FUNCTIONALITY OF GUIDE SIGNS

Research Report Number 277-1

Covering

LIGHTING OF GUIDE SIGNS - LEGIBILITY STUDY

Research Project Number 1-18-84-277

by

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DISCLAIMER

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SUMMARY

This report describes the methodology and results of a sign legibility study conducted under project 1-18-84-277 entitled "Functionality of Guide Signs". The objectives of this project related to legibility were: (1) to determine the legibility of both ground-mounted and overhead-mounted guide signs during daytime and nighttime for various situations; and (2) to relate the legibility distance to various factors which affect the signs legibility, including the materials used for both background and legend. The most popular materials currently in use for backgrounds and legends were used in this study.

The methodology used in this study was to drive two freeways in Houston, Texas and record the distance each test driver (subject) read a particular test sign. The test signs selected were both overhead and ground-mounted. The test drivers did not know the specific test signs being studied. This was accomplished using the key word technique. The test driver was given a key word (example, Scott Street) and was told to read all signs that contained Scott Street. Only one sign of the group that contained Scott Street was the test sign. The driver did not know which sign was the test sign.

The major findings and conclusions of this study are as follows:

1. LEGIBILITY OF LIGHTED VERSUS UNLIGHTED OVERHEAD FREEWAY GUIDE SIGNS

Average legibility distance for all material combinations was greater for lighted signs than unlighted signs. However, some material combinations performed equally well in both the lighted and unlighted conditions. The combination of engineer grade reflective sheeting with reflective button copy had an average legibility distance of 947 linear feet without lighting and only 908 linear feet with lighting. The results of the study show that when selected combinations of materials are used, and an unrestricted sight distance of 1,100 to 1,200 linear feet is existing, and the sign is not located in a visually complete background, sign lighting does not improve legibility.

2. GROUND-MOUNTED SIGNS COMPARED TO UNLIGHTED OVERHEAD-MOUNTED FREEWAY GUIDE SIGNS

Average legibility distances of ground-mounted signs (unlighted) are essentially the same as for unlighted overhead signs, 788-785 LF respectively.

3. COMPARISON OF DAY AND NIGHT LEGIBILITY DISTANCES

The nighttime average legibility distance for all the test signs was sixteen (16) percent less than the daytime average legibility distance of the same test signs. This substantiates a previous study report (TX 222-2F) where a decrease in legibility distance at night of fourteen (14) percent was determined.

4. FREEWAY GUIDE SIGNING MATERIALS EFFECT ON LEGIBILITY DISTANCE

The sign material combination which had the best legibility distance in both the lighted and unlighted conditions was engineer grade reflective sheeting background with button copy. However, the study shows that several other material combinations, such as high specific intensity background with removable reflective button copy, will provide adequate legibility distances in both lighted and unlighted conditions.

5. LEGEND MATERIALS AFFECT ON OVERHEAD GUIDE SIGNS LEGIBILITY

When comparing the materials used for the sign legend it was determined that the differences in legibility distances were not statistically significant. In both the lighted and the unlighted conditions the average legibility distance for all signs with reflective button copy were greater than the average legibility distance for signs with stick-on copy. In the lighted condition reflective button copy had a legibility distance of 828 L.F. and the high specific-intensity reflective stick on copy had an average legibility distance of 798 L.F.

6. SIGN LIGHTING EFFECT ON LEGIBILITY DISTANCE

Sign lighting has a negligible affect on sign legibility. The average lighted sign legibility distance was 813 linear feet and the average unlighted legibility distance was 788 L.F. In practice this 25 foot difference is not significant. At normal freeway speeds the 25 foot difference is traversed in .31 seconds. The choice of sign material combinations has more effect on legibility distance than whether or not sign lighting is used.

7. SIGN MOUNTING EFFECT ON LEGIBILITY DISTANCE

To analyze the difference between unlighted overhead guide signs and ground-mounted signs the overhead signs on the unlighted route were compared to the ground-mounted signs on both routes. The overhead mounted signs on the unlighted route had an average legibility distance of 788 linear feet, whereas the ground-mounted signs on both routes had an average legibility distance of 785 linear feet. It is obvious there is no significant difference between these two types of freeway guide signs.

A target value study was conducted as a part of this research project and a draft final report prepared. The experimental approach used to determine target value was an operational study in which the drivers were required to drive a prescribed route and identify the location of all green guide signs. The drivers were not task-loaded as in normal route following situations, resulting in the development of a minimum viewing distance and not a true representation of target value distance. Based on these results, a decision was made to not publish the draft report. Researchers may obtain a copy of this unpublished report from the Texas SDHPT, Planning and Research Division, Austin, Texas.

