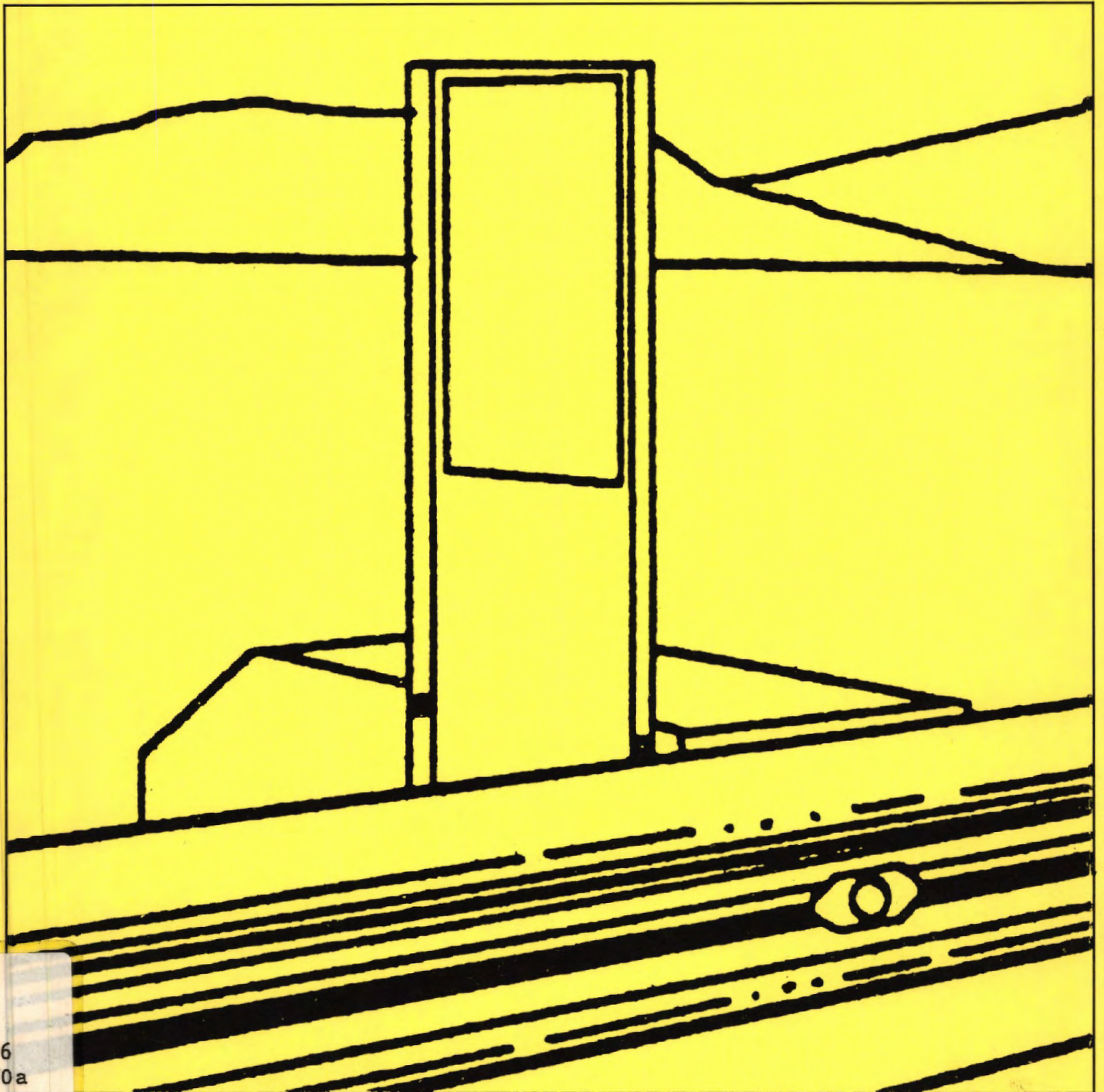




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Transportation

# Guiderail Delineation

February 1990



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# Guiderail Delineation

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Final Report  
February 1990

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## SUMMARY AND CONCLUSION

Guiderail is installed on highways as a means of protecting motorists from objects or situations that are more hazardous than the guiderail itself. Placement of the guiderail along the roadside tends to make it an obstacle which can be difficult to detect at night. Improving the nighttime visibility of guiderail through delineation can increase its detectability and recognition.

The New Jersey Department of Transportation does not presently have a guiderail delineation program. Accident data from 1983 to 1984 show the proportion of total fixed object accidents involving guiderail increased at night, especially during wet nights. Over a five year period from 1980 to 1984 guiderail accident and repair costs averaged over \$4.5 million a year. As the cost of repairing damaged guiderail continues to escalate each year primarily because of increased material and labor costs, delineating guiderail may become more attractive.

More than 20 different types of delineators or delineation methods were field tested during this study. Guiderail delineators that mount in the W-beam, on the top, and above the guiderail were field tested. Over a 38 month long evaluation period, delineators mounted inside the W-beam of the guiderail accumulated more soil than delineators mounted above the guiderail.

This study found that the installation procedure for most guiderail delineators that mount inside the W-beam is labor intensive. The attachment of guiderail delineators with adhesive proved to be unreliable. Delineators mounted with adhesive also were more vulnerable to damage at locations frequented by pedestrians.

A survey conducted on driver's perceptions of guiderail delineation revealed that recognition of the guiderail system increased 16 percent after delineators were added. Eighty-eight percent of those surveyed rated delineated guiderail as being more effective than conventional guiderail in depicting roadway alignment and the roadedge.

Implementation sites that utilize the recommended Carsonite guiderail delineator system are located on two Interstate highways in southern New Jersey. The implementation sites consist of 5 locations that span more than 10 miles combined. The implementation sites have been videotaped at night and are monitored on a periodic basis to ensure proper operation.

## RECOMMENDATIONS

After evaluating more than 20 different types of guiderail delineators in the field, it has been determined that a flexible panel and metal bracket system manufactured by the Carsonite Company is the most suitable device with regard to durability, resistance to soiling and ease of installation. The flexible panel of this system utilizes a reflective face of 3M high intensity sheeting (a material approved by the New Jersey Department of Transportation, Figure 1).

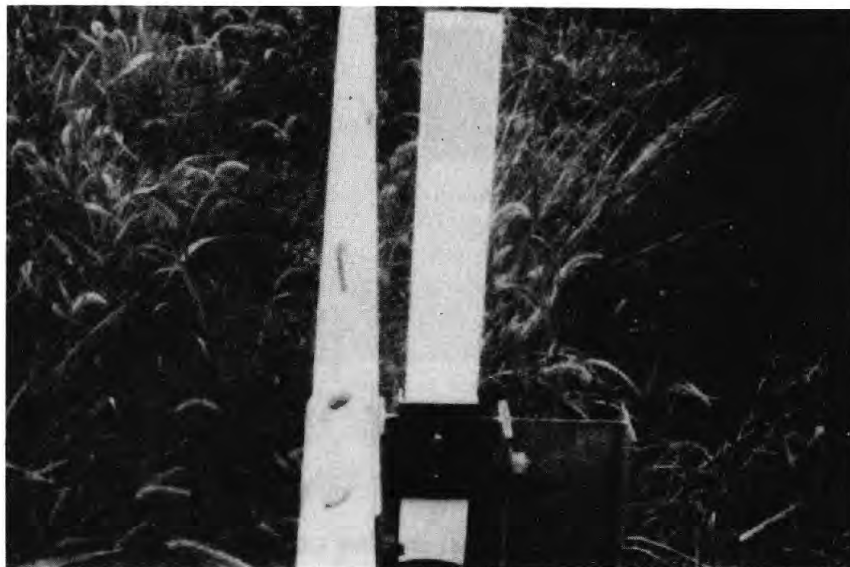
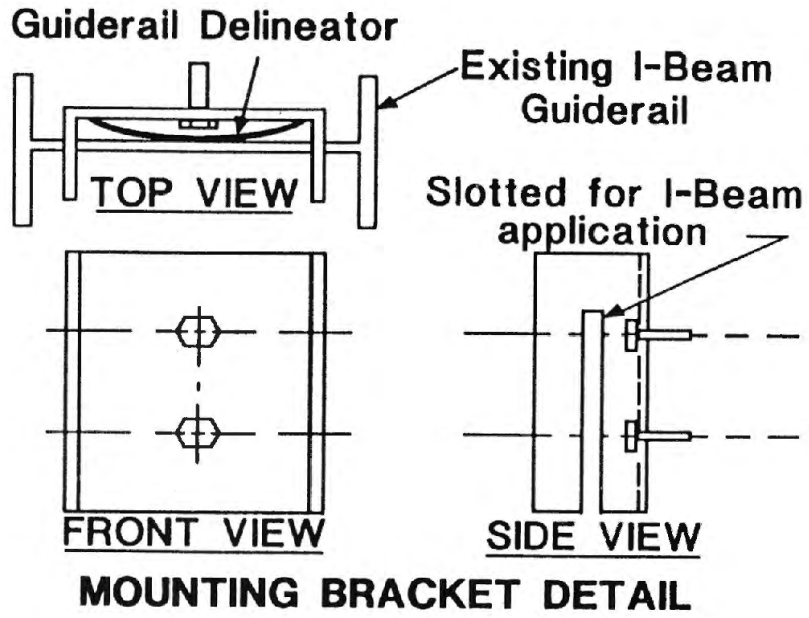
This study did not fully investigate the topic of delineator spacing. Therefore, the spacing arrangement that is suggested is one similar to the New Jersey specifications governing the spacing of snowplowable raised pavement markers which requires markers to be spaced 80 feet apart on tangent sections of road. On curves of 3 degrees or greater markers are placed at 40 feet intervals. Guiderail delineators could be installed on the terminal ends of guiderail, especially those which may lack breakaway cable terminals (BCT), in an effort to enhance its visibility.

## INTRODUCTION

### Guiderail in New Jersey

The state of New Jersey has approximately 1,039 miles (5,485,920 ft.) of guiderail on its state-maintained highway system. The predominant type of guiderail used on New Jersey's state highway system is zinc-galvanized steel W-beam of which there are approximately 934 miles. Approximately 75 miles of older cable and wood post guiderail is also present on the state highway system. The steel W-beam guiderail is used on all new state job installations and is gradually replacing the aging cable guiderail.

More than one variety of guiderail may exist at the county and municipal level. Some installations may include box-beam guiderail or an older version of



**FIGURE 1**

**CARSONITE GUIDERAIL DELINEATOR SYSTEM**

W-beam guiderail that may be flared at the top and bottom section. This should be considered during the selection of a device for delineating guiderail to insure that the device is adaptable and can be installed on more than one type of guiderail.

#### Guiderail Accident and Maintenance Costs

Prior to conducting the research study on guiderail delineation, a "Guiderail Visibility Needs Analysis" report was drafted (Smith and Desfosse, 1984). The "Guiderail Visibility Needs Analysis" report attempts to determine the benefits and advantages guiderail delineation could bring to the motoring public. An analysis performed from data on guiderail accidents did not produce any conclusive information about the underlying causes of nighttime accidents involving guiderail. It is difficult to determine and discriminate between actual guiderail accidents and other types of accidents, such as run-off-the-road accidents, because of the methods that are used to report and record accidents.

In "A Users Guide to Positive Guidance," the FHWA classifies guiderail as a typical fixed object hazard (Lunenfeld and Powers, 1985). Reflectors or delineators can make the guiderail more conspicuous during nighttime hours. Enhancing the nighttime visibility of the guiderail should increase the detectability and recognition of the guiderail.

#### Contemporary Guiderail Delineation

There are many "new" devices and methods that can be used to delineate guiderail under low light conditions. Guiderail delineators are intended to increase nighttime visibility of the guiderail.

Modern guiderail delineators may utilize various types of reflective sheeting (e.g., encapsulated bead sheeting, cube corner sheeting, etc.) or acrylic prismatic reflectors as their primary reflective component.

A variety of guiderail delineators are mounted to the post bolt of the guiderail. There are also a number of guiderail delineators that are affixed to



the guiderail by means of an adhesive. Delineator posts that are independent of the guiderail were also evaluated to determine if they could serve as a suitable type of guiderail delineator.

### STUDY PROCEDURES

A total of five guiderail delineation test sites were selected throughout the state of New Jersey to evaluate and monitor more than 20 different guiderail delineators.

One site was selected at a location in northeastern New Jersey on U.S. 1&9 Truck. Environmental conditions are relatively severe in this area. Soil, dirt and oil film seem to accumulate at an accelerated rate. These conditions can provide insight about the effects that dirt and soil have on guiderail delineation.

Three guiderail delineation test sites were chosen in central New Jersey at U.S 206, NJ 31 and NJ 29. The configuration of the U.S 206 test site is a sharp "S" curve. Three accidents involving guiderail were recorded at this site within a six month period.

A final guiderail delineation test site was selected in southeastern New Jersey near the coast on NJ 37. One of the reasons this site was selected was to ascertain the effects a saltwater environment may have on a delineator. Additionally, since pedestrian traffic is fairly common at this site, and at the NJ 29 test site, problems relating to vandalism were investigated at both locations to determine if any of the delineators evaluated were susceptible.

Twelve different types of delineators or delineation treatments were originally installed at all five test sites in December of 1983. Most of the 12 original delineators consisted of devices that mounted in the W-beam of the guiderail. As second and third generation guiderail delineators became available they were installed at the test sites along with the original remaining devices.

The second generation devices consisted mainly of delineators that were adapted from the original delineators, which were mounted inside the W-beam of the guiderail. Many of the second generation devices differed from the original delineators in that they were designed to be installed above the inside location of the W-beam, on the top bend of the beam element.

As the devices used for delineating the guiderail became more refined, a third generation of devices emerged. This group was made up primarily of delineators which mounted atop the guiderail support post.

The second generation devices were installed in June of 1984 and the third generation devices were installed in February of 1985. A majority of the second and third generation devices were installed on the top portion of the guiderail or on the top of the guiderail post itself.

All five guiderail delineation test sites were monitored on a monthly basis. The test sites located at NJ 29 and NJ 37 were monitored on a biweekly basis during the summer months when pedestrian activity was greatly increased.

Five different levels of dirt covering defined the surface condition of each individual device. The table below lists the surface description nomenclature used when the devices were monitored. (Refer to Appendix B for more detail)

TABLE 1

<u>Surface Description</u>	<u>Percent of Reflective Surface Area Concealed by Dirt or Soil</u>
Clean	0 - 19%
Light	20 - 39%
Moderate	40 - 59%
Heavy	60 - 79%
Covered	80 - 100%

In addition to rating the surface condition of each device or delineator, the physical characteristics (i.e., damage, cracking, chipping, etc.) of each device

were also recorded as the test sites were monitored. All of the guiderail delineation test sites were examined and evaluated through February, 1986. The first generation of devices were field monitored for 38 months. Second generation devices were field monitored for 31 months and third generation devices were monitored for 12 months.

### RESULTS OF THE FIELD DURABILITY STUDY

During the evaluation and durability phase of the project, 22 different guiderail delineators were monitored at five sites. The 12 delineators were placed in at least five groups at each site. The delineators were arranged in succession in the first group. This arrangement was then repeated in the following groups.

#### Guiderail Delineation Inside the W-beam of the Guiderail

The majority of delineators that were initially installed at all of the test sites were mounted in the W-beam of the guiderail. Usually delineators that mount in this location are attached to the guiderail by a post bolt, while a few are held in place with adhesives.

