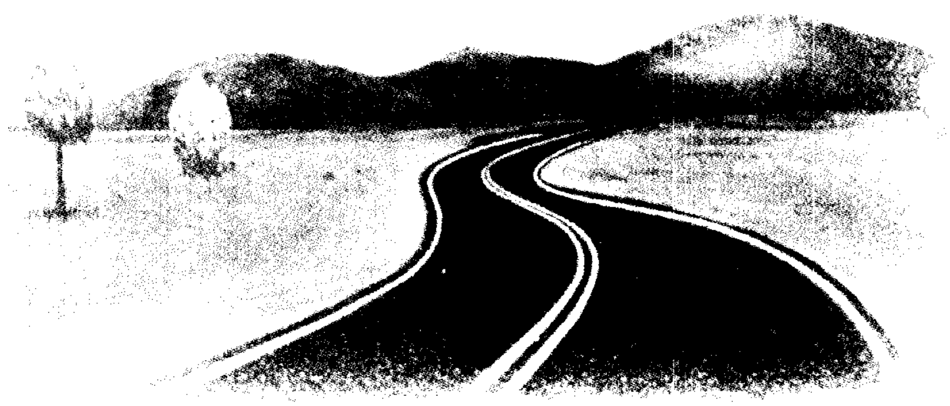
COST-EFFECTIVENESS AND SAFETY OF ALTERNATIVE ROADWAY DELINEATION TREATMENTS FOR RURAL TWO-LANE HIGHWAYS

VOL. III. APPENDIX A, SITE SELECTION AND DATA COLLECTION



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Federal Highway Administration

Offices of Research & Development

Washington, D.C. 20590

APRIL 1978
FINAL REPORT

REPORT NO. FHWA-RD-78-52

FOREWORD

This six-volume report presents the findings of a research study to assess the effect of various delineation treatments on accident rates. Cost-benefit and cost models for evaluating specific delineation treatments were developed. Delineation guidelines were formulated by executing the cost-benefit models for selected delineation treatments.

The six volumes are:

Vol. I	Executive Summary	
Vol. II	Final Report	
Vol. III	Appendix A,	Site Selection and Data Collection
Vol. IV	Appendix B,	Development and Description of Computerized Data Base
Vol. V	Appendix C,	Statistical Model Development
Vol. VI	Appendix D,	Cost of Roadway Accidents and
	Appendix E,	Cost and Service Life of Roadway Delineation Treatments.

Sufficient copies of the Executive Summary are being distributed to provide a minimum of two copies to each FHWA Regional Office, one copy to each Division Office, and five copies to each State highway agency. One copy of the Final Report is being provided to each FHWA Regional and Division Office and one to each State highway agency. Volumes III through VI are available only on request.

Charles F. Scheffey
Director, Office of Research
Federal Highway Administration

Technical Report Documentation Page

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16. Abstract

Under this research study, the effect of various delineation treatments on accident rates was assessed by analyzing accident data from more than 500 roadway sites in 10 States for tangent, winding and isolated horizontal curve sections on two-lane rural highways. Cost-benefit and cost models for evaluating specific delineation treatments were developed and guidelines formulated by executing the cost-benefit models for selected delineation treatments.

This Volume presents details on the site selection and data collection processes. Included are criteria for inclusion of sites in the study and identification of data elements and collection techniques. Recommendations for process improvements are also provided. Other volumes produced under this research study are:

Vol.	FHWA No.	Report Title
I	78-50	Executive Summary
II	78-51	Final Report
IV	78-53	Appendix B, Dev. & Descrip. of Computerized Data Base
V	78-54	Appendix C, Statistical Model Development
VI	78-55	Appendix D, Cost of Roadway Accidents and Appendix E, Cost and Service Life of Roadway Delineation Treatments.

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PREFACE

This document and its appendices constitute the final report for the study "Cost-Effectiveness and Safety of Alternative Roadway Delineation Treatments." The study was conducted by Science Applications, Inc., with the assistance of Alan M. Voorhees and Associates, Inc., Dr. James Taylor, University of Notre Dame, and Mr. John Glennon, for the Federal Highway Administration under Contract DOT-FH-11-8587.

Science Applications, Inc., and FHWA wish to acknowledge the assistance of the many people who participated in this study, particularly Robert Felsburg of AMV, Sandra Morrow, SAI, and the key individuals in the ten states listed below where data collection took place. Without their cooperation this study would not have been possible.

States	Key Personnel
Arizona, Department of Transportation	Mr. Ross E. Kelley, Traffic Engineer, Safety Projects Services
California, Department of Transportation	Mr. Perry Lowden, Chief, Sign and Delineation Section
	Mr. James B. Dobbins, County Traffic Engineer for the County of Riverside
Connecticut, Department of Transportation	Dr. Charles E. Dougan, Chief of Research and Development
Georgia, Department of Transportation	Mr. Archie C. Burnham, Jr., State Traffic and Safety Engineer
	Mr. Arthur Durshimer, Jr., Traffic and Safety Engineer
Idaho, Department of Transportation	Mr. James L. Pline, Traffic Engineer

Louisiana, Department of Highways	Mr. Grady Carlisle, State Traffic and Planning Engineer
	Mr. John E. Evanco, Highway Planning and Needs Engineer
Maryland, Department of Transportation	Mr. Pierce E. Cody, III, Chief Bureau of Highway Maintenance
	Mr. Paul S. Jaworski, Chief Bureau of Accident Studies
Ohio, Department of Transportation	Mr. John LeGrand, Chief, Bureau of Transportation Safety
	Mr. John H. White, Assistant System Facilities
Virginia, Department of Highways and Transportation	Mr. A. L. Thomas, Assistant, State Traffic and Safety Engineer
	Mr. P. J. Stenger, Associate Traffic Engineer
Washington, State Highway Commission	Mr. J. A. Gallagher, Traffic Engineer
	Mr. W. R. Curry, Traffic Operations Engineer

TABLE OF CONTENTS

TABLE OF CONTENTS (continued)

LIST OF TABLES

LIST OF FIGURES

Metric Conversion Factors

Several customary units appear in the text of this report. Generally, it is the policy of FHWA to express measurements in both customary and SI units. The purpose of this policy is to provide an orderly transition to the use of SI exclusively. It was decided that dualization of tables was not warranted because of the additional cost and delay in making this research available. Instead, the following conversion table is included.

To Convert	To	
in	mm	Multiply by 25.4*
ft	m	Multiply by 0.3048*
mi	km	Multiply by 1.609
mi/h	km/h	Multiply by 1.609
ft^2	m^2	Multiply by 0.0929
gal	L	Multiply by 3.785
^0F	^0C	Subtract 32 and multiply by 5/9
$\frac{accidents}{MVM}$	$\frac{accidents}{MVkm}$	Divide by 1.609
lb	kg	Multiply by 0.4536

The pound is a measure of force (weight) and the kilogram is a measure of mass. Mass and weight are not equivalent. For an object weighted under normal gravitational conditions, however, the above relationship may be used.

The Federal Highway Administration recognizes the "Standard for Metric Practice," E380 of the American Society for Testing and Materials, as the authority for SI usage.

*denotes exact conversion factor

APPENDIX A

SITE SELECTION AND DATA COLLECTION

One of the major elements of work in this research was the proper selection of study sites and the collection of appropriate data on those sites for use in the analysis. This section describes the conduct of these processes.

A.1 Site Selection

The site selection activity represents one of the very crucial aspects of any field research program. The proper selection of sites and the collection of appropriate data on those sites were extremely important in this study because they bear directly upon the statistical validity and general applicability of the study results. Therefore, prior to the initiation of this activity, a detailed site selection plan was developed. The first Interim Progress Report, submitted in August 1975 (unpublished), thoroughly discussed site selection plans as anticipated at that time in the study program.

The purpose of this document is to describe the process finally developed and utilized, to discuss the difficulties encountered throughout the program, and to outline the results of the study team's site selection efforts. Thus, this text will document the specific efforts of the study team and at the same time provide valuable information to the future researcher who may be faced with tasks similar to those which confronted this study team.

A.1.1 Site Selection Process

The site selection plan is illustrated in Figure 1. Each state was invited through the FHWA National Office to participate in the study. Participation required assistance by the state in identifying test sites where new delineation treatments had recently been installed

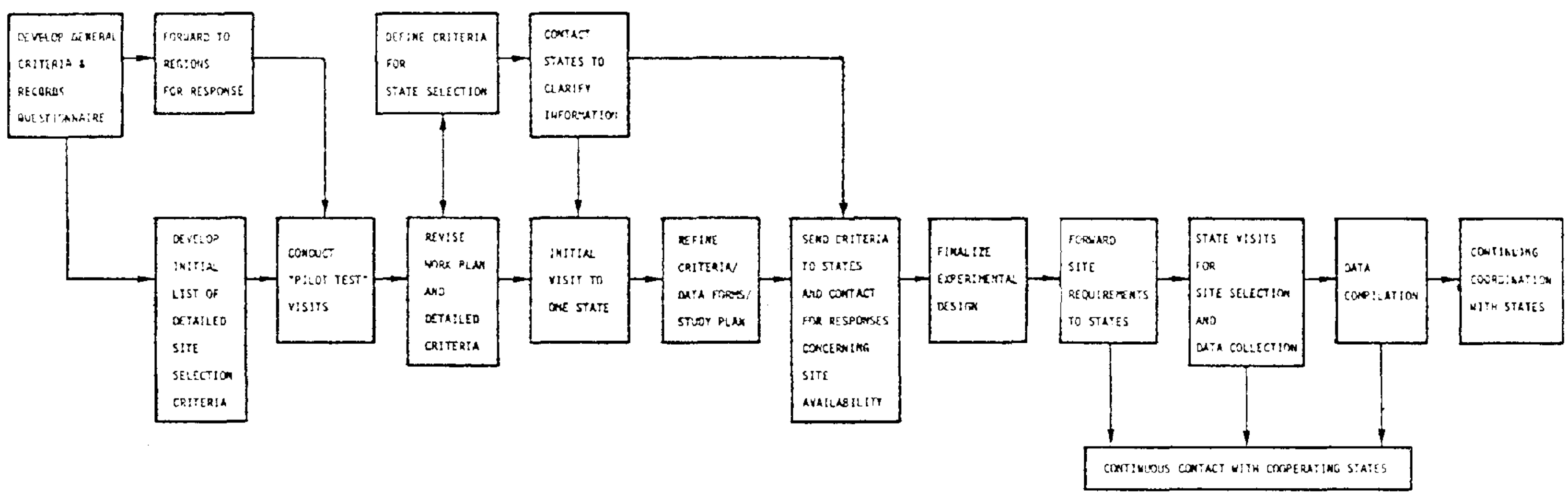


Figure 1. Schematic of site selection process and data collection activity.

and providing access to accident, geometric,and traffic data for selected sites. Initially 28 states responded positively to the invitation to participate.

These states then provided details on the availability of required information. Eighteen states were then selected as potential participants.

Prior to final selection a pilot site visit was conducted in two states to test the site selection and data collection processes and the appropriate forms which had been developed. As a result of this visit the general site requirements and the details of the data collection forms were revised.

Within the time and financial constraints of the study, it was determined that approximately 10 states would be used in the study. Figure 2 indicates those 10 states which were selected. The selection was based on a number of factors, including the following:

- The most important criteria was that those states which seemed to have the best and most complete records available to the study team for the purpose of site selection and data collection were to be chosen.

- An attempt was made to select states representing a wide geographic distribution, but it was also important that the states not be scattered to such a degree that the data gathering could not be conducted in an efficient and cost-effective manner.

- States were selected to provide the broadest range of types of sites possible.

- Participating states were chosen in order to represent a wide range of delineation practices on rural highways.