RECOMMENDATIONS

The results of this study indicate several significant recommendations for freeway guide signing:

1. Due to the negligible difference in legibility distance between lighted and unlighted overhead guide signs, when 1100-1200 L.F. of unrestricted sight distance is available, high visual clutter is not present and sign materials have good retroreflective characteristics, sign lights are not cost effective and overhead signs should not be lighted.
2. Engineer grade reflective sheeting signs outperformed all other types of signs in both the lighted and unlighted conditions. This reflective sheeting is a good all purpose sign material and has a lower initial cost than the other types of reflective sheetings tested. Engineer grade reflective sheeting is recommended for use on overhead signs.
3. The results of this study indicate that reflective materials should be used on unlighted overhead signs. Opaque signs did not prove to be quite as effective as reflective sheeting signs in the unlighted condition.
4. Button removable copy was superior to high specific-intensity reflective stick-on copy. Reflective button removable copy will produce a more legible sign and is recommended for usage under all conditions.
5. The results of this study indicate that there was virtually no difference in the legibility distance between ground-mounted guide signs and unlighted overhead guide signs. The same materials used on overhead freeway guide signs should be used on all ground-mounted signs.

IMPLEMENTATION

The Texas State Department of Highways and Public Transportation incurs great expense in the initial installation of lighting on urban freeway signing. The installation of the sign lighting systems results in increased operating and maintenance costs for many signs which may perform as well without sign lighting as with sign lighting. When considering legibility distance only, the results of this study indicate that the department could in many cases save the cost of freeway guide sign lighting. The study results indicated the reflective button copy performed better than reflective stick-on copy on both overhead and ground-mounted signs and should be used.

The results of this study indicate that sign lights should be used where there is limited sight distance (less than 1,100 linear feet) and horizontal curvature greater than 4°. Sign lights should also be used at major freeway splits where the total distance from the first guide sign to the existing ramp is less than 2,000 feet and where signs are located in high visual clutter areas.

I. SUBJECT

Increasing operational costs and maintenance costs for overhead guide sign lights make it desirable to eliminate as many sign lights as possible without diminishing overhead guide sign functionality. Limited personnel and funds make it increasingly difficult to operate and maintain sign lights. Maintenance on overhead sign lights requires lane closures which increase accidents and interrupts normal roadway operations. Elimination of as many sign lights as feasible will substantially reduce the number of lane closures necessary for maintenance operations.

Previous research has proven that opaque background coatings are more durable and maintenance free than reflective background coatings. Previous research also indicated the use of opaque background does not decrease the functionality of the ground mounted guide signs.

Preliminary studies in Houston and El Paso under State project 1-18-75-222 indicate that functionality, including legibility, conspicuity and other operational factors, of overhead guide signs without fixed sign lighting is not impaired when sight distances are 1100 feet or over. There was some indication that when button removable copy of the quality specified by the Texas Department of Highways and Public Transportation is utilized, functionality increases slightly when fixed sign lighting is not present. Also, there was some indication that as the luminance of the sign background increases from opaque materials to high specific intensity materials, the legibility may decrease.

Preliminary studies under State Project 1-9-80-270 indicate that as the luminance of legend to background ratio increases, functionality increases for ground mounted signs.

Therefore, it was desirable to take the initial studies and convert them into a full matrix to determine the requirements necessary for fully functional guide signs.

II. OBJECTIVES

1. When not currently in place on freeways in Houston, construct and erect signs as needed, utilizing button removable and high specific-intensity reflective copy as text and backgrounds of opaque material, engineer grade reflective sheeting, super-engineer grade reflective sheeting and high specific-intensity reflective sheeting.

2. Determine day and night functionality of overhead signs on freeways under existing traffic and the following conditions.

   a. Sight distances of 1000 or more feet and no horizontal or vertical curve over 2 degrees.

   b. Sight distances of 1000 or more feet with horizontal and/or vertical curves greater than 2 degrees.

   c. Under night conditions with fixed freeway lighting on and sign lighting on and off.

   d. Under night conditions with no fixed freeway lighting and sign lighting on and off.

3. Determine day and night functionality of ground mounted guide signs under above conditions as applicable.

4. Statistically analyze operational and maintenance costs and functionality of guide signs. The statistical analysis of variance regression and other parametric tests will be conducted. This shall also include but not be limited to conspicuity, human factors, economics and safety aspects.

III. BACKGROUND AND SIGNIFICANCE OF WORK

For the past several years many states have experienced problems with lighting equipment on large overhead freeway guide signs. The lighting equipment in most cases is over fifteen years old and needs replacing. The cost for replacement of this equipment will be excessive and does not include future cost of electricity to power these lighted signs.

This problem has forced many states to issue informal guidelines with respect to maintenance of lighting for freeway guide signs. These informal guidelines generally state "that non-critical guide sign lighting will not be replaced after the lighting has burned-out". In these non-critical situations power to the sign lights will be disconnected. California has petitioned the United States Department of Transportation for relief from the lighting requirements for overhead guide signs in the Manual of Uniform Traffic Control Devices (MUTCD). California has cited the massive cost of replacing literally thousands of overhead guide signs with new lighting equipment, conduit and electrical lines.

