596	672	701	715	759	750	863
9	N	856	760		713	728	769	792		892
	S	875	728		674	688	732	752		848
10	N	853	764		716	726	776	787		903
	S	876	780		714	727	787	804		915
11	N	1177	280	262	1017	1159	947	1130	408	1165
	S	1194	365	194	1054	1110	1004	1104	505	1069
12	N	756	563		543	569	577	616		726
	S	757	571		509	531	574	624		729

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
13	N	555	437		430	458	430	468		552
	S	548	453		455	488	456	513		597
14	N	654	547	475	507	530	540	572	608	672
	S	648	547	475	514	536	560	590	623	684
15	N	1778	1340		1404	1421	1386	1407		1477
	S	1496	1413		1371	1411	1329	1451		1476
16	N	416	Did Not	Did Not	279	330	356	356	434	466
	S	424	Apply	Apply	282	322	261	319	369	358
17	N	638	532		508	531	542	576		694
	S	705	533		504	528	539	585		693
18	N	860	773		734	752	783	807		897
	S	916	803		757	778	813	838		927
19	N	683	616		569	596	610	659		759
	S	687	594		594	615	613	645		748
20	N	653	539	476	531	551	551	575	606	651
	S	750	606	515	568	603	608	656	673	760
21	N	727	570		552	577	587	618		697
	S	577	611		580	603	616	653		744
22	N	931	778		726	741	783	807		914
	S	815	759		708	726	761	791		882
23	N	816	1461		1403	1423	1458	1496		1591
	S	804	1426		1425	1441	1469	1485		1585
24	N	911	876	806	826	836	884	898	924	994
	S	901	884	795	838	855	895	915	940	1014

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
25	N	836	696		642	660	700	726		832
	S	661	618		600	608	642	757		752
26	N	996	617		610	650	639	715		782
	S	760	602		593	658	625	697		838
27	N	873	803		782	809	796	842		930
	S	772	761		775	809	793	836		937
28	N	514	431		436	469	438	487		602
	S	460	452		452	486	460	520		612
29	N	932	732	595	748	794	768	823	866	950
	S	903	751	602	751	799	767	832	872	960
30	N	1090	1030		1011	1033	1042	1078		1177
	S	1137	1011		983	1008	999	1051		1136
31	N	642	713		677	684	735	747		839
	S	528	651		634	648	676	696		787
32	N	1600	1345		1323	1357	1354	1395		1490
	S	1389	1271		1238	1261	1238	1293		1343
33	N	772	649		664	697	614	695		822
	S	724	647		676	713	652	710		880
34	N	675	800		756	770	809	833		908
	S	739	815		758	778	824	847		939
35	N	623	489		482	500	521	548		651
	S	608	537		523	558	556	614		719
36	N	630	Did Not	Did Not	252	275	192	242	434	306
	S	511	Apply	Apply	328	377	255	402	418	516

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
37	N	760	772	722	738	754	790	810	830	900
	S	708	835	716	779	798	830	866	801	969
38	N	644	730	634	706	722	765	796	835	973
	S	691	780	610	700	751	763	858	856	971
39	N	578	733	660	685	703	733	759	713	844
	S	766	747	634	697	719	745	780	753	862
40	N	460	414		417	442	436	492		634
	S	433	446		387	449	404	499		577
41	N	491	482		463	498	548	577		725
	S	573	485		465	507	484	531		688
42	N	1332	1128	1013	1141	1168	1160	1202	1195	1303
	S	1190	1155	933	1135	1169	1150	1206	1197	1296
43	N	926	777	436	757	838	748	853	815	874
	S	954	766	456	779	838	771	830	893	911
44	W	1142	814	689	738	743	811	820	829	924
	E	897	760	706	697	701	764	776	846	865
45	N	750	568	400	341	369	632	661	664	510
	S	524	542	534	513	541	616	644	683	684
46	N	568	511		496	518	529	565		654
	S	606	444		464	478	494	518		627
47	N	1210	774		749	768	766	799		887
	S	764	760		755	765	766	800		871
48	N	635	483	376	490	506	510	538	570	611
	S	559	474	383	475	507	497	542	571	594