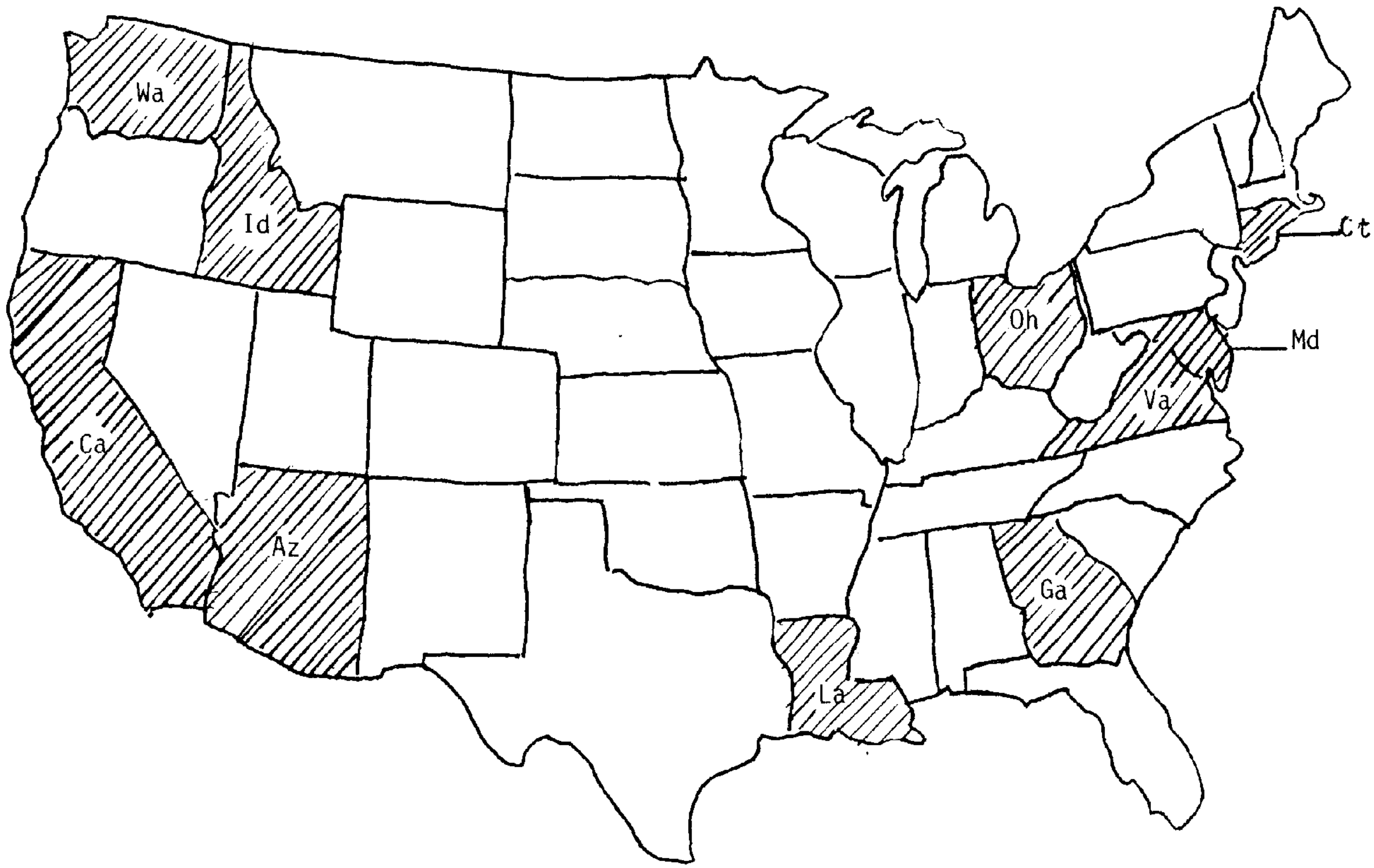


Figure 2 Geographic distribution of participating states.

A.1.1.1. Preliminary List of Sites

Accompanying the package of site selection information forwarded to the states was a request for the states to prepare a list of potential study sites which met the specified criteria. States were asked to suggest sites in as many of the cells as possible. As the study progressed, however, requests became more explicit as the cells began to fill.

A.1.1.2 State Visit for Site Review

The major portion of the effort during the site selection process involved the visit by a staff member to each of the participating states for review of the potential study sites and to finalize the site selection and data collection. Although the process varied slightly from state-to-state, the following procedures generally define the process involved:

- introductory meeting with designated state contact and other appropriate state personnel
- review and familiarization with the types of record systems available to the study team member
- review of the tentative study site provided by the states
- collect site data on the selected sites
- continue search for additional study sites beyond those preliminarily prepared by the state
- collect data on additional selected sites and continue the iterative process of searching, selecting, and collecting.

Introductory Meeting

The meeting with the state contact and other persons to be involved in the site selection effort provided the study team member with the opportunity to review the objectives of the study and to specifically detail the work to be completed in that state during his visit. It also provided the opportunity to become familiar with the operation of the various departments within the state highway agency, to become aware of the various practices for delineation and related activities within the state, and to compile other information unique to the state which would be appropriate to this study.

Review of Records

The next step, the review of available record systems, was extremely important in the process as each state has its own format and its own management system for maintaining such records. Therefore, it was necessary to adjust the site selection and data collection processes in each state to fit the specific characteristics of that state's record systems. Thus, prior to any further site selection effort, early familiarization with the records was necessary.

Review of Sites

Regardless of the level of detail in any of the record systems maintained by the state, it was necessary to visually review every site prior to its final selection for inclusion in the study. In addition to inadequacies or inaccuracies in the records, as related to those primary characteristics used in the site selection (roadway width, shoulder width, traffic volume, general horizontal alignment, degree of curvature, and the delineation treatment), there were other characteristics, primarily in the description of the roadway environment, which were important in the site selection. For instance, the existence of considerable development near the roadway was not noted in nearly all of the record systems, but was a critical factor in the elimination of potential sites. This visual review of the sites was conducted through two primary approaches, the photolog and the field review process.

Field Review

This process which the study team deemed necessary if a photolog was not available, involved a member of the study team driving the site in the field and noting the necessary information at that time. In Ohio, where we did not have access to a photolog inventory system, two individuals were utilized in the field review process, one person to drive and observe conditions, the other to observe and record the information. In an attempt to enhance the cost-effectiveness of the field review process, the sites in the remaining states which did not have a photolog were reviewed by the one individual who recorded his observations and measurements with a small hand-held tape recorder. This information was then later transcribed onto the appropriate data collection forms.

The actual review of sites in the field has several advantages over the photolog technique:

(1) The staff team is assured of the accuracy of measurements (of the roadway geometry) which they actually conduct in the field.

(2) A field review provides the study team with a current up-to-date description of the characteristics of the sites.

(3) Such a review allows for a visual observation of certain characteristics which one would not otherwise note with the photolog system. These characteristics could be very important in the determination of the appropriateness of a potential site, i.e., a disproportionately large number of farm or other slow-moving vehicles.

The field review also has considerable disadvantages:

(1) The process is very time consuming in that a considerable amount of time is spent driving between potential study sites. Additionally, time is required to backtrack in the field as necessary. This backtracking, however, is done very efficiently on a photolog system.

(2) The time constraints have a secondary effect in that they limit the size of the area which a reviewer may cover in a given time period. Therefore, in those states where field reviews were conducted, only a certain geographic portion of the state was considered.

(3) Pinpointing the location of mileposts at the beginning and ending points of the study site is based solely on the accuracy of the automobile odometer. One must locate these points by designating distances to specific reference points such as crossroad intersections.

Iterative Nature of Site Selection Process

The whole procedure of selecting study sites during the team member's visit to the state involved a continuous cycle of generating a list of potential sites, reviewing those sites, collecting appropriate data, and then renewing the search for additional potential study sites. In all of the state visits, the list of potential sites prepared by the state was usually reviewed within the first several days. The team member then began efforts to generate additional potential sites.

Several methods of approach were utilized in this renewed search. The first of these, which proved to be relatively successful, was to describe the desired combination of site characteristics to the local state highway personnel. Usually this involved meeting with traffic engineers either at the state headquarters level or on the district level. Personal discussions with these individuals proved to be more productive than attempting to discuss the requirements over the telephone. Due to the time constraint, these suggestions were usually made on the basis of general knowledge and recollections of the local engineers, with limited reliance on the review of available records.

After suggestions by local engineers where exhausted, it was learned that a study team member could uncover additional likely candidate sites by thoroughly reviewing available records for sites with the primary characteristics.

A.1.2 Difficulties Encountered

In traffic engineering research, it is not unusual to encounter difficulties in finding appropriate study sites to meet the exact demands of the study design. This study did not prove to be an exception. The staff encountered numerous problems throughout the site selection process, several of which are described in the following sections.

A.1.2.1 Difficulties in Utilizing Records to Select Sites

In a previous section of this text, it was indicated that one approach to searching for potential study sites was to review the various record systems available. The experience of the study team was that a number of problems arise when one is attempting to use the records to select the sites.

The necessary data are oftentimes not compiled in any one record system or even in any one department within the state highway organization. It was frequently necessary to pursue several sets of records to simply obtain the data on those primary characteristics nescessary to categorize a potential site in regard to the research study design matrices.

Due to this problem, the team member searching for sites had to develop a procedure for utilizing data element priorities in order to narrow the field of potential sites. By necessity, this procedure varied from state-to-state and even varied within a state depending upon the specific type of site for which one is searching. However, the following procedure was the one most frequently used and illustrates some of the concepts which had to be considered in developing the procedure. In searching for a specific type of general situation (either tangent or winding), probably the most restrictive characteristic and that which would eliminate the greatest number of possible sites is the horizontal alignment. In other words, is there a section of roadway of sufficient length which appears to meet the basic definition of a tangent or a winding section? Therefore, this criterion was typically used in the first step of searching for a study site. The method used was to review highway maps of sufficient scale to be able to ascertain the relative horizontal alignment of those highways. The next step was to search the records for the primary geometric characteristics; the roadway width and the shoulder width. These two items of data were usually available on the same record form. The next element reviewed to further eliminate inappropriate study sites was the current traffic volume, which usually was available in a separate traffic volume publication. (In some states, however, these data were available in the same record which included the geometric variables.) Finally, because the data were typically not readily available, the type of delineation on the roadway was researched. Once a site had been found with the appropriate characteristics of the above items, it was recorded to be reviewed for further detail.

Another problem which confronted the study team was the lack or inaccessibility of certain elements of data necessary for the study. Examples of these types of data include degree of curvature of horizontal curves and the date on which the delineation treatments were first installed at the site. Less than half of the participating states had detailed records on the degree of curvature of specific horizontal curves and had to refer to as-built construction drawings. The date of original delineation installation was maintained at various levels among the different state organizations and proved to be one of the most difficult and time-consuming pieces of information to obtain.

A final problem, which was not unique to any one state but common among all those involved, was the inaccuracies within the record systems. Frequently a site which had been chosen on the basis of the records was rejected during the visual review because the characteristics indicated in the records did not correspond to those in existence. Any number of reasons could cause such problems including errors during the original inventory, a simple miscoding or error in keypunching when preparing the inventory, or insufficient time to make changes to the inventory after a reconstruction project.

A.1.2.2 Site Availability

The research plan entailed six tables or matrices which had been developed to analyze the use of various treatments. A very ambitious design called for the selection of three study sites in each of approximately 200 combinations of primary geometric characteristics, traffic volumes, and delineation systems. After an early site selection effort in five states, it became evident that certain of these combinations were very unique and would prove to be difficult to find. The more critical of these combinations are outlined below.

General Situation (unless otherwise specified, apply to both tangent and winding situations).

1. Sites without any form of delineation are generally not available on the state highway system because all states have gone to a standard practice of painting at least centerlines on all roadways unless the volume is extremely low. The few sites which were found on a state highway system were all narrow, low volume, winding roads. Therefore, the study team decided to continue its search for such sites at the county level. Again, it was found that many counties, particularly since the advent of the 205 Pavement Marking Demonstration Program, have established standards of minimal requirements necessary to warrant the painting of a centerline.

2. High volume roads (2,000 to 5,000 ADT as defined by the study team) are very seldom less than 18 feet (5.4 m) in width. One of the first criteria used by the state highway agencies in determining which roads should be improved is the amount of traffic being carried on the road. Therefore, essentially all roads carrying traffic volumes in this range have been improved - in most cases to 20 feet (6 m) or more in width.

3. Roads servicing traffic volumes in the higher category seldom are without edgelines. Nearly all of the states have adopted an edgeline practice and again one of the primary criteria calls for striping those roadways which carry the most traffic.

4. Raised pavement markers were seldom found on narrow roadways. As indicated in number 2 above, most roads of less than 18 feet in width (5.4 m) carry relatively low traffic volumes. Those states which have implemented a raised pavement marker program have placed the lowest priority on very low volume roadways.