Two models of a plastic trapezoidal shaped guiderail delineator that mounts in the W-beam of the guiderail with adhesive were also field tested. The plastic outer construction of this device experienced cracking and severe breakage at the field evaluation sites (Figure 2).

A treatment of white paint and glass beads in the middle of the W-beam of the guiderail was also field tested at each test site. This treatment of paint and glass beads suffered installation problems of an uneven distribution of bead coverage, which plagued this treatment as the study continued.

Information from field evaluations and inspections indicates that guiderail delineators mounted in the W-beam accumulate approximately 24% more dirt

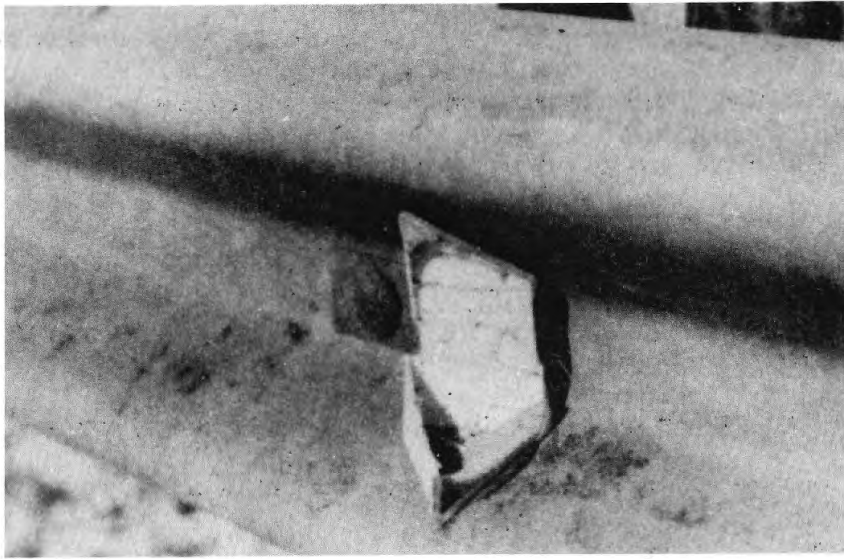


FIGURE 2

CRACKED AND BROKEN STIMSONITE  
GUIDERAIL DELINEATOR

film than guiderail delineators that mount on top of the guiderail post. The results of this comparison were shown to be significant at a P-value of less than .01 when a t-test was performed. Figure 3 demonstrates that delineators mounted both inside and above the W-beam of the guiderail accumulated soil at the same rate for a period of six months. Delineators inside the W-beam remained at or above this level for the next 12 months, while the soil accumulation level for delineators mounted above the guiderail decreased. Delineators mounted inside the W-beam of the guiderail become inoperable when snow is pushed against the guiderail during snowplowing operations (Figure 4). Figures 5 and 6 depict the percentages of missing and damaged delineators that are used inside the W-beam of the guiderail.

#### Guiderail Delineators Mounted on Posts Independent of the Guiderail

Two different types of guiderail delineators that attach to steel U-posts with metal rivets were evaluated in the field. One of these is a post-mounted delineator which is the standard unit used by the New Jersey Department of Transportation for roadside delineation. This delineator is fabricated from an aluminum panel with a face of reflective sheeting. No major problems relating to vandalism or dirt collection were experienced with the reflective panel portion of this device in the field.

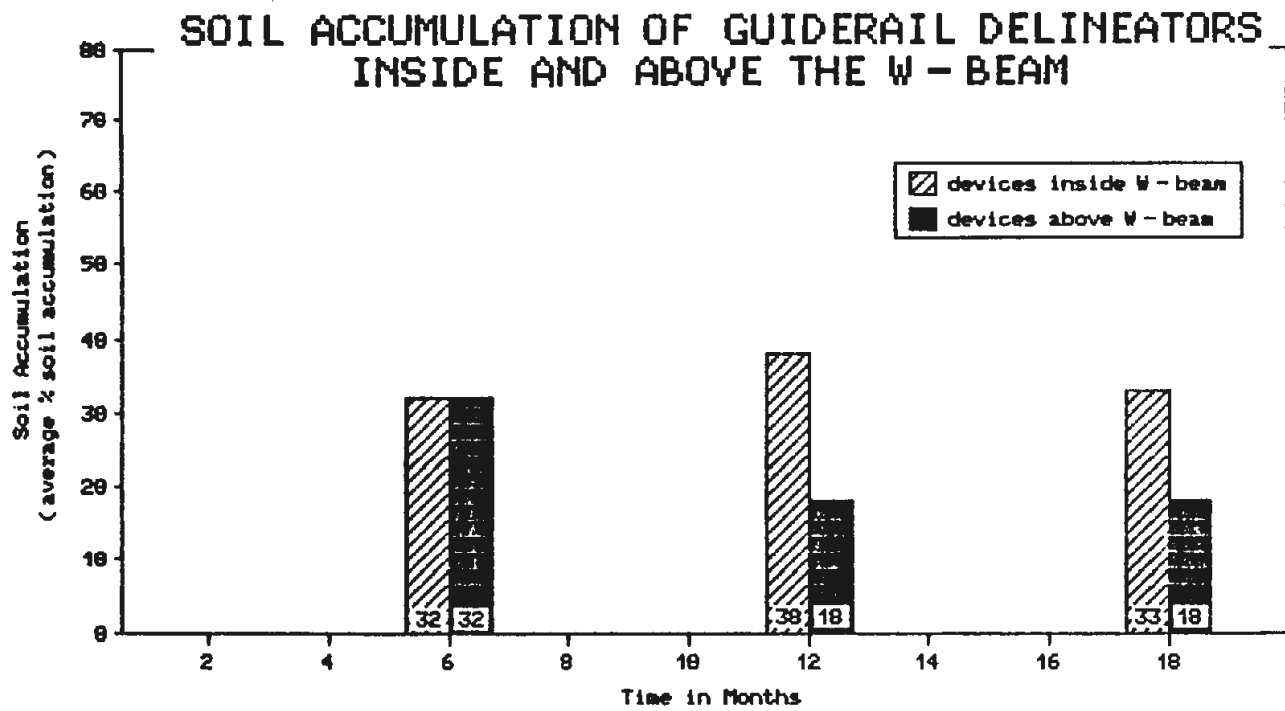
The second type of post-mounted delineator evaluated during the field study utilized an acrylic reflective face. Over an 18 month field evaluation period, 43% of the acrylic faced reflectors were damaged and 22% of the devices were missing or stripped from the steel supporting posts. However, some of the delineator posts installed experienced damage in the form of twisting and tilting of the post from their original perpendicular position.

#### Guiderail Delineation on Top or Above the W-beam of the Guiderail

A variety of guiderail delineators were field tested that attach or mount on the top portion of the W-beam or on top of the guiderail spacer-bracket. The



Figure 3



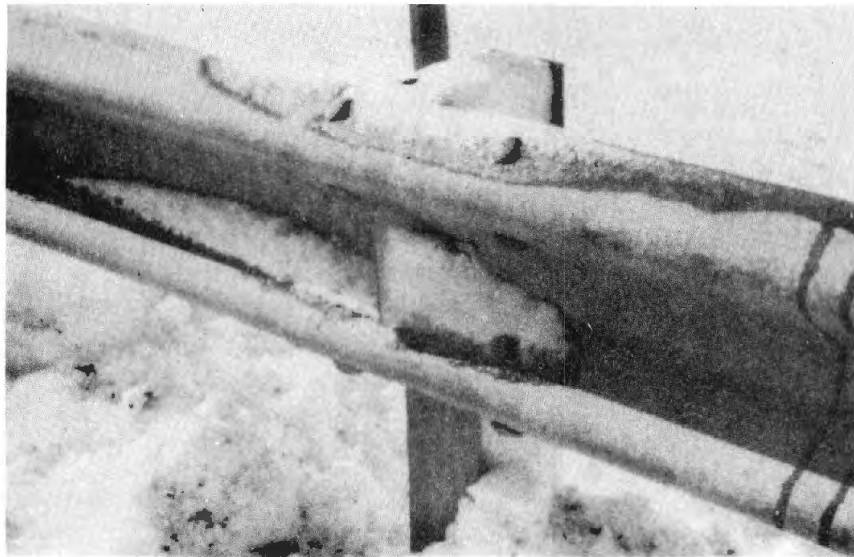


FIGURE 4  
SNOW COVERED DELINEATOR MOUNTED INSIDE  
THE W-BEAM OF THE GUIDERAIL

Figure 5

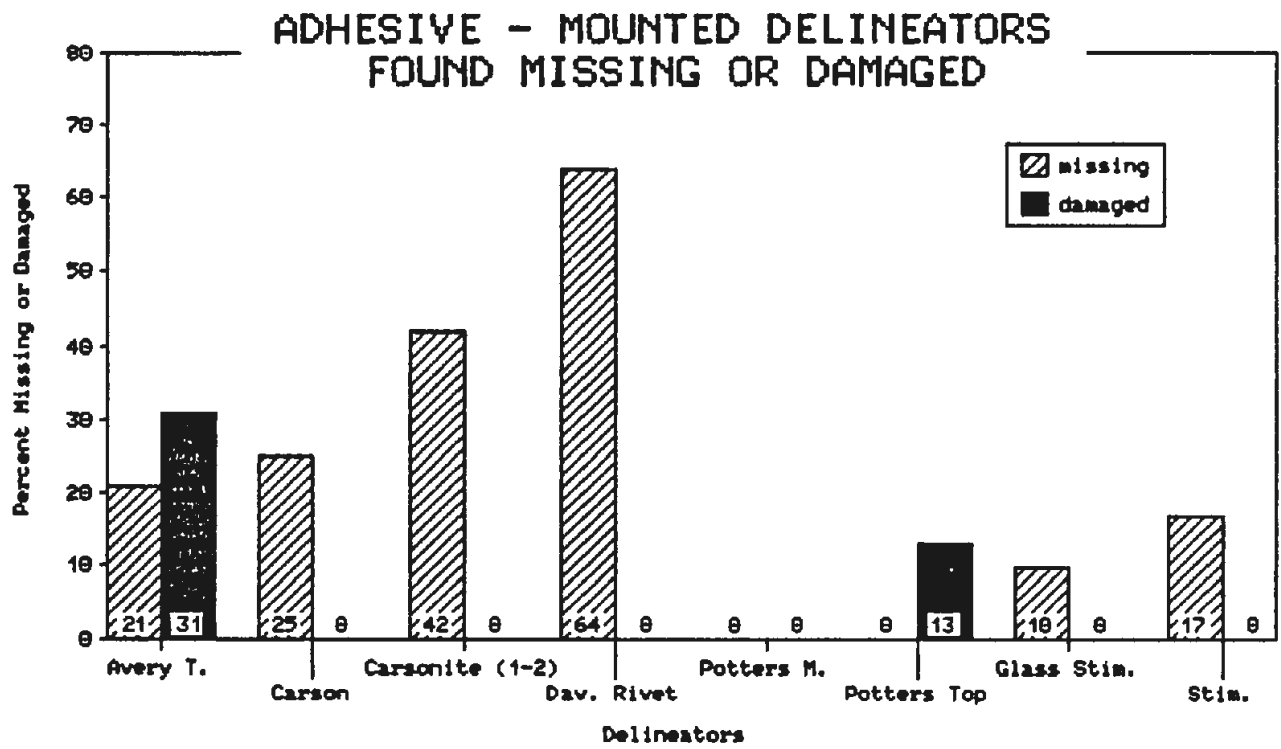


Figure 6

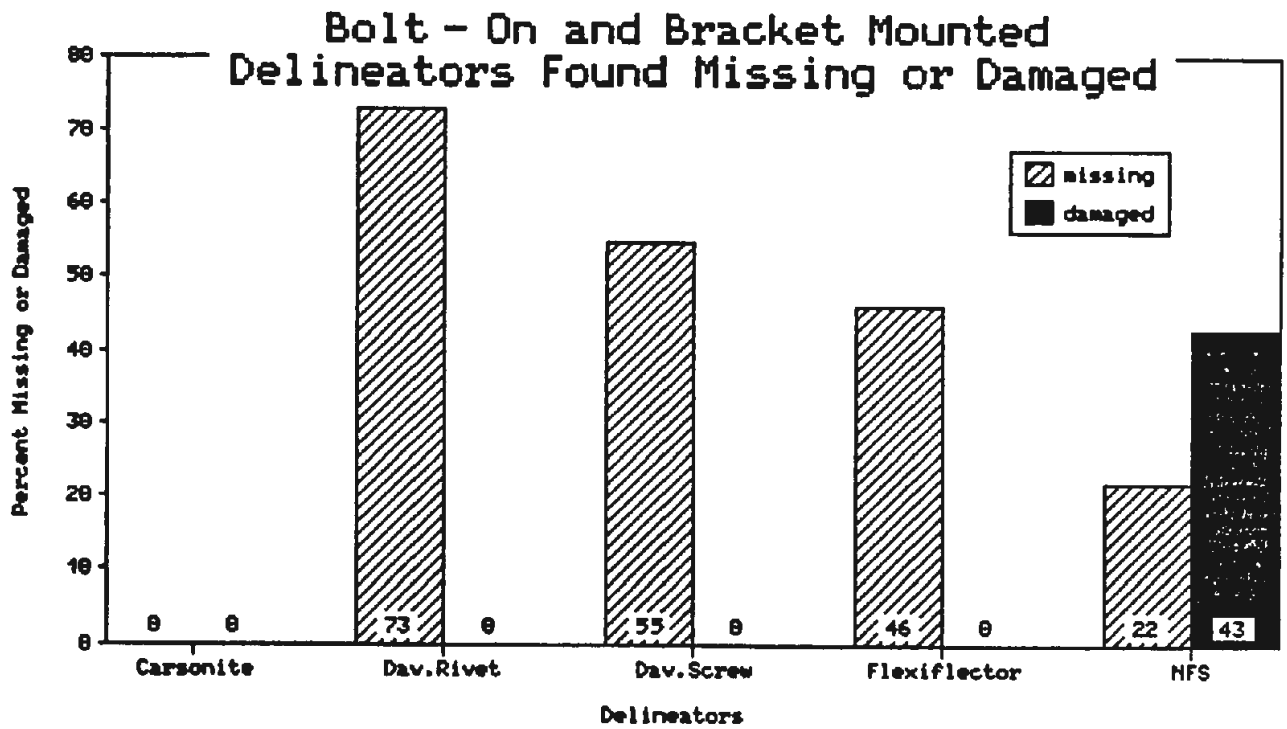
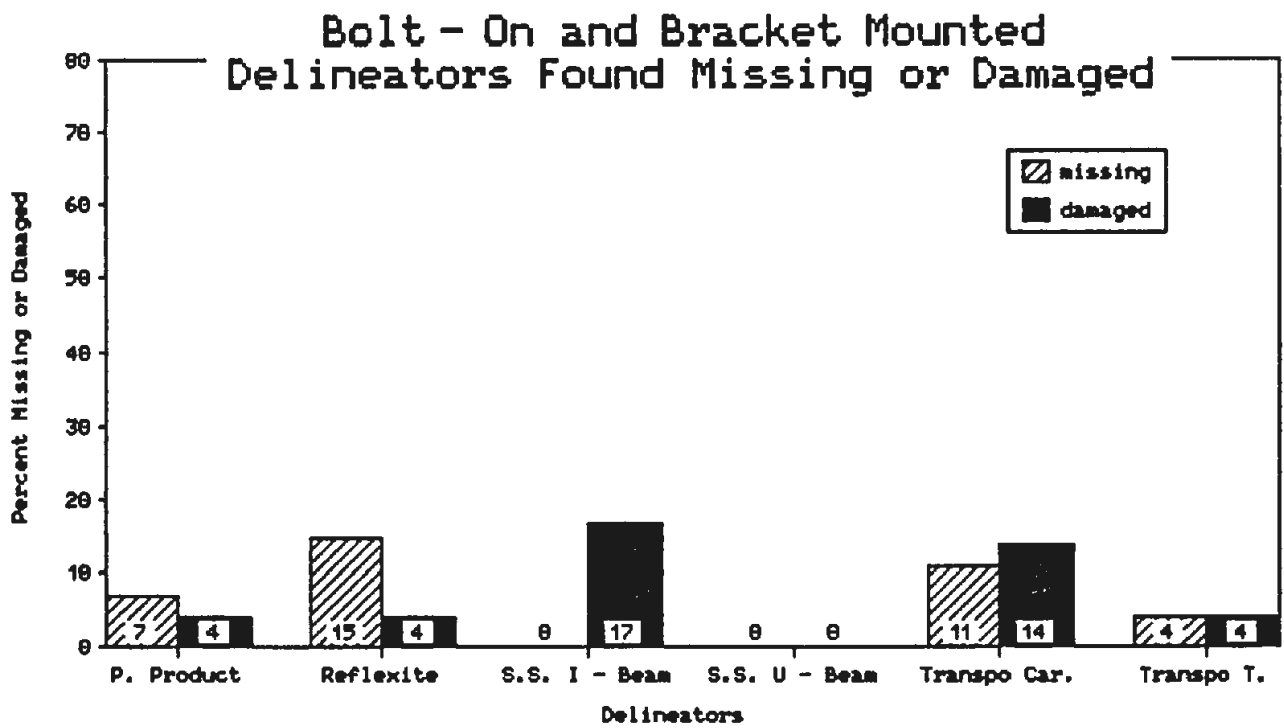


Figure 6 (con't)





delineators that mount on top or above the guiderail were attached with screws, rivets or adhesives. Attaching the delineator to the guiderail with screws or rivets necessitates drilling or punching a hole in the guiderail or post.