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
49	N	630	497	375	482	507	497	546	595	659
	S	564	504	365	481	515	499	558	599	659
50	N	456	457	355	482	521	482	523	546	611
	S	698	461	317	483	498	485	507	519	622
51	N	703	608	516	597	610	622	655	717	758
	S	677	610	512	603	614	630	666	701	758
52	N	788	709		721	741	734	760		859
	S	783	707		696	709	712	746		824
53	N	557	432		418	475	438	498		588
	S	551	420		406	433	427	487		584
54	N	1002	781		797	816	794	844		909
	S	920	680		697	737	675	709		791
55	N	650	557		530	547	579	603		691
	S	677	561		524	548	578	605		705
56	N	914	720		683	698	758	769		880
	S	819	713		669	677	745	753		851
57	N	738	297	129	330	353	309	357	428	475
	S	729	321	125	329	374	310	407	425	499
58	N	740	216	165	263	277	287	327	457	535
	S	693	301	107	229	299	255	366	307	493
59	N	952	715	653	706	742	713	766	833	819
	S	1091	686	652	684	706	694	727	809	797
60	N	539	371		380	408	392	438		564
	S	718	373		368	397	384	445		556

Zone Lengths
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
61	N	751	490		473	497	488	522		600
	S	729	452		457	474	473	504		568
62	N	652	199	Did Not	236	282	250	322	454	521
	S	551	193	Apply	226	283	242	332	469	483
63	N	830	629		606	621	640	665		760
	S	805	635		622	629	651	679		764
64	N	780	558		531	558	564	596		651
	S	747	668		625	651	659	698		788
65	N	990	900	837	884	913	890	944	954	1044
	S	1015	855	798	840	871	844	884	937	945
66	N	1212	1018		1024	1062	1012	1069		1168
	S	1248	991		984	1052	950	1045		1105
67	N	826	708		665	692	715	751		839
	S	769	636		622	632	659	669		744
68	N	767	727		672	688	730	755		849
	S	727	720		679	692	735	754		844
69	N	670	564		554	566	594	617		713
	S	634	605		575	593	613	650		751
70	N	672	590	544	564	578	601	620	672	692
	S	731	661	588	616	643	660	695	740	794
71	W	683	Did Not	Did Not	257	296	237	292	398	389
	E	448	Apply	Apply	265	351	246	388	418	463
72	W	391	744	582	692	708	751	775	750	885
	E	653	673	574	654	664	696	713	714	804

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
73	W	355	329		356	386	356	400		498
	E	477	308		345	385	347	418		493
74	W	765	764		699	708	779	787		890
	E	762	793		720	739	801	818		923
75	W	610	645	463	607	633	641	684	609	779
	E	596	630	491	619	638	643	665	655	722
76	W	425	471		384	440	425	532		657
	E	551	374		414	440	426	461		546
77	W	531	670		637	661	661	709		819
	E	745	576		577	585	587	613		656
78	W	490	481	367	488	511	489	528	498	608
	E	496	531	404	521	546	549	579	560	658
79	W	771	802		768	776	821	836		932
	E	618	777		732	741	790	805		903
80	W	458	621	427	553	605	596	666	555	644
	E	510	563	544	540	564	580	612	703	704
81	W	465	315		279	302	324	359		393
	E	379	436		416	459	428	495		592
82	W	500	442		425	455	444	491		572
	E	495	379		399	419	419	450		455
83	W	752	889		834	841	894	906		1010
	E	749	878		826	841	894	906		1018
84	W	505	621		581	605	622	652		737
	E	511	576		554	568	591	616		700

Zone Lengths:
Existing, by Michigan Criteria, and by Various Criteria

Zone No. and Direction		Existing Zone	2-1 (Mich.)	1-2	1-4	1-5	2-2	2-3	2-4	3-3
85	W	970	1035		1020	1047	1054	1114		1216
	E	1159	1036		1062	1083	1089	1118		1253
86	W	486	508	369	494	514	523	559	590	672
	E	811	479	551	454	491	484	537	781	635