5. High volume winding roads without edgelines are unusual. This stems from a combination of two factors. The first is that roads meeting the rather severe definition of a winding road used in this study are usually not major routes of travel. In most cases, it seems that if a road carries the higher level of traffic, the horizontal alignment has been upgraded, which usually involves an attempt to straighten the road as much as possible. The other factor, which probably bears more heavily on this finding, is that state highway personnel hold the belief that winding roads require more delineation than do other types of roadways. Therefore, such roads, especially when carrying considerable traffic, are usually among the first to receive edgeline treatments.

6. Narrow shoulders (less than four feet or 1.2 meters) are not usually found on high volume tangent roadways. Tangent roads tend to be higher design type facilities because of the relatively non-restrictive nature of the terrain. Specifically, a terrain which allows for a road which meets the tangent definition used in this study is usually wide open and has no major relief features and, therefore, it is not difficult to include wide graded shoulders into the construction of the roadway.

Four-lane Roadways

Most four-lane undivided roadways are set in an urban or suburban environment. Those which were initially found in rural areas were very short sections only. The majority of four-lane roadways in a rural setting are divided roadways. Over the years, divided roadways had proven to operate more safely than undivided roadways. Therefore, when designing a four-lane facility through a rural area where land was readily available, engineers typically chose to build a divided roadway.

Horizontal Curves

In addition to some of the specific and unique combinations of characteristics which are difficult to find (as described for the general situation), the study team encountered a general problem of not being able to select individual horizontal curves which met the established criteria. The greatest problem was that very few of the states had information on horizontal alignment of the roadways in a format which could be easily utilized to search for potential study curves. When it was discovered that two states had computerized horizontal alignment files on their entire rural state highway system, it was decided to re-visit each of these states to conduct an intense search for horizontal curves. Through this effort all rural highways on the states' system were completely reviewed for curves which would satisfy the requirements of the study.

The study team member first thoroughly pursued the file in order to segregate all those curves which met two basic criteria; the isolation requirement and the degree of curvature requirement. The isolation criterion was the primary characteristic used to delete study sites and required that the curve be at least 0.3 miles (0.48 km) from adjacent curves in both directions. The basis for this criterion was to utilize curves on which the motorists were not pre-conditioned to driving curve after curve. The thesis is that the delineation requirements by the motorists and the relative effectiveness of the delineation treatment are greater on such isolated curves. This criterion in itself negated the use of many of the curves on the state highway system. For example, on all rural highways on the state highway system in one state, only 778 curves met the basic isolation criterion.

The other criterion utilized at this stage in the search process was the degree of curvature, the basic requirement being that the curve have a degree of curvature equal to or greater than three degrees. The horizontal alignment file in one state was formatted such that one could easily check the isolation requirement and the degree of curvature at the same time. In the other state, however, the degree of curvature was calculated after all those curves meeting the isolation requirement had been segregated. Tables 1 and 2 represent the distribution of the degree of curvature of all isolated horizontal curves in the two states studied. Of the 778 curves reviewed, a total of 487 or 62.5 percent had degrees of curvature less than three degrees. Thus, there exists 291

Table 1. Distribution of degree of curvature of isolated* curves on rural state highways (state 1).

Degree of Curvature	Number of Curves	Percent of Total	Percent of Total (Disregarding Curves < 3^0)
0 - 1 degree	144	18.5	-
1 - 2 degrees	202	25.9	-
2 - 3 degrees	141	18.1	-
3 - 4 degrees	99	12.7	34.0
4 - 5 degrees	66	8.5	22.7
5 - 6 degrees	33	4.2	11.3
6 - 7 degrees	25	3.2	8.6
7 - 8 degrees	13	1.7	4.5
8 - 9 degrees	16	2.1	5.5
9 -10 degrees	9	1.2	3.1
Greater than 10 degrees	30	3.9	10.3
Total	778	100	100

* Curves met basic isolation criterion of being at least 0.3 miles (0.48 km) from adjacent curves in both directions.

Table 2. Distribution of degree of curvature of isolated* horizontal curves on rural state highways (state 2).

Degree of Curvature**	Number of Curves	Percent of Total
3 - 4 degrees	120	64.5
4 - 5 degrees	14	7.5
5 - 6 degrees	25	13.4
6 - 7 degrees	2	1.1
7 - 8 degrees	5	2.7
8 - 9 degrees	0	0.0
9 - 10 degrees	8	4.3
Greater than 10 degrees	12	6.5
Total	186	100.0

* Curves met basic isolation criterion of being at least 0.3 miles (0.48 km) miles from adjacent curves in both directions.

** Those curves with a degree of curvature less than three degrees were not recorded.

curves on rural highways in one state and 186 curves on rural state highways in the other state that meet both the isolation and the degree of curvature requirements. Although the percentages of curves with specific degrees of curvature vary considerably between the two states, the search in both states indicated that the majority of the curves had a degree of curvature of less than six degrees, which was the break-off point for the categories used in the study. In state 2, less than 15 percent of the curves had a degree of curvature equal to or greater than six degrees, while in state 1 the same category comprised 32 percent of the total curves above three degrees

There were additionally a number of characteristics which were deemed to be unacceptable for sites to be used in this study. These characteristics were ones which made the site unique or were factors which would influence the traffic operation and safety at the curve. Table 3 lists the most frequent of these reasons for site deletion and details the number of curves which were deleted in each of the two states due to these characteristics. As the table indicates, the greatest number of curves were deleted because they were either too close to an intersection or there was an intersection actually within the limits of the curve. Thus, these secondary characteristics deleted approximately 72 percent and 80 percent of those curves meeting both degree of curvature and isolation criteria in the two states, respectively.

With all of these unique sites identified, the study team was forced to reconsider the original six matrices which had been developed. The decision was made to delete certain cells from the study. Figures 3 through 6 represent the revised site matrices. Those matrices which dealt with four-lane rural roads were completely eliminated from the study.

A.1.3 Results of Site Selection Effort

The result of the site selection efforts was the designation of 514 study sites. Table 4 indicates how these sites were distributed

Table 3. Reasons for deletion of horizontal curves meeting degree of curvature and isolation criteria.

Reason for Deletion	State 1		State 2	
	Number of Curves Deleted	Percent of Those Deleted	Number of Curves Deleted	Percent of Those Deleted
Too close to intersection	65	30.9%	29	19.6%
Within developed area	31	14.8	26	17.6
Steep grades	27	12.9	6	4.0
Too close to other curves not listed	19	9.0	9	6.1
Multi-lane roadway	5	2.4	22	14.9
Volume too high	14	6.7	-	-
Volume too low	18	8.6	6	4.0
Railroad crossing	8	3.8	2	1.4
Approach to bridge	7	3.3	4	2.7
Miscellaneous (including insufficient information)	16	7.6	44	29.7
Total	210	100%	148	100%

CENTERLINE ON 2-LANE ROADS

Controls: Sections Ten Miles in Length
No Edgelines or Post Delineators

Table 1

Delineation Treatment	Roadway Characteristic																
	Type of Section*	Tangent								Winding							
	Roadway Width (ft.)	16-18				>18				16-18				>18			
	Volume (ADT)	0-2000		2000-5000		0-2000		2000-5000		0-2000		2000-5000		0-2000		2000-5000	
	Shoulder Width (ft.)	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4
No Centerline																	
Painted Centerline																	
RPM's on Painted Centerline																	

*Tangent - Predominantly tangent sections with no curves greater than three degrees

Winding - Predominantly curved sections with degrees of curvature greater than three degrees with tangent sections of less than 1500 feet between curves.

Shaded areas denote cells which were deleted from the study.

Figure 3. Revised matrix for centerline on two lane roads.

EDGELINES ON 2-LANE ROADS

Controls: Sections Ten Miles in Length
Roadway Width > 20 Feet
Painted Centerlines
No Continuous Post Delineators

Table 2

Delineation Treatment	Roadway Characteristic								
	Type of Section*	Tangent				Winding			
	Volume (ADT)	0-2000		2000-5000		0-2000		2000-5000	
	Shoulder Width (ft.)	<4	≥4	<4	≥4	<4	≥4	<4	≥4
No Edgelines		←			Selected sites from Table 1.**				
Painted Edgelines									

*Tangent - Predominantly tangent sections with no curves greater than three degrees.

Winding - Predominantly curved sections with degrees of curvature greater than three degrees with tangent sections of less than 1500 feet between curves.

**Selected sites designated in Table 1 with a painted centerline may have characteristics which satisfy these requirements. Therefore, the same sites may be used in both analyses, reducing the total number of sites necessary.

Shaded areas denote cells deleted from the study.

Figure 4. Revised matrix for edgelines on two lane roads.

POST DELINEATORS ON 2-LANE ROADS

Controls: Sections Ten Miles in Length
Roadway Width 20 Feet
Shoulder Width 4 Feet
Painted Centerline

Table 3

Delineation Treatment	Roadway Characteristic								
	Type of Section*	Tangent (Post Delineators on Right Side Only)				Winding (Post Delineators on Outside of Curve Only)			
	Volume (ADT)	0-2000		2000-5000		0-2000		2000-5000	
	Presence of Edgelines (Painted)	Without Edgelines	With Edgelines	Without Edgelines	With Edgelines	Without Edgelines	With Edgelines	Without Edgelines	With Edgelines
Without Post Delineators		← Selected sites from Tables 1 and 2 ** →							
With Post Delineators									

*Tangent - Predominantly tangent sections with no curves greater than three degrees.

Winding - Predominantly curved sections with degrees of curvature greater than three degrees with tangent sections of less than 1500 feet between curves.

** Selected sites designated in Table 1 with a painted centerline or those sites designated in Table 2 with painted edgelines may have characteristics which meet these requirements. Therefore, the same sites may be used in both analyses, reducing the total number of sites necessary

Figure 5. Matrix for post delineators on two lane roads.

HORIZONTAL CURVE ON 2-LANE ROAD

Controls: Should be an Isolated Curve
Must have superelevation

Table 4

Delineation Treatment	Roadway Characteristic																
	Roadway Width (ft.)	< 20								≥ 20							
	Degree of Curvature	3-6				> 6				3-6				> 6			
	Volume (ADT)	0-2000		2000-5000		0-2000		2000-5000		0-2000		2000-5000		0-2000		2000-5000	
	Shoulder Width (ft).	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4	<4	≥4
None																	
Painted Centerline																	
RPM's on Painted Centerline																	
Painted Edgelines w/ Painted Centerline																	
Post Delineators w/ Painted Centerline																	
Post Delineators w/ Painted Centerline & Painted Edgelines																	
Painted Centerline w/ Continuous GUARDRAIL*																	

* Steel guardrail (painted or corrugated but excluding CORTEN STEEL) with no retroreflective system.

Shaded areas denote cells deleted from the study.

Figure 6. Revised matrix for horizontal curves on two lane roads.

Table 4. Summary of selected sites.

Jurisdiction	Tangent	Winding	Horizontal Curve	Total
Arizona	23	12	19	54
California	41	21	6	68
Connecticut	11	9	12	32
Georgia	5	24	3	32
Idaho	18	12	6	36
Louisiana	18	6	9	33
Maryland	11	10	81	102
Ohio	11	16	6	33
Virginia	17	25	14	56
Washington	17	13	38	68
Total	172	148	194	514

by type of site (tangent, winding, or horizontal curve) and also the number of sites chosen in each state.

A.2 Data Collection

The following sections will describe the general procedures followed in obtaining the appropriate data, the specifics of the data sources available, and the difficulties encountered in the compilation and use of the data. For the purpose of the analysis, and therefore for discussion purposes in this text, the collected data have been classified into two categories, site data and accident data.

A.2.1 Site Data

Site data are those data regarding the characteristics which physically and operationally describe the section of roadway defined as a site. Included are geometric data, roadway environment features, historical traffic volumes, and the delineation treatment characteristics.

A.2.1.1 General Statement of Procedures

Although the exact means of compiling the specific data elements varied from state to state, the general procedure or flow of data collection remained relatively constant. Basically, the site data were collected in several distinct stages as follows:

- Geometric data, data on the roadway environment, and the delineation type were all recorded at the time when the site was being reviewed for appropriateness.
- Traffic volume history was then compiled through the traffic count archives if available.
- The number of grades of varying percents was not recorded because the information was generally either not available or not readily accessible. In addition, it was determined that an adequate description was provided under the General Vertical Alignment.
- The specific superelevation of a horizontal curve was not recorded in any form except the construction plans, which

were frequently not available for the types of roads being studied because of their age. Thus, this information was not compiled.

In addition to the data compiled on the Information Checklist Forms, slides were taken of those sites which were reviewed in the field, thereby providing a visual recording of the actual sites and of the various roadway environments experienced in the field.