Field inspections of the delineators that were attached with an adhesive that was recommended by the manufacturer revealed instances of the adhesive cracking and separating from the surface of the guiderail. This is demonstrated in Figure 7. The manufacturer of the adhesive does not recommend application of the material in temperatures below 40°F.

Two types of reflective material that attach to the top bend of the guiderail were field tested. Treatments of paint and glass beads were field tested in this configuration but were troubled with installation and visibility problems. The glass beads that were applied over the painted surface were not distributed uniformly, which compromised the reflective quality of the treatment (Figure 8). Pressure sensitive reflective tape was also evaluated in the field. The reflective tape experienced cracking and tearing in the field. In some cases large portions of the tape were found missing from the original application.

#### Bracket Mount Guiderail Delineation

A two part guiderail delineator system, which mounts on top of the guiderail post or spacer bracket, was evaluated at each test site. This two part delineation system consists of a flexible panel and metal bracket that is secured to the guiderail support post by a self-contained bolt(s). The panel slides between the guiderail post and the metal bracket, and can be adjusted so the panel head is at a consistent height regardless of the height of the guiderail. A small open end or allen wrench is required for installation.

During an 18 month field evaluation period, none of the bracket-mounted devices were missing or damaged at any of the five test sites. No bracket mounted delineators showed any signs of vandalism after this test period.

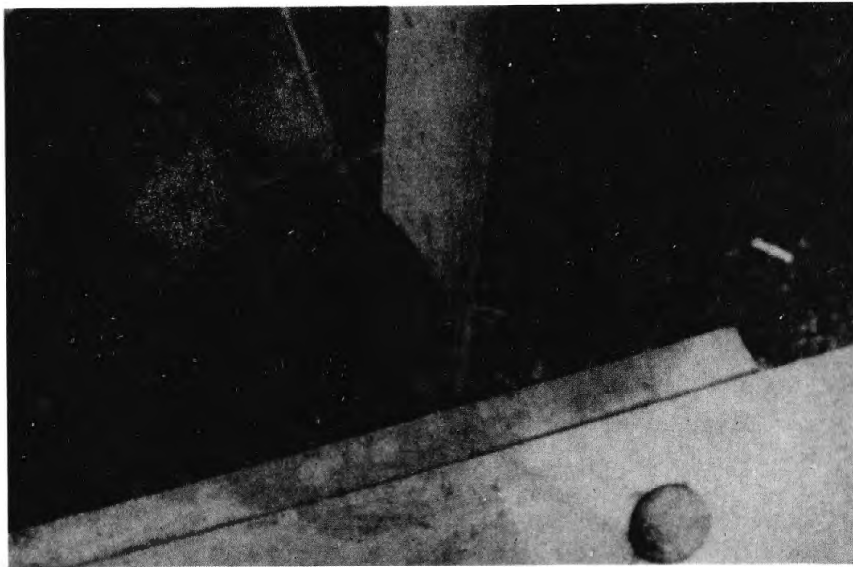


FIGURE 7  
ADHESIVE FAILURE OF A CARSON DELINEATOR PANEL

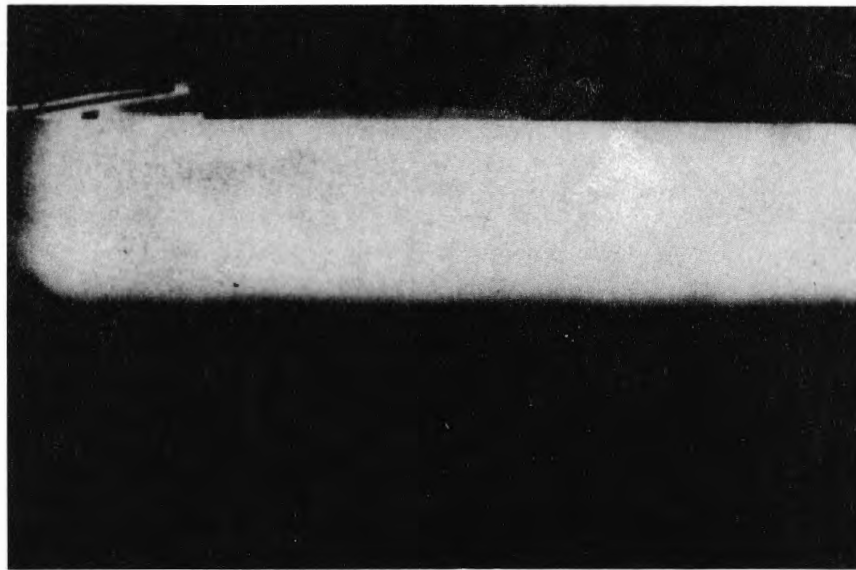


FIGURE 8

POTTERS PAINT TREATMENT SUFFERING FROM AN  
UNEVEN DISTRIBUTION OF GLASS BEADS OVER THE  
PAINTED SURFACE

Like other delineators that mount above the W-beam of the guiderail, this device accumulated less soil over the evaluation period than delineators mounted inside and on the W-beam element.

## DISCUSSION

### Guiderail Delineation Inside the W-beam of the Guiderail

When this study began most of the delineators that were manufactured for delineating guiderail were designed to be mounted inside the W-beam of the guiderail. Most delineators that mount inside the W-beam usually attach to the post bolt of the guiderail and can be difficult to install. When the post bolt of the guiderail is loosened to accept the delineator, the entire bolt assembly may turn together as one making the installation process very difficult. At older sections of guiderail, which may not be zinc-galvanized treated, some of the post bolts may be fused to the locking nuts. This was the case at one of the evaluation sites where the post bolts had to be removed by cutting them with a torch.

Another type of delineator evaluated that mounts inside the W-beam attaches to the guiderail with adhesive. Installation of this delineator is more involved than some of the others because the surface of the mounting area must be prepared and the outdoor temperature must be above 40°F to permit the adhesive to be dispensed from the tube easily. Surface preparation of the guiderail was also necessary for the application of a treatment of paint and glass beads inside the W-beam, element of the guiderail. This installation process, including surface preparation, is time consuming and translates into higher installation costs because of the increased labor involved. The paint treatment has the distinct disadvantage of having low visibility on tangent sections of guiderail that are aligned parallel to the roadway.

Data collected from delineators mounted inside the W-beam of the guiderail indicated that once a delineator became heavily soiled it tended to stay that way. Delineators mounted inside the W-beam are shielded by the upper top bend of the guiderail which prevents the delineator from being cleansed by rain.

#### Guiderail Delineators Mounted on Posts Independent of the Guiderail

Post-mounted delineators were evaluated as part of this study. The post delineators were installed behind the guiderail at specific locations near the guiderail support post.

Installing the steel u-posts is a relatively strenuous task that requires the use of a large and heavy sledgehammer or slidehammer. In colder weather the ground may harden and make installation of the metal post even more difficult.

When post delineators are installed the placement and angle of each post should be positioned for traffic. A delineator post that is installed at an incorrect angle to a vehicle's headlights will not function properly and may be of little value to the motorist.

One problem associated with the delineator posts is their vulnerability to lawn mowing and maintenance equipment. The cost of the galvanized steel u-post, the reflector, periodic maintenance, and the labor involved in installation make post-mounted delineators unattractive for use as guiderail delineators.

#### Guiderail Delineation on Top or Above the W-beam of the Guiderail

The guiderail delineators that mount on top or above the guiderail were attached with screws, rivets, or adhesives. Attaching the devices with screws or rivets requires either drilling or punching holes in the guiderail. Drilling holes in the guiderail requires an electrical power source and equipment, which can increase the cost of installation.

Delineators that were installed atop the guiderail with adhesive sometimes faced early failure, which made these delineators susceptible to vandalism in

areas that were frequented by pedestrians. Because guiderail delineators are a relatively new and uncommon form of delineation, some pedestrians may be intrigued with the devices enough to remove them from the guiderail when they become loosened from an adhesive failure.

A major disadvantage of attaching the delineators with adhesive is that the manufacturer of the adhesive recommends usage only when the outdoor temperature is above 40°F. This restriction could delay installation of delineators for months at a time in certain geographic areas.

#### Bracket Mount Guiderail Delineation

A bracket mount guiderail delineation system was developed during the field evaluation phase of this project by a participating manufacturer. This delineator system uses a flexible reflective panel insert and a metal bracket for attachment to the guiderail post. The delineator is versatile and can be used on box-beam and different types of W-beam guiderail that are supported by I-beam posts. The flexible panel of the delineator system can also be nailed to wood guiderail posts. This delineator system performed well in the field and did not experience any instances of removal or damage over an 18 month evaluation period.

There are advantages to attaching the delineators directly to the guiderail. Attaching the delineators to a uniform guiderail structure assures for a consistent installation. In cases where the guiderail is located parallel to the roadway geometry, the bracket mounted delineator's reflective face will usually appear perpendicular to the roadway. This can contribute to the installation achieving a consistent angle of incidence throughout the length of the guiderail. The mounting height of this delineator system conforms to the MUTCD standards that require roadside delineators to be four feet above the near roadway edge.

The flexible quality of this delineator is an asset, especially during the winter months. As snow is plowed and forced against and above the height of the

guiderail, the panel is able to rebound and remain visible. Certain rigid post-mounted delineators evaluated at the field test sites had a tendency to be displaced from their original vertical position. This problem would require periodic maintenance to provide optimum performance.

#### SUMMARY OF PANEL RATING SURVEY

The impressions and opinions motorists have about guiderail delineation were surveyed at six different test sites in the local Trenton area. The motorists used in the survey were all employees of the Department and members of the same divisional unit.

When comparing field test sites, both with and without delineation treatments, 11 of 18 survey responses indicated that guiderail delineation provided a benefit in the form of increased driver comfort. A total of 50 responses were collected over six test sites, with 45 responding that delineated guiderail was more effective in depicting roadway alignment and the road edge than non-delineated guiderail. Four of the 50 responses indicated that the non-delineated and delineated guiderail were equally effective. A single participant responded that the non-delineated guiderail was more effective than the delineated guiderail in depicting roadway alignment and the road edge.

Guiderail delineation was shown to be useful in determining the available space off of the roadway. In Table 2 the percentage of participants that responded to whether the guiderail made it easier to determine the usable space off the roadway is listed. The table lists the percent response both before and after delineators were added to the guiderail. Recognition of the usable space off the roadway increased at all six field test sites after delineators were introduced to the guiderail.

TABLE 2  
RECOGNITION OF SPACE BEYOND ROADWAY BEFORE AND  
AFTER DELINEATION OF THE GUIDERAIL

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Before delineation	0%	67%	18%	67%	10%	50%
After delineation	27%	80%	55%	83%	30%	67%

When compared to non-delineated guiderail, delineated guiderail was rated more effective in depicting roadway alignment and the road edge at all six test sites. Delineation of the guiderail was chosen as being helpful at 4 of the 6 test sites by the participants of the survey.

In summary, the results from the survey suggest that guiderail delineation can increase driver comfort.

Detailed results of the motorist survey are in Appendix A.



APPENDIX A

### Results of Panel Rating Survey

A total of six sites were selected to survey drivers' opinions and attitudes towards delineated and non-delineated guiderail. All of these sites were located in the immediate area for added convenience. The five sites previously mentioned in this report, were used to evaluate the durability of delineators, and were not used for this survey because delineators and markings were permanently affixed to the guiderail at each location. The individuals that participated in this survey were employees of the New Jersey Department of Transportation. Five of the sites were located on state highways with one other site located on an interstate highway ramp. Five of the sites were selected because their geometrical characteristics were similar to those of several locations that experienced at least three nighttime fixed-object accidents within one year. The six sites consisted of one straight section of roadway and five curves, which ranged from 1 to 20 degrees. The length of the guiderail at the sites ranges from 143 feet to 739 feet. Two of the sites have overhead lighting present.

The delineator used at all of the temporary survey sites is a vinyl extrusion that has a "channeled" base. The delineator utilizes a 2 x 3.5 inch section of adhesive-backed reflective sheeting on each side. This type of delineator was used at each test site because they could be temporarily placed on top of the guiderail spacer bracket for the survey. After the survey was completed at one site, the delineators were retrieved and used again at the next scheduled site.

A total of 12 persons participated in the survey. Each person was prepared individually for their nighttime trips through the test sites. Participants were informed about the location, position and length of the guiderail at each site. Each driver-participant made two trips through each site. One trip was made

through each site without delineators on the guiderail and another trip was made through each site with delineators on the guiderail.

The spacing of the delineators was varied from site to site. Delineators were observed at the following spacings and curves:

<u>Site 1</u>	1 <sup>o</sup> curve - 12.5' delineator spacing
<u>Site 2</u>	10 <sup>o</sup> curve - 25' delineator spacing
<u>Site 3</u>	13 <sup>o</sup> curve - 18.75' delineator spacing
<u>Site 4</u>	8 <sup>o</sup> curve - 12.5' delineator spacing
<u>Site 5</u>	20 <sup>o</sup> curve - 37.5' delineator spacing
<u>Site 6</u>	0 <sup>o</sup> curve - 25' delineator spacing

All of the distances used for spacing were based on a factor of 6.25 feet, which is the standard interval between most guiderail posts. Delineators were installed closer together than necessary at certain sites that had relatively flat curvatures as a means of demonstrating an inordinate amount of delineation. In some cases the delineators were spaced in relation to the degree of curvature at a given site. As the degree of curvature increased, the spacing between delineators decreased and vice versa.

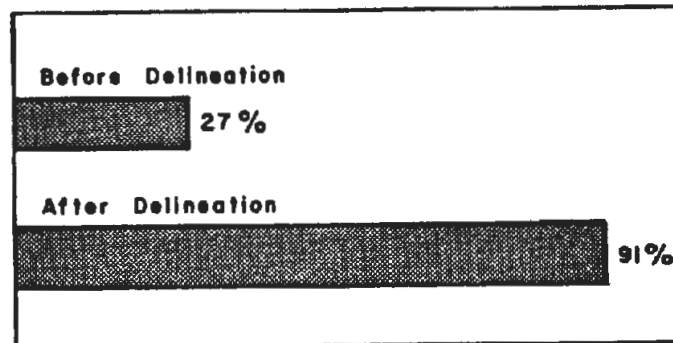
#### Site One

One of the sites selected for the survey included a 158 feet section of guiderail that was obscured by tall grass, which made the guiderail virtually undetectable at night from a moving vehicle. The degree of curvature at this site is one. Thirteen delineators were spaced at 12.5 feet intervals on the guiderail, with one additional delineator placed at each terminal end.

When people were asked to judge the spacing between delineators at this site, 82% responded that the spacing was adequate. Eighty-two percent of the respondents also stated that the delineated guiderail was more effective than the non-delineated guiderail in depicting roadway alignment and the road edge.

Before delineators were installed on the guiderail, 27% of the respondents could distinguish a part of the guiderail. After delineators were installed, 91% of the respondents could recognize a part of the guiderail. Almost 3/4 or 73% of the respondents could recognize a part of the guiderail. Almost 3/4 or 73% of the participants responded that the delineators suggested the presence of guiderail. It should be noted that briefing the participants of the survey beforehand could have influenced the aforementioned results. None of the respondents found the delineators to be a distraction that could effect their driving performance at the site. The results shown below in Table 3 suggest that guiderail delineation could be used to increase the visibility of guiderail in areas where brush and vegetative growth are difficult to control.

**TABLE 3**  
Guiderail Recognition in an Area of  
Dense Vegetative Growth



Site Two

A second survey site was selected at at 10<sup>0</sup> right curve on a two lane road with opposing traffic. The guiderail measures 739 feet in length and is situated to the right side of each lane of traffic. The guiderail is installed continuously across a bridge that is 116 feet in length. Overhead lighting is present

throughout the site. A total of 30 delineators were spaced 25 feet apart on the guiderail in the eastbound direction, which was the direction of travel for the survey. One additional delineator was placed at each terminal end of the guiderail.

Eighty-three percent of the people participating in the survey responded that the spacing between delineators was adequate. Participants responded that there were no major differences in visibility between the delineated and non-delineated guiderail. However, 83% of the driver-respondents held the opinion that delineation was helpful at this site.

#### Site Three

The third survey site chosen involved a guiderail that is 218 feet in length. The guiderail is located on the left side of a left  $13^{\circ}$  curve on a ramp leading from an interstate highway. Delineators were spaced at 18.75 feet intervals with one delineator placed at each terminal end of the guiderail (i.e., the sum of three guiderail posts spaced 6.25 feet apart).

Seventy-three percent of the respondents claimed they could see a part of the guiderail both before and after it was delineated. Prior to delineating the guiderail, 18% of the participants said the guiderail made it easier for them to determine the space off the roadway. After delineating the guiderail, this figure increased to 55% of the respondents. Greater awareness of space available on the roadway could be beneficial when space is needed for a motorist to recover from or avoid an accident or to halt a vehicle. Seventy-three percent of the people responding rated the delineated guiderail as being much more effective than the non-delineated guiderail in depicting roadway alignment and the road edge.

#### Site Four

A fourth survey site was selected on a two lane road that has an  $8^{\circ}$  left curve. Guiderail is located on both sides of the roadway with the longest section

of guiderail measuring 605 feet in length. Several overhead light standards supply light throughout the site. Seventy delineators were spaced at 12.5 feet intervals on both sections of guiderail. The photographs in Figures 9a and 9b illustrate the guiderail at this site before and after delineation.

Eighty-three percent of the people involved in the survey considered the delineated guiderail to be much more effective than the non-delineated guiderail in depicting roadway alignment and the the road edge. At this site, 83% of the individuals responded that the delineators did suggest the presence of a guiderail. This implies that guiderail delineation could be helpful in improving guiderail recognition, even at locations where overhead lighting is present.

#### Site Five

The fifth site chosen as a survey site was a left 20<sup>o</sup> curve on an exit ramp of a state highway. The guiderail is located ahead and to the right side of the driver. The guiderail measures 400 feet in length along the curve and 456 feet in length at the straight section ahead of the driver. Twenty-six delineators were spaced 37.5 feet apart on both sections of guiderail.

When delineators were introduced to the guiderail, 90% of the respondents stated that they could distinguish a part of the guiderail. Prior to delineation, 67% of the respondents could distinguish a part of the guiderail. Seventy-three percent of the participants responded that the delineators suggested the presence of a guiderail. At this particular site, 73% of the respondents believed that delineation was helpful in performing the driving task.

#### Site Six

The sixth and final site surveyed was selected at a four lane divided road. At this site, the guiderail is positioned parallel to the roadway. This particular site was selected to survey driver opinion to guiderail delineation at a location where there is not a great need for delineation. The guiderail measures only 143

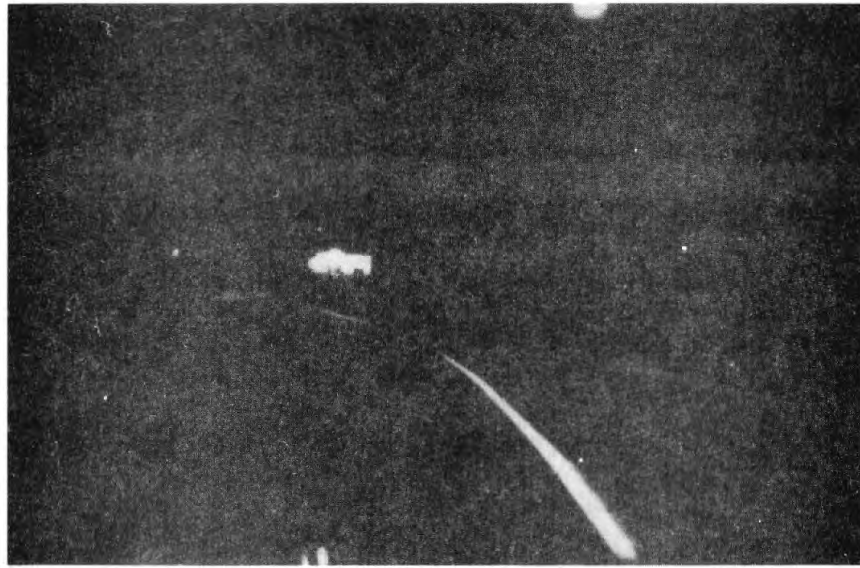


FIGURE 9a

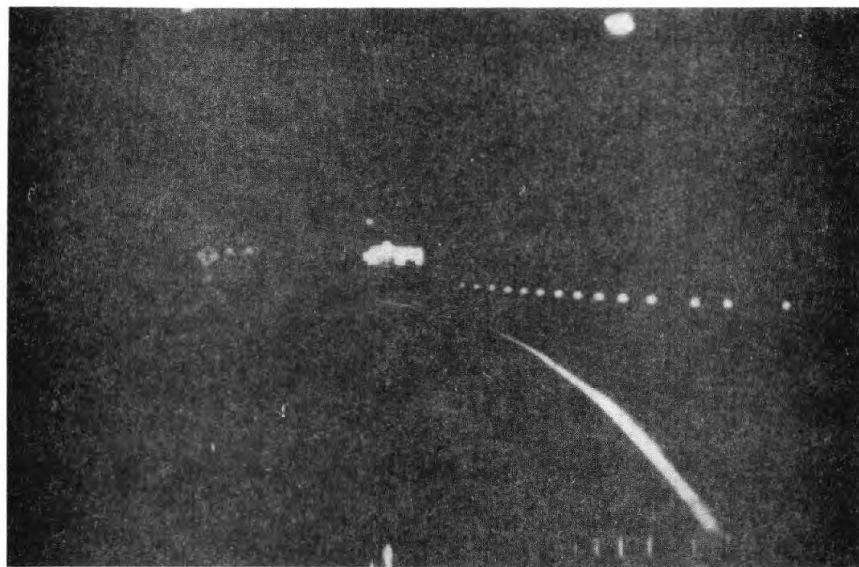


FIGURE 9b

GUIDERAIL BEFORE AND AFTER DELINEATION

feet in length and is located more than 22 feet from the road edge. The delineators were spaced at 25 feet intervals on the guiderail and at each terminal end of the guiderail.

Without any delineators on the guiderail, 100% of the participants in the survey could recognize some part of the guiderail at this site. Sixty-seven percent of the respondents considered the delineators to be an unnecessary addition to the guiderail.

Half on the people (50%) polled claimed the non-delineated guiderail made it easier for them to determine the shoulder space off the roadway. No other site surveyed received a unanimous positive response for recognition of the guiderail without delineation. The data received from this site suggests that guiderail installed more than 20 feet from the road edge not be delineated.

A complete listing of the survey results appears in tables 4, 5, and 6, on the following pages.



TABLE 4  
COMPLETE PANEL RATING SURVEY RESULTS

PARTICIPANTS FAMILIARITY WITH SITES

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Not Familiar	36%	50%	9%	67%	10%	33%
Fairly Familiar	36%	50%	36%	33%	10%	33%
Very Familiar	28%	0%	55%	0%	80%	33%

DISTINGUISHING A BEGINING OR END OF GUIDERAIL

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Without Delineation	27%	83%	73%	67%	67%	100%
With Delineation	91%	67%	73%	67%	90%	80%

THE ROLE OF GUIDERAIL IN MANEUVERING THE VEHICLE THROUGH EACH SITE

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Non-Delineated Guiderail Was No Help	91%	0%	64%	0%	50%	33%
Non-Delineated Guiderail Was a Help	9%	100%	36%	100%	50%	67%
Delineated Guiderail Was no Help	36%	0%	18%	0%	40%	50%
Delineated Guiderail Was A Help	64%	100%	82%	100%	60%	50%

TABLE 5  
COMPLETE PANEL RATING SURVEY RESULTS

DELINEATORS SUGGEST THE PRESENCE OF GUIDERAIL

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Yes	73%	50%	73%	83%	73%	83%
No	9%	17%	9%	17%	9%	17%
Not Sure	18%	33%	18%	0%	18%	0%

DELINEATORS AS A DISTRACTION THAT COULD EFFECT  
A DRIVER'S PERFORMANCE

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Yes	0%	0%	9%	0%	9%	0%
No	100%	83%	73%	100%	91%	100%
Not Sure	0%	17%	18%	0%	0%	0%

ASSISTANCE OF DELINEATION AT EACH SITE

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Helpful	36%	83%	82%	100%	73%	67%
Not Necessary	64%	17%	9%	0%	27%	33%
A Hindrance	0%	0%	9%	0%	0%	0%

**TABLE 6**  
**COMPLETE PANEL RATING SURVEY RESULTS**

**GUIDERAIL MAKING IT EASIER TO DETERMINE  
THE SPACE OFF OF THE ROADWAY**

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Without Delineation	0%	67%	18%	67%	10%	50%
With Delineation	27%	80%	55%	83%	30%	67%

**DELINEATOR SPACING USED AT EACH SITE**

	<u>Site 1</u> (12.5 ft.)	<u>Site 2</u> (25 ft.)	<u>Site 3</u> (18.75 ft.)	<u>Site 4</u> (12.5 ft.)	<u>Site 5</u> (37.5 ft.)	<u>Site 6</u> (25 ft.)
Spacing Adequate	82%	83%	100%	83%	82%	100%
Spacing Too Close	9%	0%	0%	17%	9%	0%
Spacing Too Far	9%	17%	0%	0%	9%	0%

**EFFECTIVENESS OF GUIDERAIL IN DEPICTING ROADWAY ALIGNMENT  
AND THE ROAD EDGE**

	<u>Site 1</u>	<u>Site 2</u>	<u>Site 3</u>	<u>Site 4</u>	<u>Site 5</u>	<u>Site 6</u>
Delineated Guiderail Was Less Effective	0%	0%	9%	0%	0%	0%
Both Types of Guiderail Were Equally Effective	18%	0%	9%	0%	10%	17%
Delineated Guiderail was Slightly More Effective	45%	83%	9%	17%	45%	50%
Delineated Guiderail was Much More Effective	37%	17%	73%	83%	45%	33%

APPENDIX B

A photographic representation of the five surface description types used to rate delineators at the field test sites is listed below in Figures 10 through 15.