A.2.1.2 Data Sources and Record Systems

The data sources and record systems vary considerably from state to state. This variation includes not only the types of information maintained and the format of the records, but also the general availability of the information.

Table 5 indicates the sources of the data on the primary site characteristics as they were available and utilized in the ten participating states. One can ascertain from the table that some of the data elements were available in the form of records, others had to be compiled by visually reviewing the site, and still others depended on the knowledge and recollections of local engineers. In some cases there were alternative means for compiling or verifying the data, while in other cases two or more sources were necessary to complete the required information. The following sections discuss more completely the sources used to compile the various types of data.

Geometrics

The major geometric characteristics of interest are the roadway and shoulder widths for all sites and the degree of curvature for horizontal curve sites.

Roadway Width and Shoulder Width

These basic geometric characteristics were always first determined through the use of some form of Roadway Log or Road Inventory. As shown in Table 5, the title of the file may vary considerably. Likewise,

Table 5. Sources of primary data elements.

	Arizona	California	Connecticut	Georgia	Idaho	Louisiana	Maryland	Ohio	Virginia	Washington
Roadway Width & Shoulder Width	Log of the Arizona Highway System.	Highway Log.	Roadway Log.	Road Life Inventory.	Public Roads Mileage System Report.	Surface Type Log.	Road Inventory Cross-Section File. Roadway Locator File.	Road Inventory File.	Road Inventory. Graphic Log.	Roadway & Intersection Inventory.
Traffic Volume	Traffic Annual Report.	Highway Log. Traffic Volume Book.	Annual Traffic Volume Book.	Traffic Volume Book & Map.	Traffic Volume Maps.	Traffic Annual Report.	Traffic Volume Maps.	Traffic Volume Book.	Traffic Volume Book.	Annual Traffic Report.
Degree of Curvature	Straignt Line Inventory of Curves (Partial).	Construction Drawings.	Straight Line Diagram.	Horizontal Alignment Inventory Field Notes.	Straight Line Inventory of Curves (Partial).	Field Notes of In-house Needs Study.	Horizontal Alignment Inventory.	Supplemental File.	Field Measurement.	Horizontal & Vertical Alignment Inventory.
Type of Delineation	District & HQ Engineers. Photolog.	District & HQ Engineers. Photolog.	District & HQ Engineers. Photolog.	District & HQ Engineers. Field Review.	District & HQ Engineers. Map Inventory. Photolog.	District & HQ Engineers. Photolog.	District & HQ Engineers. Photolog.	District Engineers.	District & HQ Engineers. Field Review.	HQ Traffic Engineers. Photolog.
Date of Delineation Installation	Pavement Striping Log.	District Traffic Engineers.	District Maintenance Engineers.	Central Maintenance.	HQ Traffic Engineer.	Central Traffic Services Section.	HQ & District Maintenance Engineers.	District Striping Crews.	District Traffic Engineers.	District Traffic Engineers.
Roadway Environment	Photolog.	Photolog.	Photolog.	Field Review. Photolog.	Photolog.	Photolog.	Photolog.	Field Review.	Field Review.	Photolog.

the substance and format of the file may also differ from state to state, but every state has such a file and nearly all of them contain data on the roadway and shoulder widths as well as additional information on road and shoulder surface type, road classification, and other locator and management items.

To illustrate the different styles of formats used by the states, examples of the logs from three different states are shown in Figures 7, 8, and 9. These samples were chosen to indicate a representative cross-section of formats. The log in Figure 7 includes the basic information and spreads it out over the page to provide a data sheet which is uncluttered and easy to read. The log in Figure 8 includes more columns of data, but still maintains all data for a given point on one horizontal line. The log from a third state presented in Figure 9 illustrates the other end of the spectrum. This log records considerably more data, prints it more closely without the benefit of lines to outline the columns, and records it on two lines for each reference point. The result is a full page of data which requires familiarization and care in order to efficiently use the log.

These width measurements were then verified during the visual review of the site. If the site was reviewed via the photolog, the measurement was made with a grid overlay. If the observed width and the recorded width were reasonably similar, the recorded width was assumed to be accurate. If considerable differences were observed, the photolog measurement was used. When the site was actually observed in the field, specific measurements were made with a tape. It was not unusual to find discrepancies between the widths in the field and those in the records.

Degree of Curvature

One of the major difficulties encountered in the site selection and the data collection processes was the lack of data on the degree of

ROUTE NUMBER	ROUTE MILE	SYM	PROJECT	YEAR BUILT	SURFACE TYPE	SHLDR TYPE CODE	LENGTH	LENGTH OPPOSITE DIRECTION ON DUAL HIGHWAY	LENGTH FRONTAGE ROADS AND RAMPS	LANES	LEFT SHLDR WIDTH	TRAVELED SURFACE WIDTH	RIGHT SHLDR WIDTH	MILEPOST	MAINT	SYSTEM CODE	COUNTY	F.A. ROUTE NUMBER
87	16.79	EQ	MP 13248 BK EQUALS 13269 AHD											132.48	21	2200	11	55
87	16.79		F019 1 902	66	ASPH CONC	66	0.56			4	06	48	06	132.69	21	2200	11	55
87	16.79	X	CURB TO LEFT AND RIGHT											132.69	21	2200	11	55
87	16.80	X	JCT FAS 252 COOLIDGE AVENUE											132.70	21	2200	11	55
87	17.35	EQ	MP 13325 BK EQUALS 13326 AHD											133.25	21	2200	11	55
87	17.35		F 019 1 902	66	ASPH CONC	66	0.53			4	08	48	08	133.26	21	2200	11	55
87	17.35	X	CURB TO LEFT AND RIGHT											133.26	21	2200	11	55
87	17.88	DH	F 019 1 10							4				133.79	21	2200	11	55
87	17.88	NB	F 019 1 10	63	ASPH CONC	66	0.14			2	02	24	08	133.79	21	2200	11	55
87	17.88	SB	F 019 1 10	63	ASPH CONC	66		0.14		2	08	24	02	133.79	21	2200	11	55
87	17.88	MD	12 FT CURBED MEDIAN											133.79	21	2200	11	55
87	17.88	X	CURB TO LEFT AND RIGHT											133.79	21	2200	11	55
87	18.02	X	N CITY LIM URB BDRY COOLIDGE											133.93	21	1140	11	55
87	18.02	X	S BDRY CASA GRANDE NATL MON											133.93	21	1140	11	55
87	18.02	DH	F 019 1 10							6				133.93	21	1140	11	55
87	18.02	NB	F 019 1 10	63	ASPH CONC	66	0.09			4	02	40	02	133.93	21	1140	11	55
87	18.02	SB	F 019 1 10	63	ASPH CONC	66		0.09		2	08	24	08	133.93	21	1140	11	55
87	18.02	MD	12 FT CURBED MEDIAN											133.93	21	1140	11	55
87	18.02	X	CURB TO LEFT AND RIGHT											133.93	21	1140	11	55
87	18.11	DH	F 019 1 10	63						4				134.02	21	1140	11	55
87	18.11	NB	F 019 1 10	63	ASPH CONC	66	0.20			2	04	24	04	134.02	21	1140	11	55
87	18.11	SB	F 019 1 10	63	ASPH CONC	66		0.20		2	04	24	04	134.02	21	1140	11	55
87	18.11	MD	VARIABLE PAVED MEDIAN											134.02	21	1140	11	55
87	18.31	DH	NON FA 94B	53						4				134.22	21	1140	11	55
87	18.31	NB	NON FA 94B	53	MIX BIT	66	0.10			2	02	24	02	134.22	21	1140	11	55
87	18.31	SB	NON FA 94B	53	MIX BIT	66		0.10		2	02	24	02	134.22	21	1140	11	55
87	18.31	MD	VARIABLE PAVED MEDIAN											134.22	21	1140	11	55

Figure 7. Sample road log.

05/22/75 LISTING OF STATE SYSTEM BASIC ROAD INVENTORY DATA IN 80 CH. FORMAT RI-06 PAGE 146

COU	MCL	ROUTE	LOG	LENG	SURFACE SUMMARY TYP	BS	BPR	SW	RW	SYS CL	FA CL	POP	COMBINED-OR-DIVIDED ---LEFT---MED--RIGHT--	YR	FAP RTS	CHG	SEQ	TRN	MNT	O/U	MUNICIPALITY	DH IW VY	ACS	LNS	DIS	CONTRL TR	CONTRL RI
FAI	2	158R	0175	0005	G	X	I	24	36	A	5	0329	G T -- 20 -- G L -- 04	68					40	O	LANCASTER		N	2	05	2	1
FAI	2	158R	0180	0068	G	X	I	24	35	A	5	0329	G T -- 20 -- G L -- 04	68					40	O	LANCASTER		N	2	05	1	1
FAI	1	158R	0248	0509	G	X	I	24	36	A	4		G T -- 20 -- G L -- 04	68					40				N	2	05	9	9
FAI	1	158R	0757	0115	G	L	I	24	36	A	4		- - -- -- -- - - -- --	61					40				N	2	05	9	1
FAI	1	158R	0872	0012	G	K	I	24	36	A	4		- - -- -- -- - - -- --	74					40				N	2	05	9	2
FAI	2	158R	0884	0020	G	K	I	24	36	A	4	0024	- - -- -- -- - - -- --	74					40	U	BALTIMORE		N	2	05	1	1
FAI	2	158R	0904	0050	G	L	I	24	36	A	4	0024	- - -- -- -- - - -- --	74					40	U	BALTIMORE		N	2	05	1	2
FAI	2	158R	0954	0027	G	I	I	24	36	A	4	0024	- - -- -- -- - - -- --	65					40	U	BALTIMORE		N	2	05	1	1
FAI	2	158R	0981	0011	G	I	I	24	36	A	4	0024	- - -- -- -- - - -- --	65					40	U	BALTIMORE		N	2	05	2	1
FAI	2	158R	0992	0038	G	I	I	24	36	A	4	0024	- - -- -- -- - - -- --	65					40	U	BALTIMORE		N	2	05	1	1
FAI	1	158R	1030	0242	G	I	I	19	25	A	4		- - -- -- -- - - -- --	59					40				N	2	05	8	8
FAI	1	158R	1272	0108	G	I	I	19	25	A	4		- - -- -- -- - - -- --	59					40				N	2	05	1	8
FAI	1	158R	1380	0203	G	I	I	19	25	A	4		- - -- -- -- - - -- --	59					40				N	2	05	2	8
FAI		158R		15.54	ROUTE MILEAGE																						
FAI	1	159R	0000	0674	G	I	I	20	26	A	4		- - -- -- -- - - -- --	50					40				N	2	05	1	1
FAI	1	159R	0674	0159	G	X	I	24	30	A	4		G N -- 18 -- G L -- 06	69					40				N	2	05	1	2
FAI	1	159R	0833	0062	G	X	I	24	30	A	4		G N -- 20 -- G L -- 04	69					40				N	2	05	1	1
FAI	1	159R	0895	0048	G	X	I	24	30	A	4		G N -- 18 -- G L -- 06	69					40				N	2	05	1	2
FAI	1	159R	0943	0015	G	L	I	24	44	A	4		- - -- -- -- - - -- --	69					40				N	2	05	1	1
FAI	1	159R	0958	0099	G	E	I	24	30	A	4		G R -- 18 -- G L -- 06	69					40				N	2	05	1	2
FAI		159R		10.57	ROUTE MILLAGE																						
FAI	1	188R	0000	0451	G	I	I	18	24	L	4		- - -- -- -- - - -- --	55					50				N	2	05	1	1
FAI	1	188R	0451	0421	G	I	I	18	24	L	4		- - -- -- -- - - -- --	55					50				N	2	05	2	1
FAI	1	188R	0872	0273	G	I	I	18	24	L	4		- - -- -- -- - - -- --	55					50				N	2	05	1	1
FAI	2	188R	1145	0058	G	I	I	20	26	L	5	0329	- - -- -- -- - - -- --	65					50	O	LANCASTER		N	2	05	2	2
FAI	2	188R	1203	0006	G	X	I	30	30	L	5	0329	G T -- 18 -- G I -- 12	65					50	O	LANCASTER		N	2	05	2	1
FAI	2	188R	1209	0028	G	X	I	30	30	L	5	0329	G T -- 18 -- G I -- 12	65					50	O	LANCASTER		N	2	05	1	1
FAI	2	188R	1237	0048	G	X	I	30	30	L	5	0329	G T -- 18 -- G I -- 12	65					50	O	LANCASTER		N	2	05	2	1
FAI	2	188R	1448	0035	G	N	I	36	36	A	5	0329	- - -- -- -- - - -- --	66					40	O	LANCASTER		N	2	05	1	2
FAI	2	188R	1483	0007	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	1	1
FAI	2	188R	1490	0023	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	2	1
FAI	2	188R	1513	0033	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	1	1
FAI	2	188R	1546	0010	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	2	1
FAI	2	188R	1556	0027	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	1	1
FAI	2	188R	1583	0018	G	I	I	36	36	A	5	0329	- - -- -- -- - - -- --	65					40	O	LANCASTER		N	2	05	2	1
FAI	1	158R	1601	0052	G	I	I	18	22	A	5		- - -- -- -- - - -- --	71					40				N	2	05	9	9
FAI	2	188R	1653	0021	G	I	I	18	22	A	5	0329	- - -- -- -- - - -- --	71					40	O	LANCASTER		N	2	05	1	1