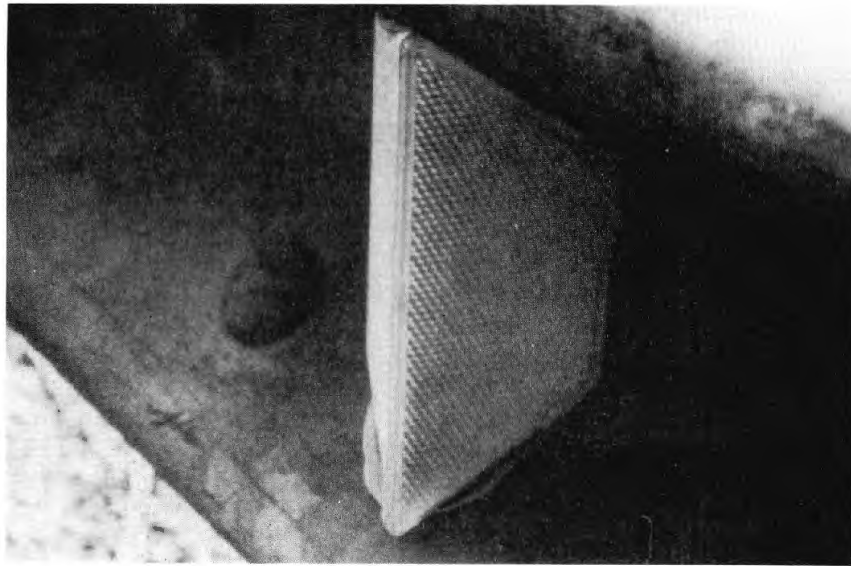


FIGURE 10

SURFACE DESCRIPTION RATING "CLEAN"  
0-19% CONCEALED WITH SOIL

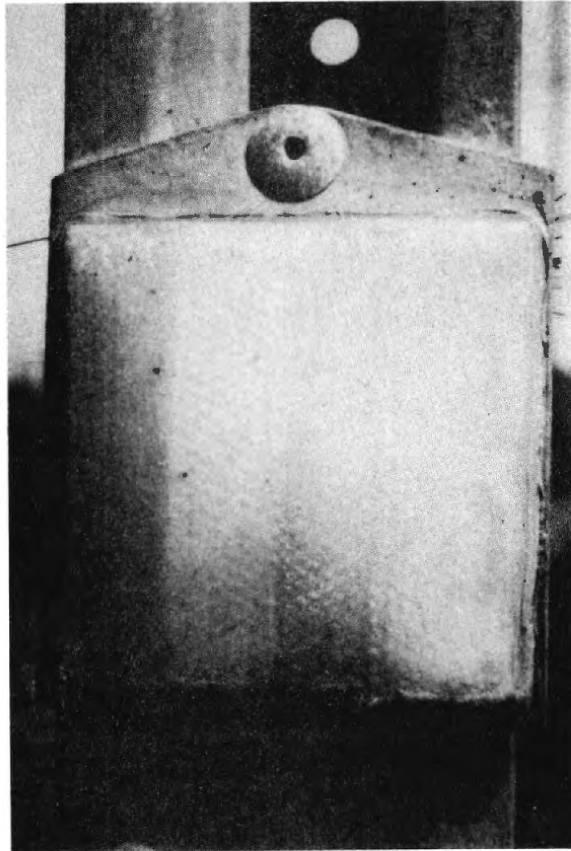


FIGURE 11

SURFACE DESCRIPTION RATING "LIGHT"  
20-39% CONCEALED BY SOIL

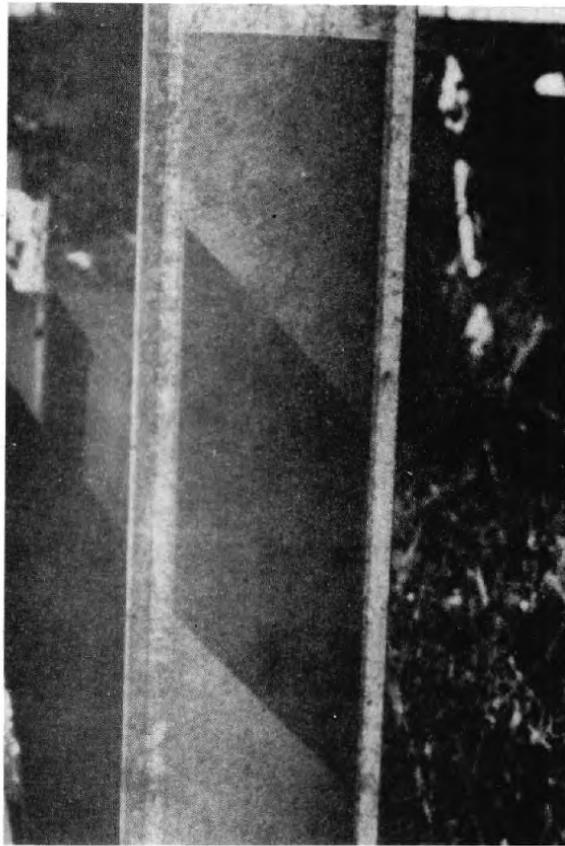


FIGURE 12

SURFACE DESCRIPTION RATING "MODERATE"  
40-59% CONCEALED BY SOIL

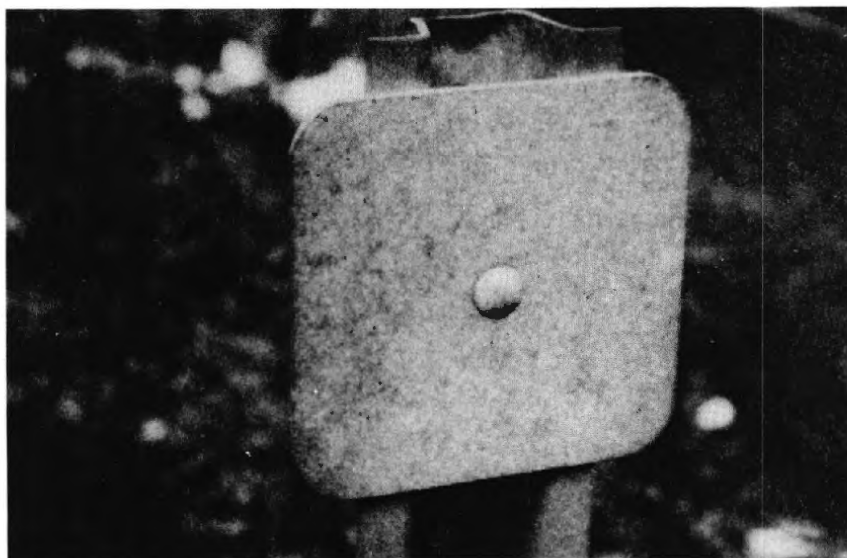


FIGURE 13

SURFACE DESCRIPTION RATING "HEAVY"  
60-79% CONCEALED BY SOIL





FIGURE 14

SURFACE DESCRIPTION RATING "COVERED"  
80-100% CONCEALED BY SOIL

APPENDIX C

## SUMMARY

### SURVEY OF STATES PRACTICES ON DELINEATING GUIDERAIL

As part of the study on guiderail delineation, a survey was conducted to determine what experience other states have on the subject of delineating guiderail. Various authorities in the New Jersey area were also included in this survey. The survey was accomplished by circulating a questionnaire to all 50 states.

A total of 49 states responded to the questionnaire used in the survey. Twenty eight states reported that they have a criteria for determining when or how guiderail on their road system is delineated. Delineators which install inside the W-beam of the guiderail are the most prevalent type used by states that delineate guiderail. When questioned about the proportion of the state-maintained guiderail delineation, ten states replied that they delineated 25 percent to 49 percent of the guiderail. Alaska, Colorado, New York and Tennessee responded that they delineate from 50 percent to 74 percent of all guiderail under state jurisdiction. Alabama, Florida, Idaho, Montana, New Hampshire and Wisconsin replied that they delineate from 75 percent to 99 percent of their states' guiderail.

Seven states nationwide responded that they delineate 100 percent of their state-maintained guiderail. These states include Arizona, Louisiana, Massachusetts, Nebraska, Nevada, North Dakota and Wyoming.

Survey of States Delineating Guiderail

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>								
Alabama Highway Department	633	75%*	Stimsonite and Miro-flex devices are used to delineate the guiderail.	No criteria given. Project installation plans designate which locations are delineated.									
Alaska Department of Transportation	1511**	50%	Syro Steel or equivalent	Not Given	"Reflectors should be fabricated with hi-intensity sheeting."								
Arizona Department of Transportation	1703	100%	Amerace Corp. guiderail tabs are used for guiderail delineation. The tab has a face of reflective sheeting that measures 2" x 1-3/4".	<p>1. A minimum of three markers shall be continuously visible.</p> <p>2. The front edge of the markers shall be oriented perpendicular to the roadway edge.</p> <p>3. Tubular thrie beam barrier markers may be used on guiderail when specified; however, they do not replace delineators.</p> <p><u>Spacing Table for Barrier and Bridge Markers</u></p> <table> <tr> <td>Tangent to 5°</td> <td>100'</td> </tr> <tr> <td>5° to 10° Curve</td> <td>75'</td> </tr> <tr> <td>10° to 20° Curve</td> <td>50'</td> </tr> <tr> <td>Over 20° Curve</td> <td>25'</td> </tr> </table>	Tangent to 5°	100'	5° to 10° Curve	75'	10° to 20° Curve	50'	Over 20° Curve	25'	
Tangent to 5°	100'												
5° to 10° Curve	75'												
10° to 20° Curve	50'												
Over 20° Curve	25'												

\*Post-mounted delineators independent of the guiderail may be included in this figure.

\*\*Estimate

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>
Arkansas Highway and Transportation Dept.	400	1%	Manufacturers are Stimsonite and Astro Optics	No criteria	
California Department of Transportation	3,480	25%	Object markers are used to delineate the leading end of guiderail installations that are less than 12' from the shoulder edge.	No criteria	"Several years ago we attached aluminum reflector assemblies to the top of the wood spacer block of the guiderail. This concept was abandoned due to the reflector being only 27" above the roadway and in the splash zone. If roadway delineation is needed, we use a full roadside delineator behind the guiderail."
Colorado Highway Department	Not Available	50%	Reflective sheeting is applied to a metal "clip" and the clip is attached to the guiderail.	No criteria	"Reflectorized metal clips were used to delineate the guiderail five years ago."
Connecticut Department of Transportation	2,557	25%	None used by the Maintenance Section.	No criteria	

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Delaware Department of Transportation	117	1%	Reflectorized aluminum washers are placed in the valley of the beam at each fifth guiderail post. The reflective washer has a 5" x 2-3/4" face of silver encapsulated lens sheeting or amber sheeting.	No criteria	"We use reflectorized washers on all guiderail delineation installations."
Florida Department of Transportation	1,474	75%	A galvanized steel or aluminum mounting bracket is used to attach an acrylic plastic reflector to both galvanized-steel and aluminum guiderail.	<u>Reflector Spacing</u> . Reflector installed at <u>beginning</u> of guiderail. . 25' space and a reflector. . 50' space and a reflector. . 75' space and a reflector. . 100' space and a reflector. . Then: . 150' space on tangents or curves 20' or less. . 100' space on curves over 20'. . From then on: . 200' spacing  NOTE: For installations of less than 62.5' provide one reflector at each end and at appropriate center.	-45-

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>												
Georgia Department of Transportation	1,370*	1%	Devices used to delineate guiderail are: Carsonite Model No. CFGR-427, Avery-Fasign, 3M-Scotchlite, Seibulite of America-Seibulite, and Sakai Trading Co.-Kiwalite	No criteria													
Hawaii Department of Transportation	186	25%	Potter's Industries, Inc. Guardian RM-1 (Flexible Post) and 3M Hi-intensity reflectorized sheeting on an aluminum panel is used to delineate guiderail.	No criteria													
Idaho Transportation Department	450	75%**	The Amerace Corp. barrier delineator #962 and Astro Optics Corp. Models JD-1, JD-2 and B-1 are used to delineate guiderail.	<p>1. When delineation is used only on curves, three delineators shall be placed before and after the circular portion of the curve.</p> <p>2. If horizontal and vertical curves are combined, use more restrictive spacing.</p> <p><u>Spacing for horizontal curves***</u></p> <table border="1"> <thead> <tr> <th>Degree of Curve</th> <th>Spacing on Curve</th> </tr> </thead> <tbody> <tr> <td>0<sup>0</sup>-0.9<sup>0</sup></td> <td>300'</td> </tr> <tr> <td>1.0<sup>0</sup>-3.9<sup>0</sup></td> <td>150'</td> </tr> <tr> <td>4.0<sup>0</sup>-11.9<sup>0</sup></td> <td>100'</td> </tr> <tr> <td>12.0<sup>0</sup>-23.9<sup>0</sup></td> <td>75'</td> </tr> <tr> <td>24.0<sup>0</sup>-Up</td> <td>50'</td> </tr> </tbody> </table>	Degree of Curve	Spacing on Curve	0 <sup>0</sup> -0.9 <sup>0</sup>	300'	1.0 <sup>0</sup> -3.9 <sup>0</sup>	150'	4.0 <sup>0</sup> -11.9 <sup>0</sup>	100'	12.0 <sup>0</sup> -23.9 <sup>0</sup>	75'	24.0 <sup>0</sup> -Up	50'	
Degree of Curve	Spacing on Curve																
0 <sup>0</sup> -0.9 <sup>0</sup>	300'																
1.0 <sup>0</sup> -3.9 <sup>0</sup>	150'																
4.0 <sup>0</sup> -11.9 <sup>0</sup>	100'																
12.0 <sup>0</sup> -23.9 <sup>0</sup>	75'																
24.0 <sup>0</sup> -Up	50'																

\*Estimate

\*\*25% of old guiderail painted and 50% of guiderail delineated with reflectors attached to wood posts.

\*\*\*Represents only one portion of the complete table. Other tables specify the spacing for crests, vertical curves and tangent sections.

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is delineated	Comments
Illinois Department of Transportation	218	1%	Delineators used are Astro-Optics Model 181 and Amerace Model 965.	<p>Typical Guiderail Delineation Applications</p> <ol style="list-style-type: none"> <li>1. Curve-Two Lane, Two-Way - Use 50' spacing.</li> <li>2. Tangent - Two Lane, Two-Way - Use 50' spacing and a minimum of 3 markers per location.</li> <li>3. Tangent or Curve Multi-Lane or One-Way - Use 50' spacing.</li> <li>4. Narrow Bridge - Two Lane, Two-Way - Use 50' spacing.</li> <li>5. Bridge - Two Lane, Two-Way - Use 50' spacing.</li> </ol>	"Illinois' guiderail delineation program is relatively new with approximately 5,000 units (devices) installed at approximately \$4.00 each."
Indiana Department of Highways	Not Available	0%		No criteria	
Iowa Department of Transportation	425	25%	The Stimsonite Model 965 trapezoidal shape delineator and Type 2 and 3 object markers are used to delineate guiderail. (Type 2 and 3 markers are variations that use a 3" round reflector.)	Delineation is limited and used where guiderail encroaches the roadway or shoulder edge.	
Kansas Department of Transportation	838	0%	None	No criteria	



<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>
Kentucky Department of Transportation	2,835	0%		No criteria	
Louisiana Department of Transportation	360	100%*		Delineate the open end of guiderail and bridge abutments. The center point of long sections of guiderail is also delineated.	
Maine Department of Transportation	743	1%		No criteria	
Maryland Transportation Department	1,349	25%	Maryland fabricates guiderail delineators from .125" aluminum plates. The plates are 4 inches in diameter and are faced with reflective sheeting.	No criteria	

\*Delineation is by means of a hazard marker at the open end of guiderail and at bridge abutments.

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Massachusetts Department of Public Works				<p>4. In no instance shall delineators be installed on sections of guiderail which deviate substantially from the alignment of the roadway or which are located more than 8' from the edge of the paved surface.</p> <p>NOTE: Delineators shall match the color of the edge lines as stipulated in the Mass. MUTCD.</p>	
Michigan Department of Transportation	1,973	25%	<p>Reflectorized washers are attached to the guiderail by using the post-bolt. The reflectorized washers are supplied by: the Anderson Safeway Guiderail Co., the Syro Steel Co., S and F Tool and Die Co., Greenthumb Landscaping and Reflexite.</p>	<p><u>Notes governing use of reflectorized washers</u></p> <ol style="list-style-type: none"> <li>1. Do not use reflectorized washers where roadway is lighted.</li> <li>2. Post bolt washers are placed over reflectorized washers.</li> <li>3. Reflectorized washers are spaced at the following intervals:               <ol style="list-style-type: none"> <li>a. 50 foot on tangent sections and curves of 50° or less.</li> <li>b. 25 foot on curves of more than 50°.</li> </ol> </li> </ol>	<p>*Any information relating to delineation and snow accumulation/removal would be appreciated.</p>

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Massachusetts Department of Public Works	Not Available	100%*	L & C Flashing Barricades, Inc. manufactures the demountable, reflectorized delineators that are attached to the post-bolt in the valley of the W-beam. The triangular delineators have a 2½" x 5" reflective surface of high intensity sheeting. The delineators are constructed from 12 gauge, hot dipped galvanized steel.	<p><u>Locations</u> Locations for guiderail delineation work will be on state highways on a statewide basis. The priority shall be secondary routes, primary routes and lastly interstate routes.</p> <p><u>Installation</u> 1. Delineators are to be installed on every 10th guiderail post. In guiderail runs of less than 10 posts, two delineators shall be used, one at either end. 2. On curves, delineators will be spaced at a minimum of every third guiderail post based on the degree of curve. No less than 3 delineators shall be visible at normal viewing distance. 3. Leading and trailing ends at bridges - 3 delineators - 1 at the connection of the terminal nector and the 25' plate; 1 at the middle of the 25' plate; and 1 at the connection of the 25' plate and the normal guiderail panel.</p>	"The Massachusetts Department of Public Works has found that guiderail delineators are an effective aid for night driving."

\*100% projected to be installed by December 1985.

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>
Michigan Department of Transportation				<p>4. Three reflectorized washers at 12'-6" intervals on approach ends starting at the second post of the guiderail ending with cable anchorage.</p> <p>5. A reflectorized washer is placed on the second post from departing end.</p> <p>6. Reflectorized washers are placed on the upper beam element only.</p>	
Minnesota Department of Transportation	NO RESPONSE RECEIVED.				
Mississippi State Highway Department	234	25%	Carsonite flexible delineators are nailed to wood guiderail posts or bolted to steel I-beam posts.	<p>New guiderail installation plans determine what is delineated. No specific criteria is given. A four year program of delineating guiderail on the interstate system is nearing completion. Primary and secondary roads are delineated on a random basis by districts.</p>	<p>"We are pleased with the performance of flexible delineators attached to every third guiderail post. They are substantially cheaper initially (+1/4 the cost of steel post plus delineator) and are extremely impact resistant."</p>
Missouri Highway and Transportation Department	1,190	0%		No criteria	

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Montana Department of Highways	793.3	75%	Reflective washers and flexible delineator posts are attached to all metal guiderail.	Flexible delineator posts are attached to the guiderail at "high snow" areas. The flexible panel is 30 inches high and has a 6 inch piece of reflective sheeting.	
Nebraska Department of Roads	505	100%	Delineation devices are manufactured "in house," using 3M High Intensity sheeting. Reflective paint is also purchased from 3M.	<ul style="list-style-type: none"> <li>- A 3" x 16" high intensity band is nailed to both sides of the wood posts supporting beam guiderail.</li> <li>- A 4" x 6" double-faced high intensity delineator is nailed to the wood spacer - block of safety beam guiderail.</li> <li>- Silver reflective paint is applied to the top of both sides of cable guiderail supporting posts.</li> </ul>	"Guiderail and bridge rail delineation was placed in Nebraska in 1977. Although no effectiveness studies have been made, the delineation has been received favorably by the travelling public."
				Guiderail delineation is at 25' spacing for guiderail installations 200' in length or less. For guiderail over 200' 50' spacing is used. Bridge rails are delineated at the same spacing. High intensity sheeting is applied to the top of various types of bridge rail posts.	

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>																																							
Nevada Department of Transportation	Not Available	100%	A Ray-O-Lite 3½" dia. white prismatic acrylic reflector is mounted to a 18" x 3" section of flexible post. The flexible post is then attached to the spacer-block of the guiderail with 4 - #8 PC pallet nails (screw type) or 4 tempered steel nails that are shot from a nail-gun.	<u>Delineator or Guidepost Placement Along Guiderail</u> a. 50 feet spacing on tangents and on curves of 300 feet radius or greater. b. On curves of lesser radii the spacing may be computed from the formula $S = 3 \sqrt{R - 50}$ . c. Delineators shall be omitted on flared sections of guiderail.																																								
New Hampshire Department of Public Works and Highways	777	75%	W-beam guiderail delineators are manufactured by Visi-Flash Rental Eastern, Inc. The triangular delineator measures 3" x 5" and is 0.10" thick.	<u>Spacing for Beam Guiderail Delineators on Horizontal Curves</u> <table border="1"> <thead> <tr> <th><u>Radius on Curve (In Feet)</u></th> <th><u>Spacing on Curve (In Feet)</u></th> <th><u>Adjusted for Posts Spacing (In Feet)</u></th> </tr> </thead> <tbody> <tr><td>50</td><td>20</td><td>25</td></tr> <tr><td>150</td><td>30</td><td>25</td></tr> <tr><td>200</td><td>35</td><td>37.5</td></tr> <tr><td>250</td><td>40</td><td>37.5</td></tr> <tr><td>300</td><td>50</td><td>50</td></tr> <tr><td>400</td><td>55</td><td>50</td></tr> <tr><td>500</td><td>65</td><td>62.5</td></tr> <tr><td>600</td><td>70</td><td>62.5</td></tr> <tr><td>700</td><td>75</td><td>75</td></tr> <tr><td>800</td><td>80</td><td>75</td></tr> <tr><td>900</td><td>85</td><td>87.5</td></tr> <tr><td>1000</td><td>90</td><td>87.5</td></tr> </tbody> </table>	<u>Radius on Curve (In Feet)</u>	<u>Spacing on Curve (In Feet)</u>	<u>Adjusted for Posts Spacing (In Feet)</u>	50	20	25	150	30	25	200	35	37.5	250	40	37.5	300	50	50	400	55	50	500	65	62.5	600	70	62.5	700	75	75	800	80	75	900	85	87.5	1000	90	87.5	"Nearly 100% of the W-beam guiderail has delineation. About 50% of the cable guiderail has delineation."
<u>Radius on Curve (In Feet)</u>	<u>Spacing on Curve (In Feet)</u>	<u>Adjusted for Posts Spacing (In Feet)</u>																																										
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<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>
New Jersey Department of Transportation	1,009	0%*		No criteria	
New Mexico State Highway Department	Not** Available	Not Available	Two types of reflective washers are used to delineate guiderail. A "L" shaped washer that has a 2½" x 1-3/4" face of silver reflective sheeting is attached to the post bolt of the guiderail. An alternate reflective washer that has a triangular reflective face measuring 2-3/4" x 5" is also attached to the post bolt of various guiderail.	Reflective washers shall be placed facing approaching traffic at 25 ft. intervals on one-way and divided roadways.  On two-way roadways, reflective washers shall be placed at 12½ ft. intervals with every 2nd washer facing opposing traffic.  Amber reflective washers in lieu of silver shall be used when the guiderail is on the left side to approaching traffic on multi-lane facilities.	

\*Post-mounted delineators are installed along the roadside.

\*\*Information was obtained only for Districts 3, 4 and 5.

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
New York Department of Transportation	4,200	50%	<p>The N.Y.D.O.T. fabricates their own delineator for box beam guiderail from 10 gauge steel. The delineator has a 3" x 3" face of reflective sheeting. A 5/16" hole is drilled in the top of the box beam rail element and the delineator is attached with a 3/8" self-tapping bolt.</p> <p>An aluminum alloy delineator of 0.080" thickness with silver reflective sheeting is attached to the end cap on posts supporting cable guiderail.</p>	<p>When box beam guiderail is parallel to the pavement edge, or median barrier is used, reflective markers shall be attached at every 32nd post (192 feet) on tangents and every 16th post (96 feet) on curves.</p> <p>Where cable guiderail is parallel to the pavement edge, every 6th post (96 feet) shall be reflectorized.</p>	
North Carolina Department of Transportation	1,310	25%	Reflectorized tape is applied to BCT-1 anchors.	Formal procedures for delineating guiderail are being developed.	"New standards will require placement of delineators on new W-beam guiderail installations."
North Dakota State Highway Department	50.7	100%	A .080" aluminum plate with a 6" x 4" face of reflective sheeting is attached to the guiderail posts.	Reflectorized plates are attached to guiderail at 24' centers on guiderail less than 250' in length and at 48' centers for guiderail over 250' in length. The reflector should be the same color as the pavement marking adjacent to the reflector.	



State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Ohio Department of Transportation	3,337	1%	Stimsonite Model 965	<u>Guidelines</u> 1. Color of the median reflector should match the color of the nearest edge line pavement marking. 2. Spacing as follows: a. Tangent sections and curves flatter than 3° - --- 100 feet apart. b. Curves of 3 to 15° --- 50 feet apart. c. Curves over 15° --- 25 feet apart. 3. Flashing method should be used when applying adhesive to accelerate the drying time of the adhesive.	"We have delineated both concrete and W-beam median barrier guiderail."
Oklahoma Department of Transportation	2,200	1%	Stimsonite 3" button reflector or flexible posts made by Carson are attached to the guiderail posts.	Delineate the end only of guiderail in "triple-yellow" (stripes).	
Oregon Department of Transportation	1,374*	1%	Carsonite flexible delineator posts are attached to the guiderail posts.	No criteria	"Our present policy is to delineate highways in accordance with our standard delineator drawings. Attachment of delineators to guiderail is the contractor's option."

\*From 1980 inventory

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Rhode Island Department of Transportation	.Not Available	1%	Reflectorized triangular delineators made by AKT Corp. are mounted in the W-beam of the guiderail.	Reflectorized triangular delineators are used on all guiderail projects under design as of April 16, 1984.	"Delineators greatly increase the visibility of the guiderail. Delineated guiderail is visible from about 0.3 miles. Non-delineated guiderail is not detected until the driver is within 0.1 mile of the guiderail."
South Carolina Department of Highways	.Not Available	0%		No criteria	
South Dakota Department of Transportation	313.9	1%	Stimsonite Model PN965W guiderail delineator and Syro Steel Co. Model SK-7403 Butterfly delineator.	No criteria	
Tennessee Department of Transportation	1,819.4	50%	Various manufacturers supply the 3½" diameter prismatic reflector that is attached to a 32" long delineator post. The delineator post is then bolted to the guiderail post with two 5/16 x 2½" bolts.	No criteria given, other than delineators installed on bridges only when guiderail is continuous across bridges. Spacing on bridges is at 12 ft., 6" intervals. The color of delineators matches that of the edge line.	

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Pennsylvania Department of Transportation	9,305	25%	Delineators used for guiderail are the Stimsonite Model No. 965 and the Reflexite No. 710	<p>On interstate highways where the roadway is not lighted, guiderail located on the left within 6 feet of the shoulder edge is delineated.</p> <p>Where right side guiderail is in place delineators shall be included within the guiderail unless the lateral distance is greater than 6 feet off the shoulder.</p> <p>Where left side guiderail is in place and the guiderail is within 6 feet of the shoulder, delineators shall be placed in the line of guiderail (<u>post-mounted delineators</u>), otherwise the delineators shall be placed 2 feet behind the outer edge of the shoulder or the face of the curb.</p>	

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Texas Department of Highways and Public Transportation	Not Available			No criteria	
Utah Department of Transportation	557	1%	Astro Optics-AKT delineators are attached to guiderail. Angled reflective washers or tabs are also used for guiderail delineation. The reflective washers are constructed from 0.164" galvanized steel and have a 2 1/4" x 1-3/4" face of reflective sheeting.	No specific criteria is given. Guiderail is delineated at "problem" areas.	"Guiderail delineation is becoming more important. In Utah (median) guiderail is being replaced with concrete barrier wherever possible."
Vermont Agency of Transportation	Not Available	25%	An aluminum triangular reflectorized washer (generic brand) measuring 5" x 3" is secured to the post bolt of the guiderail.	All new installations are delineated with a device every 35' (plus or minus).	"Guiderail delineators are very cost-effective devices which provide the only effective visual guidance at night during bad weather."
Virginia Department of Highways and Transportation	2,760	0%	Amerace Corp. manufactures the Stimsonite device used for guiderail delineation of construction zones.	Only guiderail located at construction zone sites is delineated.	"While not used on guiderail, we do require delineators on concrete median barriers and bridge rails."

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guide-rail is Delineated</u>	<u>Comments</u>																		
Washington Department of Transportation	1,720	0%		No criteria																			
West Virginia Department of Highways	5,100	0%		No criteria																			
Wisconsin Department of Transportation	Not Available	75%	The Armco Co. produces the guiderail delineator from 0.089" galvanized steel. The triangular delineator has a 5" x 2-3/4" face of reflective sheeting and is mounted in the valley of W-beam guiderail via the post-bolt.	<u>Reflector Spacing on Guiderail</u> <table border="1"> <thead> <tr> <th></th> <th><u>Length of Guide-rail</u></th> <th><u>Reflector Spacing</u></th> </tr> </thead> <tbody> <tr> <td>One-Way Traffic</td> <td>200'</td> <td>50'</td> </tr> <tr> <td>Two-Way Traffic</td> <td>200'*</td> <td>25'</td> </tr> <tr> <td></td> <td>200'*</td> <td>50'</td> </tr> <tr> <td>Two-Way Traffic</td> <td>200'</td> <td>50'</td> </tr> <tr> <td></td> <td>200'</td> <td>100'</td> </tr> </tbody> </table>		<u>Length of Guide-rail</u>	<u>Reflector Spacing</u>	One-Way Traffic	200'	50'	Two-Way Traffic	200'*	25'		200'*	50'	Two-Way Traffic	200'	50'		200'	100'	
	<u>Length of Guide-rail</u>	<u>Reflector Spacing</u>																					
One-Way Traffic	200'	50'																					
Two-Way Traffic	200'*	25'																					
	200'*	50'																					
Two-Way Traffic	200'	50'																					
	200'	100'																					
Wyoming State Highway Department	Not Available	100%	Reflective "tabs" for W-beam and box-beam are furnished by various steel fabricators. Reflective tabs, or washers, are constructed of 8 gauge galvanized steel and have a face of reflective sheeting.	Reflective washers (tabs) are used in place of the plate washer on every fourth guiderail post.	"We delineate all guiderail for snow removal purposes as well as the general motorist. The guiderail is a hazard that is normally located well within the 30' safety zone."																		

\*Every other reflector reversed for two-way visibility.

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Atlantic City Expressway	26	1%	3M Co. SGAD-44	No Criteria	"Guiderail delineators should be used on curves."
New Jersey Highway Authority	200	Not Available	Metal-Triangular delineators are mounted in W-beam guiderail. Post-mounted delineators are used to "delineate" wood guiderail.	A delineator should be placed immediately in front of the first post on all runs of guiderail. Additional delineation every <u>264 feet (optionally mounted on rail)</u> , with a minimum of 3 delineators on short runs.	"As we gain experience with the many new and promising delineation devices for the roadway (guiderail delineators, raised pavement markers, flexible delineators, etc.), our guidelines may be revised to address some or all of the above."
New Jersey Turnpike Authority	200	0%		No criteria	"Some cases of <u>coincident guiderail delineation</u> occur where <u>post-mounted delineators</u> are used in the median or at the right shoulder edge."
New York Thruway Authority	460	1%	None	Areas with and without guiderail are marked at 132' intervals with <u>post-mounted delineators</u> (independent of the guiderail).	"The beginning and end of the guiderail are marked with a green reflector to assist snowplow operators."

<u>State or Organization</u>	<u>Miles of Guiderail</u>	<u>Percent of Guiderail Delineated</u>	<u>Manufacturers, Device Names and Mounting Technique</u>	<u>Criteria Determining When or How Guiderail is Delineated</u>	<u>Comments</u>
Palisades Interstate Park Commission (NJ and NY)	47.3	75%*	Syro Steel Co. Model #6061 delineator is constructed of 0.080" aluminum alloy and has a face of silver-white reflective sheeting.	<p><u>Box Beam Guiderail</u> (controlled oxidizing)</p> <p><u>Box Beam Median Barrier</u> (controlled oxidizing)</p> <p>Where box beam guiderail is parallel to the edge of the pavement and on median barrier, attach the reflective marker to the rail system every 96 feet. Do not attach reflective markers to the approach or terminal ends or end assemblies.**</p> <p>- Or -</p> <p>Reflective markers may be mounted on every 4th post on curves and every 8th post on tangents. Install where the rail is parallel to the pavement edge and <u>not</u> on the approach or <u>terminal end sections</u>.*</p> <p>*NOTE: Terminal ends of rail are <u>buried</u>.</p>	

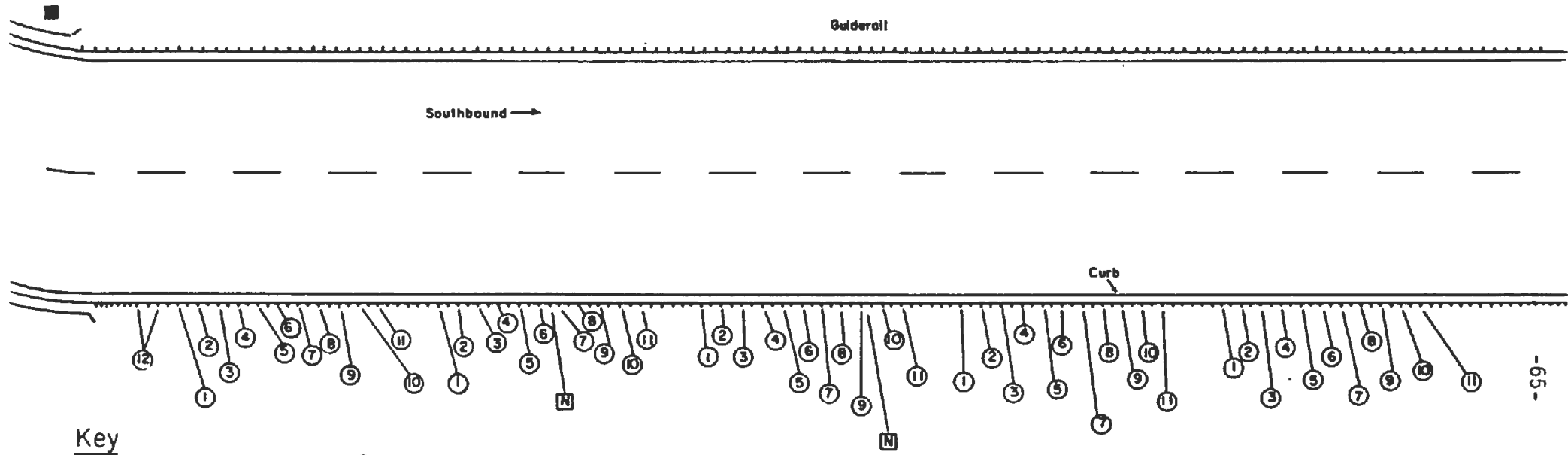
\*\*All delineation information pertains to guiderail only in NY. Guiderail is not delineated in NJ.