Figure 8. Sample road log.

```
AXR156                                                                                                   PAGE     7
                                                                                                   DATE  04/23/75

P  POST P LENGTH N COUNTY  DATE  OF H A CITY REF FED  INS  *    LEFT ROADBED    * * MEDIAN* *   RIGHT ROADBED    *  SIGNIF
P  MILE *          A  ODOM    RECORD  G C CODE DAT RTE  FLE   S NO S OT-SH T-W IN-SH T C P   V S NO S IN-SH T-W OT-SH  CHANGE
                                                              T LN F TO TR WID TO TR Y L A WDA T LN F TO TR WID TO TR EFF-DATE

         *      DESCRIPTION      * ACC-CNTL *ADT INFORMATION*   LEFT ROADBED     * * MEDIAN* *   RIGHT ROADBED    *
                                   EFF-DATE  LK-BK  P LK-AHD      EFF-DATE          EFF-DATE        EFF-DATE

                                                  09-KER-058

R099.837  00.019    022.585 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 C 7 G 467 B 02 Z 00 00 039 00 00 70-06-24
          END BR 50-346 LT         70-06-24            S 007207       70-06-24         70-06-24         70-06-24
R099.846  00.139    022.594 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          END BR 50-346 RT         70-06-24            S 007209       70-06-24         70-06-24         70-06-24
R099.985  00.055    022.733 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          CL TRIPLE 8 FT RCB       70-06-24            S 007234       70-06-24         70-06-24         70-06-24
R100.040  00.054    022.788 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          CL TRIPLE 8 FT RCB       70-06-24            S 007244       70-06-24         70-06-24         70-06-24
R100.094  00.048    022.842 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          CL TRIPLE 8 FT RCB       70-06-24            S 007254       70-06-24         70-06-24         70-06-24
R100.142  01.420    022.890 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          CL TRIPLE 8 FT RCB       70-06-24            S 007263       70-06-24         70-06-24         70-06-24
R101.562  00.322    024.310 70-06-24 D F       G00 P025 002  C 02 Z 10 10 024 05 02 J 7 Z 467 C 02 Z 05 02 024 10 10 70-06-24
          CAMERON RD OC 50-347     70-06-24            S 007525       70-06-24         70-06-24         70-06-24
R101.884  00.258    024.632 70-06-24 D E       G00 P025 002  H 02 Z 10 10 024 05 02 J 7 Z 367 H 02 Z 05 02 024 10 10 70-06-24
                                   70-06-24            S 007585       70-06-24         70-06-24         70-06-24
 102.737E 00.133    024.890 64-01-01 D F       G00 P025 002  H 02 Z 10 10 024 05 02 J 7 Z 047 H 02 Z 05 02 024 10 10    - -
                                   64-01-01            S 007632       64-01-01         64-01-01         64-01-01
 102.870  00.483    025.023 64-01-01 D E       G00 P025 002  H 02 Z 04 04 024 00 00 H 7 Z 047 H 02 Z 00 00 024 04 04    - -
                                   64-01-01            S 007657       64-01-01         64-01-01         64-01-01
 103.353  00.085    025.506 64-01-01 D F       G00 P025 002  H 02 Z 04 04 024 00 00 H 7 Z 047 H 02 Z 00 00 024 04 04    - -
          CAMERON                  64-01-01            S 007746       64-01-01         64-01-01         64-01-01
 103.438  00.011    025.591 64-01-01 D F       G00 P025 002  B 02 Z 00 00 024 00 00 H 7 Z 047 B 02 Z 00 00 024 00 00    - -
          LA ROSE CREEK 50 139     64-01-01            S 007761       64-01-01         64-01-01         64-01-01
 103.449  00.957    025.602 64-01-01 D F       G00 P025 002  H 02 Z 04 04 024 00 00 H 7 Z 047 H 02 Z 00 00 024 04 04    - -
                                   64-01-01            S 007763       64-01-01         64-01-01         64-01-01
 104.406  00.014    026.559 64-01-01 U F       G00 P025 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 007940       64-01-01         64-01-01         64-01-01
 104.420  00.185    026.573 64-01-01 U F       G00 P025 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
          MONOLITH                 64-01-01            S 007943       64-01-01         64-01-01         64-01-01
 104.605  02.152    026.758 64-01-01 U F       G00 P025 002  H 01 Z 00 00 019 00 00 B 7 Z 002 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 007977       64-01-01         64-01-01         64-01-01
 106.757  00.540    028.910 64-01-01 U F       G30 0898 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
          BEG. IN LIEU FAP 25      64-01-01            S 008374       64-01-01         64-01-01         64-01-01
 107.297  00.073    029.450 64-01-01 U E       G30 0898 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 008473       64-01-01         64-01-01         64-01-01
 107.370  00.070    029.523 64-01-01 U F       G30 0898 002  H 02 Z 00 00 019 00 00 B 7 Z 002 H 02 Z 00 00 019 04 04    - -
                                   64-01-01            S 008487       64-01-01         64-01-01         64-01-01
*      * PROFILE POINT TOTALS          LENGTH   007.591     DVM        59,210     COUNTY CUMULATIVE DVM          197,129
 107.440  00.068    029.593 64-01-01 U F       G30  000 002  H 02 Z 00 00 019 00 00 B 7 Z 007 H 02 Z 00 00 019 04 04    - -
          RANDSBURG CUTOFF         64-01-01  008500 P 005500       64-01-01         64-01-01         64-01-01
 107.508  00.088    029.661 64-01-01 U F       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 107.596  00.013    029.749 64-01-01 U C       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 107.609  00.052    029.762 64-01-01 U C       G30  000 002  B 01 Z 00 00 019 00 00 B 7 Z 007 B 01 Z 00 00 019 00 00    - -
          CACHE CREEK 50 201       64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 107.661  00.239    029.814 64-01-01 U C       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 107.900  00.785    030.053 64-01-01 U C       G30  000 062  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 108.685  00.006    030.838 64-01-01 U C       G30  000 062  B 01 Z 00 00 019 00 00 B 7 Z 007 B 01 Z 00 00 019 00 00    - -
          LA AQUEDUCT 50 147       64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 108.691  02.390    030.844 64-01-01 U C       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 111.081  00.318    033.234 64-01-01 U C       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 111.399  00.242    033.552 64-01-01 U C       G30  000 002  H 01 Z 00 00 019 00 00 B 7 Z 007 H 01 Z 00 00 019 04 04    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
 111.641  00.186    033.794 64-01-01 U C       G30  000 002  H 02 Z 10 08 022 00 00 B 7 Z 002 H 02 Z 00 00 022 10 08    - -
                                   64-01-01            S 005500       64-01-01         64-01-01         64-01-01
*      * PROFILE POINT TOTALS          LENGTH   004.387     DVM        24,129     COUNTY CUMULATIVE DVM          221,258
 111.827  00.173    033.980 64-01-01 U C       G30  000 003  H 02 Z 04 04 022 00 00 B 7 Z 007 H 02 Z 00 00 022 04 04    - -
          JCT ST 14 NORTH          64-01-01  005500 P 014100       64-01-01         64-01-01         64-01-01
 112.000  00.069    034.153 64-01-01 U C       G30  000 003  H 02 Z 10 08 022 00 00 B 7 Z 007 H 02 Z 00 00 022 10 08    - -
          GX-N MOJAVE RR XING      64-01-01            S 014100       64-01-01         64-01-01         64-01-01
 112.069  00.862    034.222 64-01-01 U C       G30  000 003  H 02 Z 00 00 030 00 00 B 7 Z 007 H 02 Z 00 00 030 00 00    - -
                                   64-01-01            S 014100       64-01-01         64-01-01         64-01-01
 112.931  00.036    035.084 64-01-01 U C       G30  000 003  H 02 Z 00 00 030 00 00 B 7 Z 002 H 02 Z 00 00 030 00 00    - -
          MOJAVE                   64-01-01            S 014100       64-01-01         64-01-01         64-01-01
*      * PROFILE POINT TOTALS          LENGTH   001.140     DVM        16,074     COUNTY CUMULATIVE DVM          237,332
 112.967  00.043    035.120 64-01-01 U E       G30  000 003  H 01 Z 00 00 032 00 00 B 7 Z 007 H 01 Z 00 00 032 00 00    - -
          JCT ST 14 SOUTH          64-01-01  014100 P 006500       64-01-01         64-01-01         64-01-01
 113.010  00.240    035.163 64-01-01 U E       G30  000 003  H 01 Z 12 12 016 00 00 B 7 Z 007 H 01 Z 00 00 016 16 16    - -
                                   64-01-01            S 006500       64-01-01         64-01-01         64-01-01
 113.250  00.853    035.403 64-01-01 U E       G30  000 003  H 01 Z 08 00 016 00 00 B 7 Z 007 H 01 Z 00 00 016 08 00    - -
                                   64-01-01            S 006500       64-01-01         64-01-01         64-01-01
 114.103  03.572    036.256 64-01-01 U E       G00 P025 003  H 01 Z 08 00 016 00 00 B 7 Z 007 H 01 Z 00 00 016 08 00    - -
          END IN LIEU FAP 25       64-01-01            S 006500       64-01-01         64-01-01         64-01-01
 117.675  03.572    039.828 64-01-01 U F       G00 P025 003  H 01 Z 08 00 016 00 00 B 7 Z 007 H 01 Z 00 00 016 08 00    - -
                                   64-01-01            S 006500       64-01-01         64-01-01         64-01-01
```

Figure 9. Sample road log.

curvature of horizontal curves in the states. All of the states have one common source of this information, construction or "as built" drawings of the roadways. However, this source is extremely limiting for a number of reasons. First, it is difficult and time consuming to research such plans because the archives are usually voluminous and the filing and recording systems are not typically set up for quick reference by milepost. Second, many of the secondary roads being analyzed in this study were constructed many years ago and have not been redesigned in recent years. Therefore, the plans may no longer be on file or possibly the road was built without the benefit of engineering drawings. In any event, the use of such plans for data collection is at best cumbersome.

Less than one-half of the participating states have record systems through which the degree of curvature of a specific curve can be determined with relative ease. Some states have specific computerized files on horizontal and vertical alignment on their State Highway Systems. These inventories provide little information beyond the location and the magnitude of curves and grades, but can be easily cross-referenced with the highway logs to determine a more complete site description.

In one state, the data on horizontal alignment was combined with considerable other data elements in a unique graphic display referred to as a "straight line diagram." This display consists of a straight line at the top of the sheet which represents two miles of the roadway, numerous pieces of information (including crossroads, houses, bridges, etc.) shown graphically adjacent to the roadway, and more detailed data on geometrics, traffic control devices, and traffic operating characteristics on the bottom of the sheet. An example of such a diagram is shown in Figure 10.

In two other states, the study team had access to field notes made during an inventory for a highway needs study. The detailed data on degree of curvature had not been computerized into a format suitable for easy use in this study, but one could search through the field data sheets

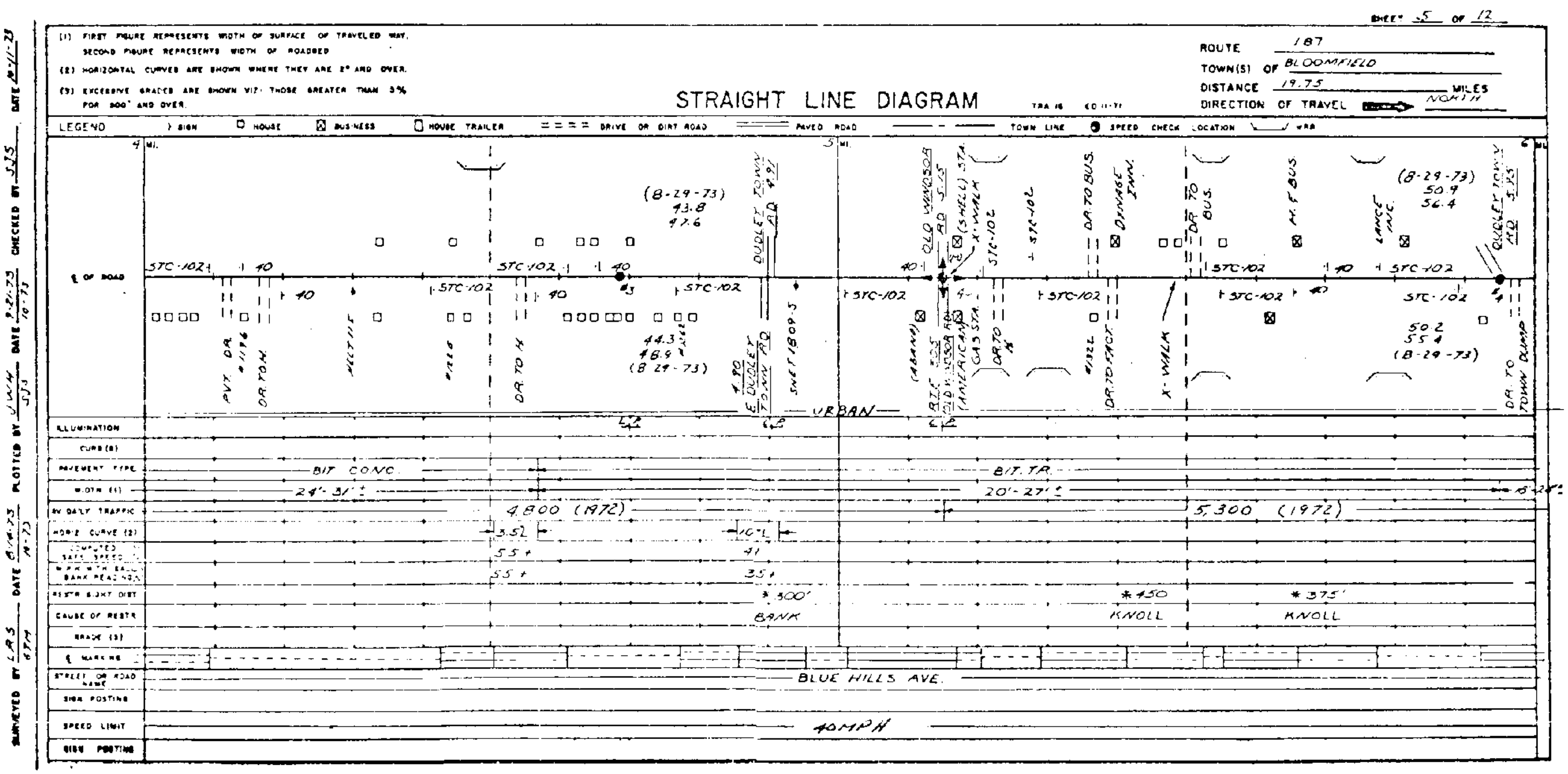


Figure 10. Straight line diagram.

for the appropriate curve. This, however, proved to be a very time-consuming task.

In those states in which no horizontal alignment file was available and in which the sites were reviewed in the field, a field-expedient method for measuring the degree of curvature was utilized. This method involved the measurement of the middle ordinate of a 62-foot chord measured at any convenient point on the curve and is illustrated in Figure 11.

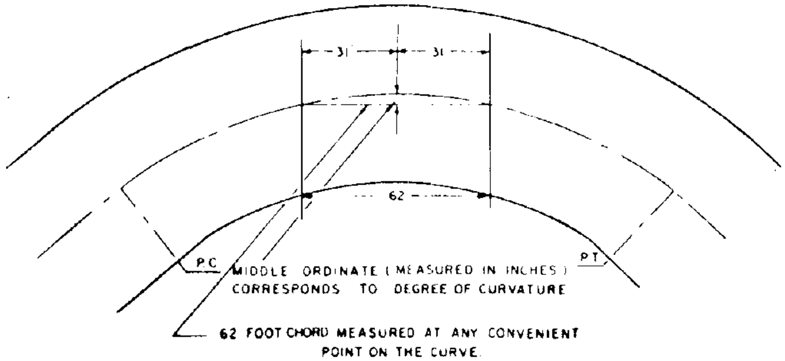
Traffic Volumes

The traffic data used in this study was the annual average daily traffic (AADT) as published by the states. It should be noted that these are not actually counted traffic volumes, but instead have been estimated through a standard procedure.

The primary basis for this estimating procedure is a continuous record of traffic collected at a select number of permanent automatic traffic recorder stations (A.T.R.). These recorders consist of a tube or an electrical triggering device placed in the roadway and record traffic 24 hours a day, every day of the year. The stations are located along the Interstate, Primary, and Secondary Systems both in rural and urban areas. The criterion in determining their location is to provide hourly, daily, and monthly factors for the various types and styles of traffic which are representative of the conditions experienced in any area of the state.

In support of the A.T.R.'s, 24-hour counts are conducted with portable traffic recorders at numerous locations throughout the highway network. These stations are usually located at points of major traffic breaks and are typically placed at intervals of approximately 3.0 to 10.0 miles (4.83 to 16.09 km). The resulting counts are then adjusted to an estimate of annual average daily traffic by compensating for seasonal influence, weekly variation, and other variables as indicated by the traffic observations at the A.T.R.'s.

METHOD FOR DETERMINING DEGREE OF CURVATURE AND CENTRAL ANGLE OF HORIZONTAL CURVES



CENTRAL ANGLE MAY BE DETERMINED BY MULTIPLYING THE LENGTH OF THE CURVE FROM P.C. (BEGINNING OF CURVE) TO THE P.T. (END OF CURVE) BY THE DEGREE OF CURVATURE (AS FOUND ABOVE) AND DIVIDE THAT PRODUCT BY 100'.

EXAMPLE: $\frac{500' \text{(LENGTH OF CURVE)} \times 5'' \text{(INCHES AT MIDDLE ORDINATE)}}{100'} = 25° \text{ CENTRAL ANGLE}$

INCHES AT MIDDLE ORDINATE	DEGREE	RADIUS	CENTRAL ANGLE	SIGN REQUIRED
0 - 3 INCHES	0 - 3	2000' AND OVER	ALL	NONE
4 - 14 INCHES	4 - 14	400'-1500'	UNDER 45°	CURVE
4 - 14 INCHES	4 - 14	400'-1500'	45° AND OVER	CURVE
15 - 27 INCHES	15 - 27	200'- 400'	UNDER 45°	CURVE
15 - 27 INCHES	15 - 27	200'- 400'	45° AND OVER	TURN
28 IN. AND OVER	28 AND OVER	0 - 200'	ALL	TURN

Figure 11. Field expedient method for measuring degree of curvature.

When using the traffic volumes in any analysis, one must realize that there may be some error introduced into the accident rates calculated. The California Department of Transportation has developed a chart which depicts how the expected error varies with the volume level (see Figure 12). This chart indicates that for the types of roads (in terms of the traffic volumes they are carrying) which are included in this study the percent deviation at the 90% confidence level would range from 15-40%.

Delineation Data

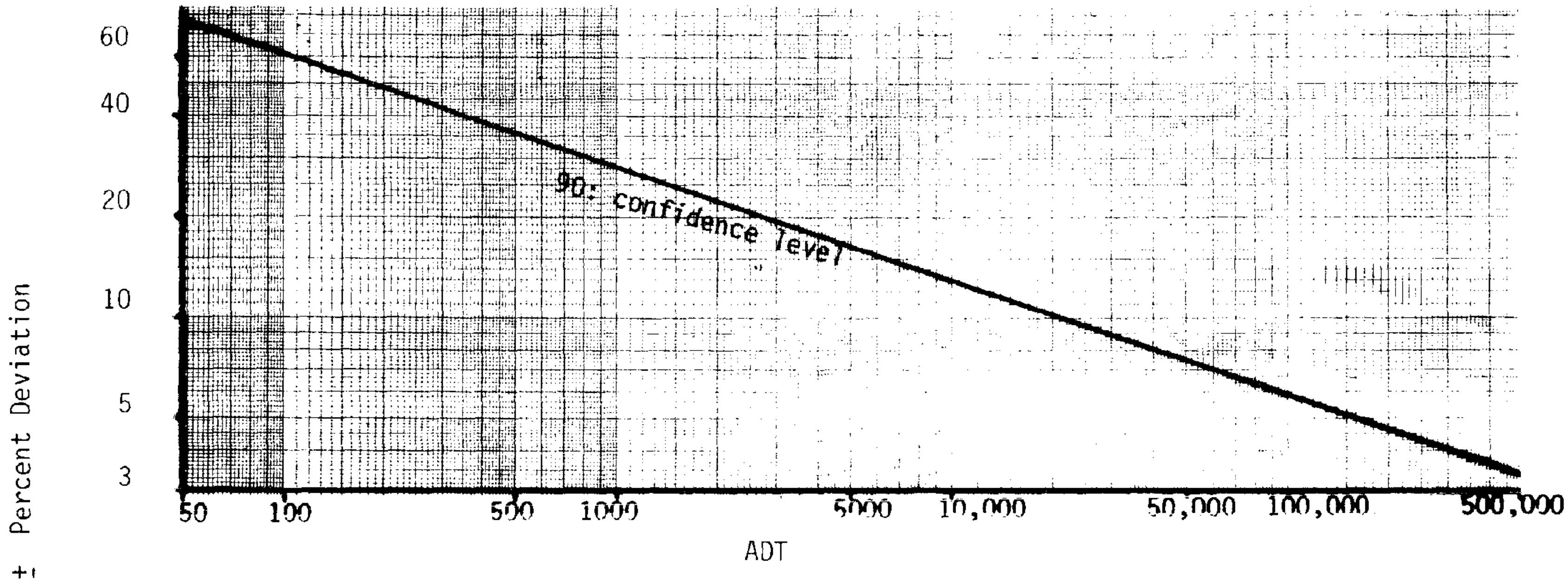
The type of delineation which is present on any specific roadway is poorly recorded in most states. Particularly at the headquarters level, information on even the presence or absence of a centerline or edgelines is usually insufficient. The few exceptions are those roadways on which a centerline or edgelines have been installed under the 205 Pavement Marking Demonstration Program. In these cases, a special record of these installations is maintained by the central staff.

In most cases, the personnel at the district level were able to provide the necessary information. In some of the districts, the District Traffic Engineer maintains a color-coded map which serves as an inventory of the delineation on the highways in his district. Even if an inventory or other form of record is not maintained, district personnel are familiar with the roads on a day-to-day basis and thus are able to recollect the type of delineation in place.

This knowledge was helpful in selecting potential study sites. All sites were visually reviewed and the type of delineation was compiled at that time.

In attempting to determine the date of the original delineation installation, the same difficulties existed as those just described. However, this element of data is extremely critical to the study. Due to the nature of the analysis, the study team must be able to relate the

Accuracy Limits of Average Daily Traffic (ADT)



The graph shows the percent deviation that can occur for various volumes. If the estimated ADT was compared to an average based on a 365 day count, it probably would be different, but for 90 out of 100 times the percent variation would not be larger than that shown above.

Source: California Department of Transportation

Figure 12. Accuracy of traffic estimates.

accident occurrences to the type of delineation which was in existence at the time of the accidents. Therefore, an effort was made to secure either the exact date of the original installation or the most accurate estimate possible.

For many of the installations (particularly centerlines), the problem was eased by the fact that the date was not necessary if the treatment had been installed prior to the first year for which accident data were being analyzed. At the other extreme, exact dates were usually available on installations within the past year or two.

For sites which did not fall into either of these categories, the problem was more acute. In many of the states, the district traffic or maintenance engineers maintain a record of work conducted by the delineation crew. These records are, however, normally maintained in a chronological order rather than by section of roadway. Thus, in order to obtain the date of the original installation, it was necessary to search back through the files until one found the first entry for that particular site and treatment. This proved to be a time-consuming effort and was left to the district personnel to research and forward to the study staff. In other cases, such records have only begun to be maintained and it was necessary to rely on the recollection of local traffic and maintenance engineers and the striping crew to provide the best estimate of the date.