State or Organization	Miles of Guiderail	Percent of Guiderail Delineated	Manufacturers, Device Names and Mounting Technique	Criteria Determining When or How Guiderail is Delineated	Comments
Pennsylvania Turnpike Commission	917	100%	The devices used to delineate W-beam guiderail are the Stratolite #75 and #310 made by the Rupert Mfg. Co. Amerace's Stimsonite #965 is also used to delineate guiderail.	Where guiderail is located in line with a reasonably uniform continuous delineator offset of between 2 feet and 6 feet behind the outer edge of the shoulder or curb face, delineators shall be placed in the line of the guiderail.	



APPENDIX D

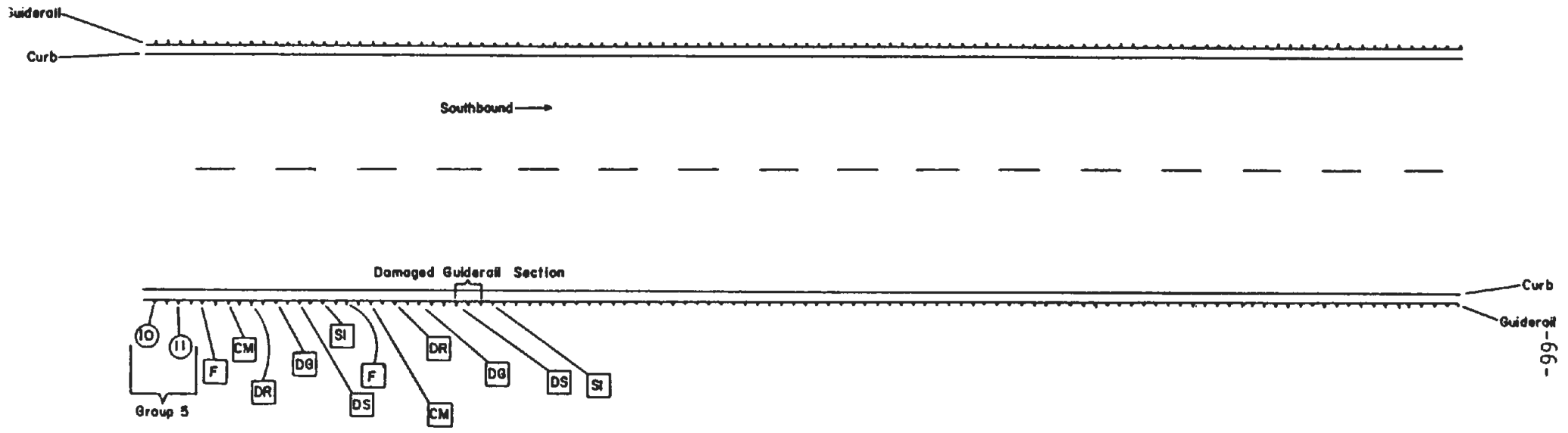
U.S. 1-9 (TRUCK) M.P. 0.2



Key

- [N] = No Stopping or Standing Sign    ① = Potter's Top (paint)
- ② = Proven Products    ③ = Stimsonite    ④ = Potter's Middle
- ⑤ = Transpo TrL    ⑥ = Sign-Shop    ⑦ = Transpo Cir.
- ⑧ = Reflexite    ⑨ = Avery Tape    ⑩ = NFS    ⑪ = Carson
- ⑫ = Corsonite    ■ = Overhead Lighting

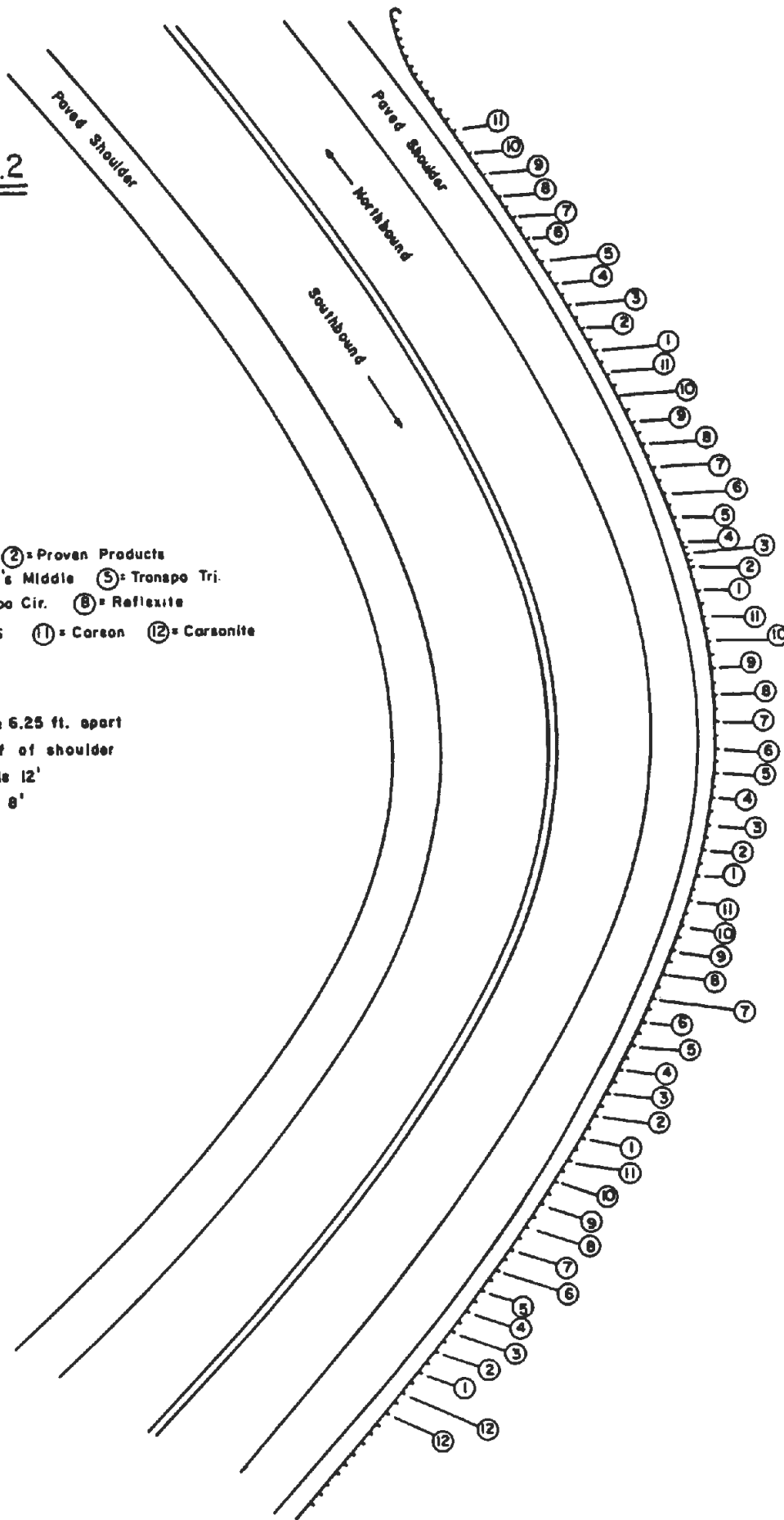
Note: - Spacing between guideway posts is 6.25 ft.  
 - Roadway width is 12ft. (2 lanes)



KEY

- IO = NFS    II = Carson    F = Flexiflector    CM = Carsonite (Metal Mount)
- DR = Davidson (Rivet)    DG = Davidson (Glue)    DS = Davidson (Screw)
- SI = Sign Shop (I-Beam)

NJ. 31 M.P. 11.2



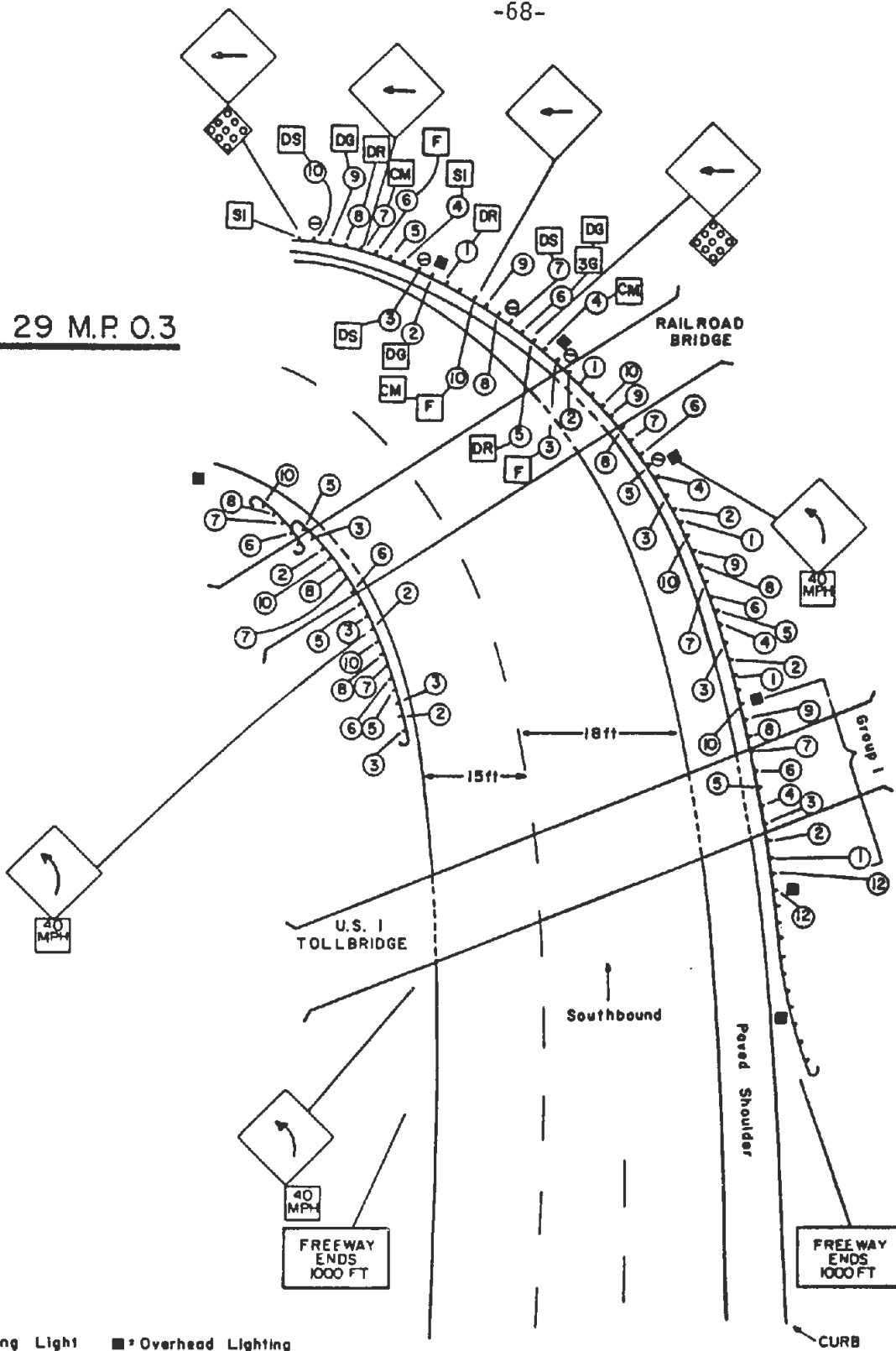
Key

- ① = Potter's Top (paint)    ② = Proven Products
- ③ = Stimsonite    ④ = Potter's Middle    ⑤ = Tranapo Tri.
- ⑥ = Sign-Shop    ⑦ = Transpo Cir.    ⑧ = Reflexite
- ⑨ = Avery Tape    ⑩ = NFS    ⑪ = Carson    ⑫ = Carsonite

NOTE:

- Guideway posts are 6.25 ft. apart
- Guideway is 2' off of shoulder
- Roadway width is 12'
- Shoulder width is 8'