Roadway Environment

There is very little information available on the surrounding roadway environment in any of the record systems available in the participating states. The straight-line diagram shown in Figure 10 does record such information as the location of houses and other developments and the presence of driveways as well as cross streets. Therefore, some insight to the character of the lands adjacent to the roadway is given.

It should be noted, however, that such a diagram cannot compete with the detail available through the photolog. Indeed, a diagram of this type would be a duplication of effort for those states which possess a photolog system. On the other hand, it could be a useful tool for those states without a filming program.

A.2.2 Accident Data

The accident data referred to in this study are those data which provide a history of the accident occurrence at the selected sites. In reviewing these data, one can make an assessment of the actions involved in the accident and thereby analyze the possible relationship between the accident and accident causal factor.

A.2.2.1 Procedures for Data Retrieval

In all of the participating states, the accident data have been computerized in the form of a summary of each accident. The advent of these computerized summaries has not only allowed the states to file a large amount of accident data in a compact form, but has also made the retrieval of desired data a relatively simple matter. The computer provides the traffic engineer with the opportunity to easily retrieve accident data in any form, whether it be for a given section of roadway or for a specific common characteristic of the accident.

In most states, in order to request the data for a specific study site, one simply needs to input the route number, the mileposts of the site boundaries, and the years of data in which one is interested. In other states (depending upon the locator system used), it is also necessary to indicate the county in which the site is situated.

It should also be noted that although such a computerized retrieval approach is the normal procedure for a data request, the states have an optional means of retrieving data for relatively small requests. This alternative approach was, in fact, used by a number of the states when the data for this study were compiled.

In the central traffic engineering offices of the state, a complete run of all accidents is usually maintained for at least several years. The main purpose of this file is to provide a quick reference for review of a particular case by the engineers working on a specific study.

The study team encountered several situations for which the accident data are not available in the computerized summary form. For example, accidents occurring on roads on the Secondary System in one state are not computerized. Likewise, in one state, none of the accidents which occurred prior to 1972 are available in a computerized form. The only records which are available for these accidents are copies of the original officer's report, which although maintained by the state patrol, can be accessed by the state highway department. These reports are filed either by route or other locator information or in chronological order of occurrence. A manual search through the files was usually required to extract these reports; in some cases copies of the report were reviewed through a microfilm reader.

Any of the accidents included in the computerized summary file can also be obtained in the form of the original officer's report through the state patrol. Such reports can be requested by utilizing the case number uniquely assigned to each accident. In those states where a case number is not unique to each accident, one may request the report by identifying the route, the milepost, the date and the time of the accident.

A.2.2.2 Information Coded for Computerized File

A considerable amount of detail is provided by the reporting officer when he files his report. These data are in varying forms in the reports; standard checked boxes and filled data spaces, written text describing the accident and its factors, and even a graphic depiction of the accident. However, not all of these data are readily suited for coding in the computerized file. Each state has, therefore, studied its needs for accident analysis and has selected those data elements to be coded.

Table 6 illustrates the primary data elements used in accident analysis and which are commonly found in the computerized accident summary files. The table is in matrix form and indicates which states provide the various data elements in their summaries.

One can readily see from the matrix that nearly all states provide for the most basic and most important information for analyzing an accident. The categories, which were most critical to this study, include locational data, the type of accident (including prior movement and contributing factors), the severity of the accident, and the roadway and environmental conditions which existed at the time of the accident.

The variety of the data elements shown in the table indicate there is no uniformity in the accident data provided by the different states. For example, only four of the ten states provide an estimate of the amount of the property damage involved, which gives one a sense of the degree of severity if the accident involved only property damage.

In summary, although each state provides different information, the majority of the most critical data is provided by all states.

A.2.2.3 Accident Data Formats Used by States

Like the wide variations displayed in the road logs previously illustrated, the accident data formats also have considerable differences. This stems from the fact that each state provides slightly different data from that of the other states and each has its preference as to the layout of the data for facilitating the use of the data.

The format in Figure 13 represents a style which uses as much directly readable verbiage as possible. Thus, one can easily review the accident data without having to consult a translation or coding guide. The disadvantage of this style of format is that considerably more space is necessary to store less data than in other formats.

Table 6. Data elements included in accident summaries.

		ARIZONA	CALIFORNIA	CONNECTICUT	GEORGIA	IDAHO	LOUISIANA	MARYLAND	OHIO	VIRGINIA	WASHINGTON	RIVERSIDE COUNTY
	Case No.		X	X	X	X	X	X	X	X		X
Location	District		X			X				X	X	
	County		X	X	X		X	X	X	X	X	
	Route	X	X	X	X	X	X	X	X	X	X	X
	Milepost	X	X	X	X	X	X	X	X	X	X	
	Intersecting Routes			X				X	X	X		X
	Intersection Relationship	X	X	X	X	X	X	X	X	X	X	X
Time	Date	X	X	X	X	X	X	X	X	X	X	X
	Day of Week		X		X	X	X	X	X	X		
	Hour of Day	X	X	X	X	X	X	X	X	X	X	X
Accident	Type of Collision	X	X	X	X	X	X	X	X	X	X	X
	Severity	X	X	X	X	X	X	X	X	X	X	X
	Primary Cause/ Contributing Factors	X	X		X	X		X	X	X		X
	Prior Movement	X	X	X		X	X	X	X	X	X	X
	Object Involved		X	X	X	X	X	X		X	X	X
	Lane Location	X	X		X	X	X	X	X		X	
	Property Damage	X			X					X	X	
	Violation	X	X		X		X					
Vehicles	Number of Vehicles	X	X	X	X	X	X	X	X	X	X	X
	Type of Vehicles	X	X	X	X	X	X	X	X	X		X
	Direction of Travel	X	X	X	X	X		X	X	X	X	X
	Speed						X		X	X		
	Vehicle Defects						X			X		
Persons Involved	Persons Killed or Injured	X	X	X	X	X	X	X	X	X	X	X
	Condition of Driver	X	X				X	X	X	X		X
	Residence	X			X	X				X		
	Age				X	X			X			
Road Conditions	Surface Type	X		X			X	X	X			
	Surface Condition	X	X	X	X	X	X	X	X	X	X	X
	Road Condition	X	X		X	X	X	X		X		X
	Traffic Control	X			X	X	X	X	X			
	Access Control	X	X									
	Alignment	X		X		X	X		X	X	X	
Environmental Conditions	Weather	X	X	X	X	X	X	X	X	X	X	X
	Illumination	X	X	X	X	X	X	X	X	X	X	X

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                      STUDY PERIOD 01/01/72 THRU 12/31/74

S.H.     25 SECTION 02510A MAIN ROUTE          DISTRICT 2 ACCIDENT LISTING       DATE 04/21/75  PAGE 52

11.11     DATE       04-21-72  TURNING ACCIDENT, GOING SAME WAY         NO TRAFFIC CONTROL        CLEAR WEATHER
          FRIDAY     HOUR 21   IN LANE NO. 3, AT AN INTERSECTION        DARK                      DRY ROAD SURFACE
          SERIAL NO. 721170046 ACCIDENT INVESTIGATION UNKNOWN           STRAIGHT LEVEL ROAD       NO SURFACE DEFECTS
     00  FATAL,  02 INJURY
     1. PASSENGER CAR,            MAKING LEFT TURN    GOING EAST,          IN COUNTY RESIDENT, AGE 16,
     2. PICKUP,                   OVERTAKING AND PASSING, GOING EAST,      IN COUNTY RESIDENT, AGE 19,

12.11     DATE       01-12-73  1-VEHICLE STRUCK SHEEP ACCIDENT                                    RAINY WEATHER
          FRIDAY     HOUR 24   IN LANE NO. 3, NOT AT AN INTERSECTION    DARK                      WET ROAD SURFACE
          SERIAL NO. 730170296  ACCIDENT INVESTIGATION UNKNOWN          STRAIGHT LEVEL ROAD
     00 FATAL,    00 INJURY
     1. PASSENGER CAR,            GOING STRAIGHT AHEAD, GOING EAST         IN COUNTY RESIDENT, AGE 16,

13.11     DATE       07-23-71  1-VEHICLE STRUCK FENCE                   NO TRAFFIC CONTROL        CLEAR WEATHER
          FRIDAY     HOUR 07   IN LANE NO. 8, NOT AT AN INTERSECTION    DAWN OR DUSK              DRY ROAD SURFACE
          SERIAL NO. 001282400  ON SCENE INVEST. BY STATE POLICE        STRAIGHT LEVEL ROAD       NO SURFACE DEFECTS
     00 FATAL     01 INJURY   DIRECT CAUSE WAS DRIVER DISTRACTED OR INATTENTIVE,
     1. PASSENGER CAR,            GOING STRAIGHT AHEAD, GOING EAST         IN COUNTY RESIDENT, AGE 16,
                                                                           OTHER IMPROPER DRIVING

14.20     DATE       10-18-74  1-VEHICLE STRUCK CATTLE ACCIDENT         NO TRAFFIC CONTROL        CLEAR WEATHER
          FRIDAY     HOUR 08   IN LANE NO. 8, NOT AT AN INTERSECTION    DAWN OR DUSK              DRY ROAD SURFACE
          SERIAL NO. 743010072  ON SCENE INVEST. BY SHERIFF OR DEP.     STRAIGHT ROAD ON          NO SURFACE DEFECTS
     00 FATAL,    01 INJURY   DIRECT CAUSE WAS LOOSE STOCK ON ROADWAY      HILLCREST
     1. PANEL TRUCK,              GOING STRAIGHT AHEAD, GOING WEST         IDAHO RESIDENT, AGE 71

14.93     DATE       10-28-71  1-VEHICLE OVERTURNED OFF OF ROAD         NO TRAFFIC CONTROL        CLOUDY WEATHER
          THURSDAY   HOUR 21   IN LANE NO. 8, NOT AT AN INTERSECTION    DARK                      BLACK ICE ON ROAD
          SERIAL NO. 002013800  ACCIDENT INVESTIGATION UNKNOWN          CURVED ROAD ON GRADE      NO SURFACE DEFECTS
     00 FATAL,    00 INJURY
     1. PICKUP,                   SKIDDING,           GOING WEST,          IDAHO RESIDENT, AGE 45
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Figure 13. Accident summary printout.

A.2.2.4 Accident Locating Systems

One of the primary requirements in being able to use accident data records in a beneficial manner is being able to locate the point(s) at which the accidents have occurred with reasonable accuracy. In order to provide for such a capability, all states have instituted a locating technique referred to as mileposting. Whether markers are actually placed in the field or the mileposts are imaginary and exist only on paper, this technique involves the numbering of consecutive milepoints along a roadway. The beginning point of the road is milepost 0.0 and the mileposts are numbered in ascending order, usually as the road runs from south to north or from west to east.

A reference system of all crossroads and the corresponding mileposts is thus established. In reporting an accident, the investigating officer records the distance and direction to the accident from the nearest intersection. With this information,and knowing the milepost of the referenced intersection, the accident data coder is able to calculate the milepost at which the accident occurred.

As previously inferred, some states actually have placed milepost markers along the roadway in the field. Investigating police officers can thus reference a distance to these markers rather than to a crossroad. However, it should be noted that these markers cannot always be physically placed exactly on the milepoint. Frequently, physical restrictions such as driveways, bridge structures, or severe cuts or fills may limit the placement of the markers. Therefore, because these mileposts do not necessarily coincide with the actual milepost system utilized in the accident files, an adjustment is necessary. A computer program can be used to request an accident summary at a specific location including a table of equations which equates the mileposts in the field to the actual mileposts.

Many of the states number the mileposts consecutively from beginning to end of the road. Others begin the numbering system anew at each county line. Still others break the roadway into even shorter sections.

One of the states was found to have a unique locating system. Each highway is divided into smaller sections which are referred to as control sections. These control sections begin and terminate at easily definable points such as major intersections or bridge structures or at points where the characteristics of the roadway make a definite change. Each control section has a unique number and may vary in length from one mile to fifteen miles. Thus, the state uses two different sets of mileposts. The first, which is utilized in the photolog system, is referred to as control section mileposts and begins with 0.0 at the beginning of each control section. The second, referred to as route mileposts, begins at the state line and is numbered consecutively to the end of the route. These route mileposts are utilized in the computer accident file. Therefore, after one has designated the limits of the selected site by the control section mileposts shown on the photolog, these limits must be converted to route mileposts in order to request the appropriate accident data.