N.J. 29 M.P. 0.3

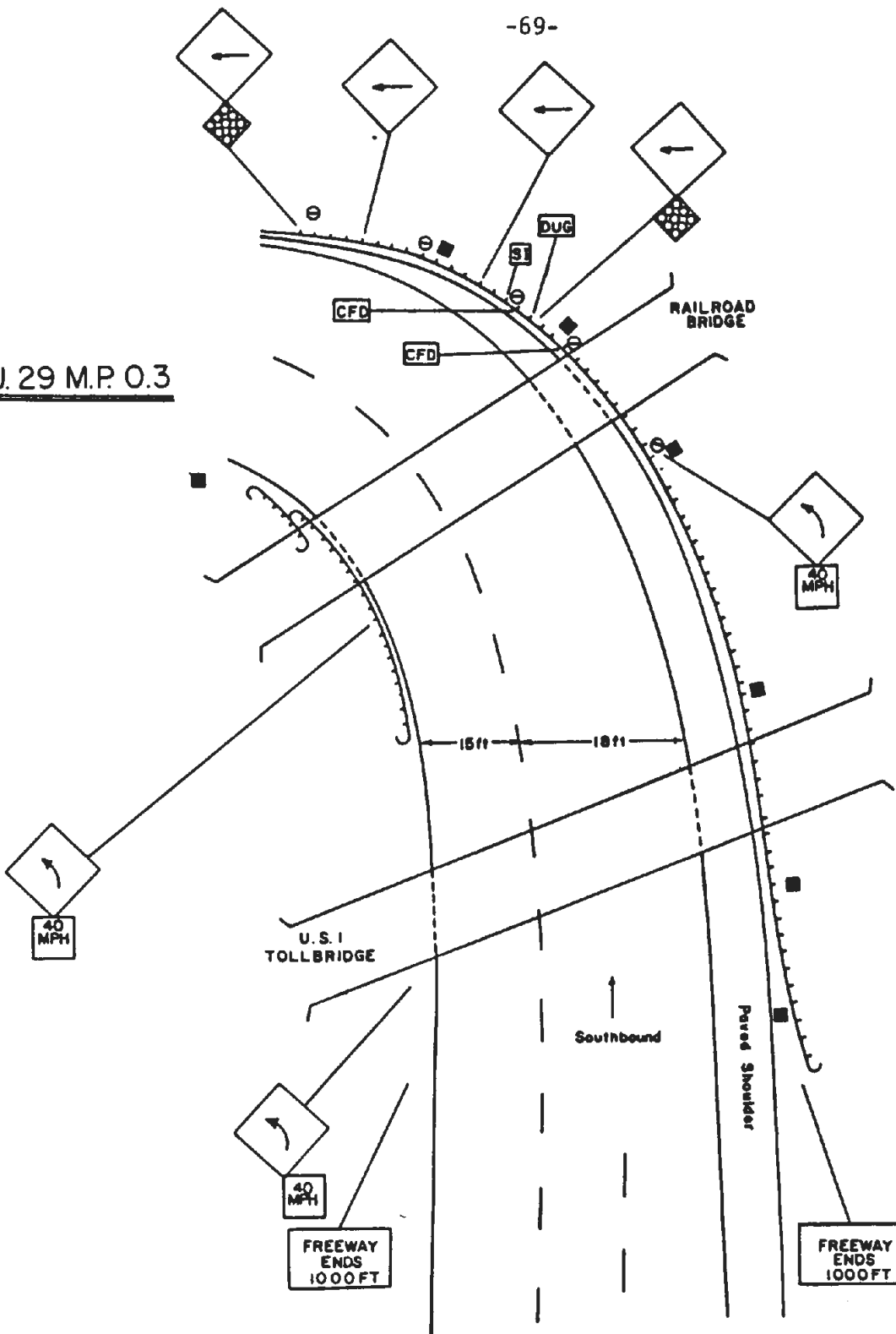


**Key**

- ⊕ = Flashing Light    ■ = Overhead Lighting
- ① = Potter's Top (point)    ② = Proven Products
- ③ = Stimsonite    ④ = Potter Middle    ⑤ = Transpo Tri.
- ⑥ = Sign-Shop    ⑦ = Transpo Cir.    ⑧ = Reflexite
- ⑨ = Avery Tape    ⑩ = NFS    ⑫ = Carsonite
- F = Flexiflector    CM = Carsonite (Metal Bolt Mount)
- DR = Davidson (Rivet)    3G = Glass Stimsonite
- DG = Davidson (Glue)    DS = Davidson (Screw)
- SI = Sign Shop (I-Beam)

Note.- Length of guiderail is 776 ft (Right side of roadway)  
 - Length of guiderail is 258 ft (Left side of roadway)

N.J. 29 M.P. 0.3



Note

See sheet 1 of 2  
for key

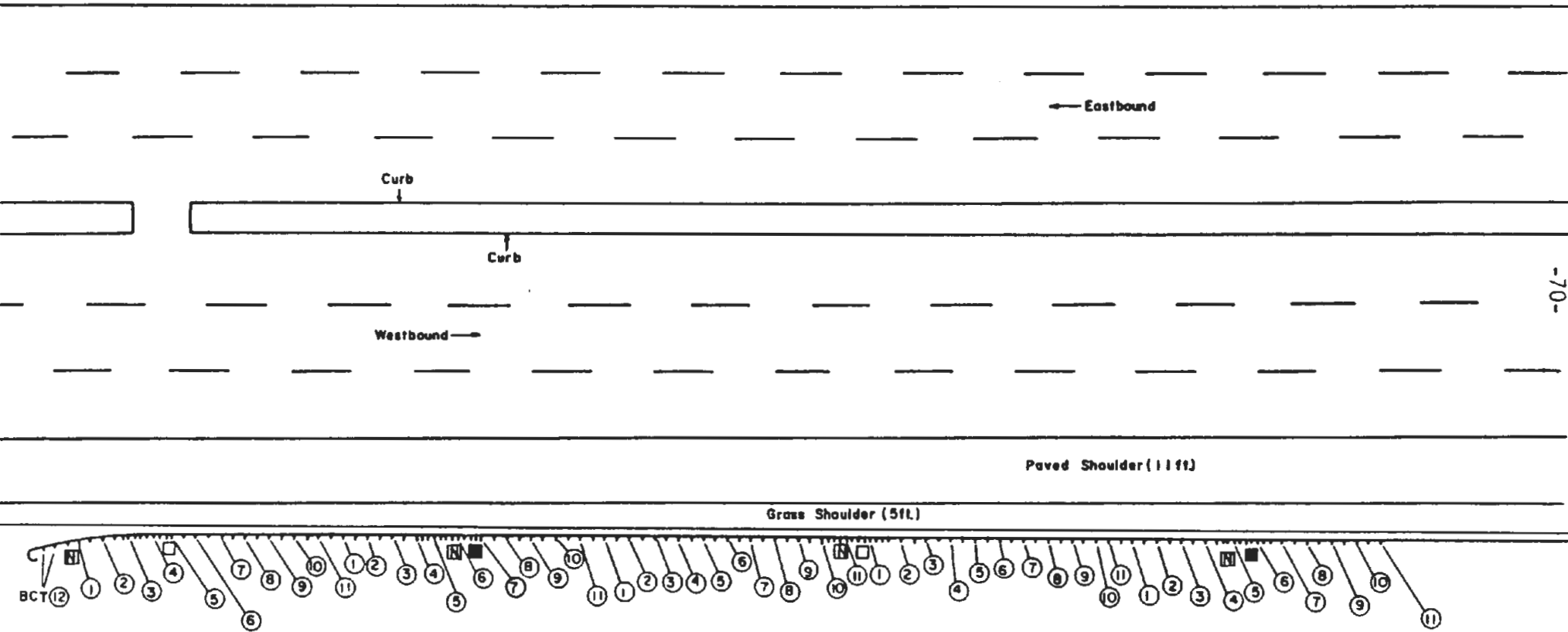
# N.J. 37 M.P. 44.2

## Key

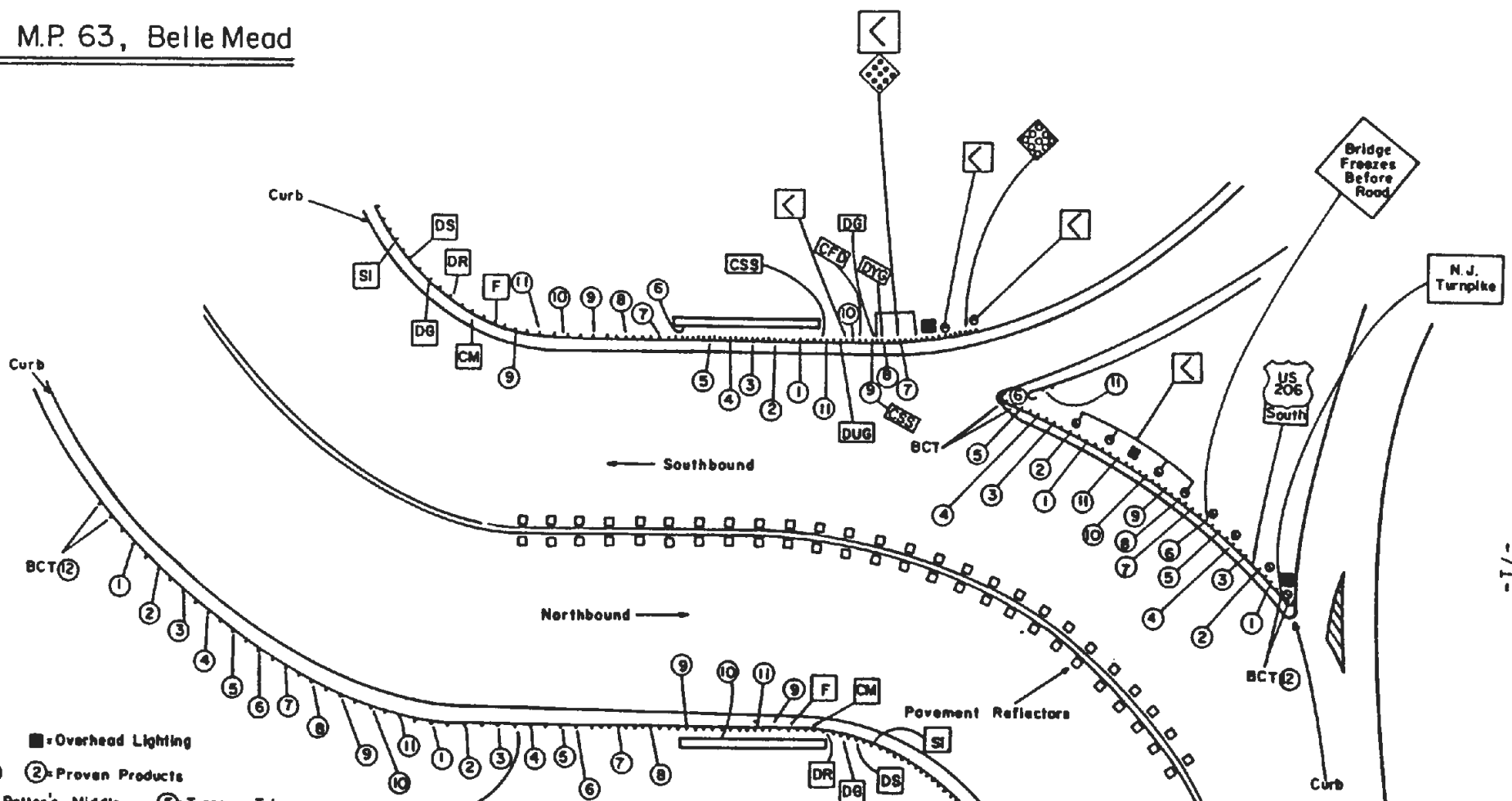
- Ⓝ = No Stopping or Standing (sign)
- Ⓛ = Potter's Top (paint)
- Ⓜ = Potter's Middle
- Ⓡ = Transpo Cir.
- Ⓝ = NFS
- Ⓛ = Telephone-Pole
- Ⓟ = Proven Products
- Ⓡ = Transpo Tri
- Ⓝ = Reflexite
- Ⓛ = Carson
- Ⓝ = Stimsonite
- Ⓡ = Sign-Shop
- Ⓝ = Avery Tape
- Ⓛ = Carsonite (nailed)
- = Overhead Lighting

### Note:

-Guardrail posts are 6.25 ft. apart (posts are 3.125 ft. apart near telephone poles or overhead lighting)



U.S. 206 M.P. 63, Belle Mead



- ey
- :Flashing Light    ■ = Overhead Lighting
  - :Potter's Top (point)    ② = Proven Products
  - :Stimsonite    ④ = Potter's Middle    ⑤ = Transpo Tri.
  - :Sign-Shop    ⑦ = Transpo Cir.    ⑧ = Reflexite
  - :Avery Tape    ⑩ = NFS    ⑪ = Carson    ⑫ = Carsonite (rolled)
  - :Flexiflector    CM = Carsonite (Metal Mount)
  - :Davidson (Rivet)    3G = Glass Stimsonite
  - :Davidson (Glue)    DS = Davidson (Screw)
  - :Sign Shop (I-Beam)    CFD = Carsonite Fiberglass Drivable
  - :Carsonite Spring Steel    DUG = Davidson U-Bess (Glue)

Note:- Carsonites on guiderail in N.B. direction are silver & black  
 - Carsonites on guiderail in S.B. direction - first device is yellow & black, second device is silver & black  
 - All of the guiderail within the test area is equipped with rubrail  
 - Pavement reflectors are not necessarily located as drawn



APPENDIX E

Guiderail Delineator Hardware Evaluation

Product information and samples of delineators were requested from more than 20 companies. The name of each company is listed with their product and type of reflector used. The letters A through D indicate at what point a product was rejected or accepted by means of testing. Numbers 1 through 6 indicate the reasons for this acceptance or rejection.

- A = Rejected following a brochure or sample review.
- B = Rejected following a full-scale visibility test.
- C = Rejected following a full-scale visibility test including a dirt accumulation and durability evaluation.
- D = Accepted and used as product prototype at demonstration sites.
  - 1. Low visibility.
  - 2. Impracticable mounting configuration.
  - 3. Not specifically designed for application on guiderail.
  - 4. Experienced durability problems.
  - 5. Excessive accumulation of dirt inhibited reflective quality.
  - 6. Conforms to project test and configuration requirements.

<u>Name of Company</u>	<u>Product</u>	<u>Results</u>	<u>Reasons for Acceptance or Rejection</u>
Potter's Industries	a)Potter's top paint treatment.	B	1
	b)Potter's middle paint.	B	1
Proven Products	Reflector utilizes glass beads and mounts inside W-beam.	C	2 & 5
Amerace Corp.	a)Stimsonite Trapezoidal reflector utilizes cube-corner lens. Mounts inside W-beam.	C	4 & 5
	b)Stimsonite Trapezoidal reflector with glass lens coating over acrylic cube-corner lens. Mounts inside W-beam.	C	4 & 5
Transpo Industries	a)Triangular reflector of galvanized steel uses reflective sheeting. Mounts inside W-beam.	C	2 & 5
	b)3/4" dia. acrylic cube-corner reflector. Mounts inside W-beam.	C	2, 4, 5
NJ Dept of Trans.	a)5 inch square panel of 3M reflective sheeting mounted on U-post independent of guiderail.	C	3
	b)1 7/8" x 3 1/2" panel with 3M reflective sheeting which was riveted or screwed to the top of the guiderail support post.	C	2 & 5
Reflexite Corp.	Triangular reflector of Lexan construction using encapsulated bead sheeting. Mounts inside W-beam.	C	2 & 5
Avery International	Pressure sensitive encapsulated bead sheeting applied to top or middle of beam element.	C	1, 3, 4, 5

<u>Name of Company</u>	<u>Product</u>	<u>Results</u>	<u>Reasons for Acceptance or Rejection</u>
NFS Industries	3" square acrylic reflector mounted on U-post independent of guiderail.	C	3 & 4
Carsonite International	a)3" or 4" x 27" flexible panel utilizing a 3" x 12" area of reflective sheeting. Panel was attached to guiderail support post with manufacturer specified adhesive.	C	4
	b)3' x 27" flexible panel with 3" x 12" area of reflective sheeting. Attached to guiderail post with metal mounting bracket. Panel may also be nailed to wood post (ie. BCT).	D	6
	c)1½" x 12" flexible panel with reflective sheeting. Mounts on top of guiderail post with flexible panel inserting into metal mount which is driven onto post.	A	2
	d)Device constructed of spring steel having a 3" x 3" area of reflective sheeting. Device is driven onto top of guiderail post with hammer.	A	2
Flexiflector Inc.	Flexible device with serrated 2" x 4" area of reflective sheeting. Mounts atop beam element with metal fasteners or adhesive.	C	1, 2, 4, 5
Davidson Plastic Company	a)2" x 3½" panel of extruded vinyl with a ½" strip of encapsulated bead sheeting. Attached to top of guiderail post with self-tapping screws.	C	1, 2, 4
	b)2" x 3½" vinyl panel riveted to top of guiderail post.	C	1, 2, 4

<u>Name of Company</u>	<u>Product</u>	<u>Results</u>	<u>Reasons for Acceptance or Rejection</u>
Davidson Plastic Company	c) 2" x 3½" vinyl panel attached to top of guiderail post with adhesive.	C	1, 4
	d) 3½" x 3½" panel of extruded vinyl with a 2" x 3½" area of reflective sheeting. The bottom of the panel is channelized to fit over the guiderail post. Attachment is with adhesive.	C	4

REFERENCES

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