The accuracy with which the states attempt to locate accidents varies. Most of the states report accidents to the nearest hundredth of a mile. However, others believe that the accuracy is not better than to the nearest tenth of a mile. It appears that locating accidents to the nearest tenth of a mile is more realistic. In reviewing the data for this study, it was not uncommon to find apparent locating errors.

The level of accuracy in reporting the distance to known reference points is also a limiting factor. One inherent problem in measuring the distance lies in the use of the automobile odometer, which may be inaccurate and which can only be read to the nearest tenth of a mile. At times, the patrolman estimates the distance rather than measuring it. A simple error in noting the direction from the reference point is significantly compounded when this information is translated to the milepost.

Some roads are not included in a milepost system. State secondary roads and off-system roads generally fall into this category. On such roads, the accident is still located at a measured distance from an intersection but no milepost can be assigned to that point. For accidents on the secondary roads in one state, which were not computerized, the appropriate accident reports were extracted from the files by designating the ends of the site at known reference points.

On off-system roads, accidents are not located to a specific point, but are only designated as having occurred within a certain section or sub-section of roadway. The beginning and ending points of the sections or sub-sections are easily identifiable physical features such as intersections or river crossings. Therefore, when selecting off-system roads as study sites:

- It was necessary to choose a site which covered the entire section or sub-section, accidents could not be located within the smaller segment.
- A map which was available in the accident analysis section had to be used to find the beginning and ending points of these sections or sub-sections. When requesting accident data for these sites, it was only necessary to specify the route number and the number of the section or sub-section.

A.3 Miscellaneous Delineation-Related Practices

In the course of visiting the states a variety of miscellaneous delineation-related information was noted. The following sections highlight the delineation application and maintenance practices observed during those visits.

A.3.1 Delineation Application Practices

Nearly all of the states have developed guidelines to be used in directing their delineation programs. Most states have adopted the policies and standards set forth in the *Manual on Uniform Traffic Control Devices (MUTCD)*. Some states have published their own manuals on delineation and other traffic control devices; these manuals, however, tend to be identical or very similar to the MUTCD. The following are observations on current practices regarding the delineation applications studied in this research project. The standard practices, as outlined in the MUTCD, are not included in these discussions on the assumption that such practices are common knowledge.

A.3.1.1 Centerlines

1. Programs for painting centerlines on two-lane rural roads on the state highway system have existed in all states for a number of years.

2. A majority of the states indicated that they paint centerlines on all state highways, regardless of the width of the road. It should be noted, however, that very few roads with widths less than 18 feet (5.48 m) exist on state highway systems. Most roads on the system are equal to or greater than 20 feet (6.08 m) wide.

3. Three participating states were found to have specified that they will not paint a centerline on a road which is less than 16 feet (4.87 m) wide. This is based on the premise that a road narrower than this width cannot easily handle two lanes of opposing traffic and that a centerline would encourage motorists to drive too close to the edge of the roadway at all times.

4. Centerline striping on county road systems is not as complete and encompassing as that on state systems and, therefore, guidelines are more critical at this level. One county has adopted a centerline striping policy which outlines the following warrants or guidelines:

   - average daily traffic of 500 vehicles or more

   - pavement width to provide at least two lanes of acceptable widths

   - route continuity, or part of the select system

- established through highways (All intersecting streets have authorized stops).
- high accident rate
- multi-lane facility
- special hazards due to alignment or fog
- once a road or street has been centerline striped, it should be continued on the striping list.

A.3.1.2 Edgelines

1. The practice of edgelining 2-lane rural highways has been generally adopted and implemented by the participating states. The practice, however, is more recent than centerlining. With the advent of the 205 Pavement Marking Demonstration Program, a majority of the participating states have been expanding their edgelining programs.

2. The majority of the states which participated in this study have established general guidelines which provide for painting edgelines on only those roads which are equal to or greater than 20 feet (6.08 m) wide. The basis for the establishment of this minimum width is the belief that edgelines defining travel lanes of less than 10 feet (3.04 m) are too restrictive to motorists.

3. Three states, however, were found to have guidelines that provide for all roads equal to or greater than 18 feet (5.48 m) to be edgelined.

4. One state had a policy to paint edgelines on all roads equal to or greater than 22 feet (6.70 m) wide.

5. It should be noted that all such guidelines are flexible and the decision to place edgelines on a certain roadway which does not meet the width standard can be made by the local traffic engineers. In all states, it was not unusual to observe roads which were edgelined, but which did not comply with the guidelines, such as narrow and winding roads.

6. One state discussed the possibility of edgelining without centerlines on 2-lane rural roads. On the cost side of

the issue, it was pointed out that edgelines typically last longer than centerlines because they are not crossed as often. Safety is also not believed to be seriously affected.

A.3.1.3 Post Delineators

1. Post delineators are used in nearly all states, but usually only at spot locations which present a specific need for unique or additional delineation. Such locations include horizontal curves and roadside hazards.

2. Of the states which participated in the study, two states have a practice of using continuous post delineators on 2-lane rural highways. One state has made it a practice to install post delineators along all state highways. This practice was implemented in 1968, prior to the adoption of an edgelining practice, and on many of their roads today both treatments exist. The other state began installing post delineators in the early sixties and many of their rural highways have continuous post delineators. In the past, the installation of the delineators was at the discretion of the District Traffic Engineer.

3. In those states where continuous post delineators are not standard, a number of reasons were cited for not implementing such a practice. The greatest concern is the high cost of maintenance. Factors most commonly noted which add to the maintenance requirements beyond normal wear-and-tear are vandalism and damage caused by snowplowing. Another point raised was that the presence of post delineators along the road interferes with mowing efforts.

4. In lieu of post delineators, one state has experimented with leaving the snowplowing guide poles in the ground throughout the year. These poles are reflective at the top, thereby providing delineation at night. However, losses due to vandalism and other causes proved to be prohibitive.

A.3.1.4 Raised Pavement Markers (RPM)

1. Raised pavement markers are only used in those states where snowplowing is not required. Several states are experimenting with snowplowable markers; these vary in

type from rubber markers to metal markers recessed into the pavement. No state has yet found a marker which is dependable enough to routinely install under snow conditions.

2. Most of the states which use RPMs, only use them on a select group of roads and not on 2-lane rural ro-ds. One state places raised pavement markers only on Interstate highways and on high volume roadways in urban areas. Another uses RPMs only on multi-lane facilities. At least one state is embarking on a large scale implementation program for RPMs while another has had such a program for many years.

A.3.2 Delineation Maintenance Practices

The following are observations on those delineation maintenance routines which are common to most of the 10 states as well as several unique practices which are of interest:

1. Most of the states paint the centerline on rural highways once a year. The edgelines, however, do not wear as quickly and are, therefore, painted on the average of once every other year.

2. Two elements which play major factors on the maintenance requirements of centerlines and edgelines are traffic volume and weather conditions. One state indicated that in general, the pavement markings on low volume rural roads require repainting only once in two years, while those on rural roads carrying high traffic volumes need to be painted once a year. In other states the climate can change maintenance routines. In parts of the state, where snowfall is relatively light, edgelines on rural highways are typically painted once every two years. In sections where heavy snowfalls are commonplace, the edgelines need to be painted every year.

3. The need for maintenance prior to any regularly scheduled painting is usually observed and noted during other maintenance or engineering activities in the field. In addition to this common procedure, in one state roads are systematically field-checked at night to determine the general condition of the centerlines and edgelines. This practice is very worthwhile, because a line may appear to be adequate during daylight hours, but may

have lost its reflective qualities which makes it ineffective at night.

4. In an effort to conserve paint and cut maintenance costs, one state has implemented rather unique maintenance standards for roadway markings. Skip lines on centerlines are repainted every year with lines 4 inches (101.60 mm) wide. Approximately the 7.5 feet (2.28 m) of a 15 foot (4.57 m) skip line are repainted every other year with the remaining 7.5 feet (2.28 m) repainted in the alternate years. Edgelines are repainted every two years. Three (76.20 mm) of the outer side of the line (the line is currently 4 inches (101.60 mm) wide) are repainted every fourth year. Three inches (76.20 mm) of the inner side are repainted in the alternate two year periods.

A.4 Conclusions and Recommendations

Based on the experience gained by visiting each of the participating states and by working with the personnel and the record systems in those states, the study team has developed the following thoughts and comments relating to the areas of operation to which it was exposed.

1. The fact that each state has its own unique accident summary data format makes it difficult to conduct traffic safety research on a national or even regional basis. As in this study, it becomes necessary for the research team to recode and re-format the data from the various states into a standard form in order to analyze the data as a common data base. This task can be very costly and time-consuming to complete.

   Not only is it awkward for researchers to use data from different states, but nonuniformity in the data base perhaps also discourages states from conducting joint in-house research. Such joint efforts could be quite effective and less costly to the states. For example, two neighboring states which are similar in many characteristics could pool their data bases in a study of common interest and applicability in order to avoid a duplication of effort and at the same time improve the overall validity of the study results.

The study team believes that it could be beneficial if all states utilized the same data format and the same coding procedures for their accident data. A research effort directed toward the development of a uniform accident data format will be desirable. There are many items to be considered in developing such a format, including the unique desires of each state and the capabilities of each state's computer facilities. But the effort could result in significant benefits to all involved in the area of traffic safety.

2. As noted previously, one of the major problems in attempting to use accident records for a micro-scale analysis is the degree of inaccuracy which is inherent in the accident locating procedures. One means of lessening such errors would be to request on the accident reporting form a distance to two reference points, one in each direction, rather than one. This would be particularly easy in those states which actually have mileposts located along the roadway in the field.

   The use of two sets of mileposts, as some states currently use, also contributes to the accident location error. A single set, perhaps the route mileposts, which run consecutively from beginning to end of the route, would be better.

3. Better maintenance records on delineation are desirable. In many states, the only form in which such records exist is handwritten notes at the district level. Consideration should be given to establishing standards or guidelines for the development of computerized records, copies of which could then be readily available to traffic and maintenance engineers alike at both the headquarters and district levels. It seems that it would be appropriate for this file to be organized by route section and it should include at least the type of delineation, its original installation date, the dates of its maintenance, and the average length of time between required maintenance over the last five years. It should be noted that the advent of the 205 Pavement Marking Demonstration Program has improved delineation records and may be the impetus necessary to encourage states to develop more complete and centralized maintenance records on delineation.

4. It is recommended that the research in this program be extended to include the initial results of the 205 Pavement Marking Demonstration Program. Most of the states participating in the funding of delineation installation through the 205 Program will have one full year of data available in the forthcoming spring, and some will have even more data by that time. The program requires that the states compile and submit complete data on accidents, vehicle-miles of travel, and appropriate accident rates for the treated roads for time periods both before and after the installation of the delineation treatments. A review of these data may reveal patterns that could be helpful in interpreting the results of this study. This review could be carried even further by classifying the sites into the analysis matrices developed herein and using the data to expand the data base in the analyses.

5. The study team is convinced of the usefulness of a photolog system to a state highway department and recommends its use by all the states. The following are samples of its uses which were actually observed by the study staff during the state visits and which illustrate its capabilities.

   - Inventories of such items as traffic signs, pavement markings, roadway surface type and many others can be conducted from the photolog.

   - When coding or reviewing a specific accident report or in analyzing a high accident location, one can readily observe visually the site to clarify certain characteristics.

   - In the planning or preliminary design of a new facility (such as a bridge or intersection) one can study the proposed location throughout the planning or design phase as unexpected issues arise.

   - Highway departments receive numerous letters from citizens who are concerned about a particular situation on a state highway. State personnel can quickly look at the film of the particular location and make an informed response to such citizens.

   - Within state highway organizations, there is a great deal of interaction between personnel in the districts and at the central headquarters. If a photolog is available at both levels, the two parties can review the film and their discussions on a particular topic can be much more effective.

The most advantageous characteristic of the photolog is that all of these uses can be conducted without leaving the office and, therefore, considerable savings in personnel time and travel costs can be accrued. In the long run, if the photolog is utilized to its fullest capabilities, such savings can offset the cost of implementing and maintaining the photolog.

6. It is suggested that the coordination between the states in their research studies be encouraged. Research is often applicable to several or all states and an effort should be made to disseminate such research results to all appropriate states and other agencies. The coordination would alleviate the likelihood of duplication of effort. The need for improving interstate coordination exposed itself to the study team in several instances where two states were conducting similar research and in situations in which one state was developing some research hardware which had already been developed in another state.

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