The U. S. Department of Transportation, specifically the Federal Highway Administration (FHWA) has taken the position that all overhead guide signs shall be lighted unless the background is reflectorized and the sign does not have a critical sight distance of less than 1100-1200 feet. Section 2A-16 of the MUTCD specifically states:

> Regulatory and warning signs, unless accepted in the standards covering a particular sign or group of signs, shall be reflectorized or illuminated to show the same shape and color both day and night. **ALL OVERHEAD SIGN INSTALLATIONS SHOULD BE ILLUMINATED WHERE AN ENGINEERING STUDY SHOWS THAT REFLECTORIZATION WILL NOT PERFORM EFFECTIVELY.** Reflectorization, nonreflectorization, or illumination of guide signs shall be as provided in subsequent sections.

The MUTCD addresses the reflectorization of freeway guide signs in section 2E-6 which is in the expressway sign section.

Letters, numerals, symbols, and border shall be reflectorized. The background of expressway guide signs may be reflectorized or non-reflectorized. However, the mixing of signs with reflectorized or non-reflectorized backgrounds in the same general area should be avoided.

In general, where there is no serious interference from extraneous light sources, reflectorized signs will usually be adequate. However, on expressways where much driving at night is done with low beam headlights, the amount of headlight illumination incident to an overhead sign display is relatively small. Therefore, all overhead sign installations should normally be illuminated. The type of illumination chosen should provide effective and reasonably uniform illumination of the sign face and message. When a sign is internally illuminated the requirement for reflectorized legend and borders does not apply.
Various methods used for illumination are specified in Section 2A-17 of the MUTCD.

Illumination may be by means of:

1. A light behind the sign face, illuminating the main message or symbol, or the sign background, or both, through a translucent material; or

2. An attached or independently mounted light source designed to direct essential uniform illumination over the entire face of the sign; or

3. Some other effective device, such as luminous tubing or fiber optics shaped to the lettering or symbol, patterns of incandescent light bulbs, or luminescent panels that will make the sign clearly visible at night.

The requirements for sign illumination are not considered to be satisfied by street or highway lighting, or by strobe lighting.

And finally, when reflectorization is required, Section 2A-18 of the MUTCD specifies the means by which reflectorization may be achieved.

Reflectorization may be by means of:

1. Reflector "buttons" or similar units set into the symbol, message and border; or

2. Reflective sheeting, either on the sign background or where a white legend is used on a black or colored background in the symbol or message and border.

IV. FREEWAY SIGN LEGIBILITY STUDY METHODOLOGY

In January 1981 a freeway guide sign illumination legibility study 1-18-75-222 was conducted in the Houston, Texas area. Additional studies were conducted in El Paso and Dallas, Texas. Various factors were studied using fifteen (15) signs in Houston, ten (10) signs in El Paso, and sixteen (16) signs in Dallas, Texas.

This study investigated the legibility distance of signs constructed using opaque backgrounds, engineering grade reflective sheeting, and high specific-intensity reflective sheeting backgrounds with reflective button and stick-on legends. The average legibility distance for lighted freeway guides signs was 781 feet and for unlighted freeway guide signs was 762 feet (a difference of 19 linear feet). These results indicate that sign lighting and background materials do not have significant effects on legibility distance.

The study procedure and test signs were modified from that used in the 1981 study. Sixteen (16) test signs were selected on both routes, eight (8) overhead and eight (8) ground mounted. Any sign mounted 17.5 feet or higher was classified as an overhead regardless of location within the visual field. All signs lower than 17.5 feet were classified as ground-mounted.

The study procedure used in the operational study precluded the test driver from knowing the specific test signs being studied. In this type of study a normal eye pattern was desirable and the subject should not know which sign was being evaluated. To accomplish this, the subject was given a key word which they had to read aloud to the test administrator, who would record the legibility distance for at least one additional sign plus the test sign. The test subject would scan all signs normally and would read aloud the entire message on the sign. The test administrator would record the distance from when the subject started reading the sign until the subject passed the sign. Signs which the subjects misread or missed entirely were noted on the answer sheet and not included in the analysis of the data. Table 1 presents the list of the key words, the number of signs with that key word, and the signs which were included in the data that was collected.

The primary objective of this study is to determine the legibility distance for lighted and unlighted freeway guide signs of various materials. Table 2, presents the factors considered in this study. The factors include weather, roadway geometrics, sign location, sign illumination, freeway illumination, background materials, and legend (copy) material.

Ambient Weather

Ambient weather was determined at the time the test run was conducted. Those signs read in the rain were so marked in the comments section on the data form. There was limited rain data and no fog data.

Roadway Geometrics

Roadway geometrics were obtained from existing roadway plans. Horizontal curves of less than 2° were considered tangent sections of freeway. Texas generally will not place freeway guide signs on roadway with horizontal displacements

Table 1. List of Key Words, Number of Signs with Key Words and the Number of Signs Legibility Distances Were Recorded

Key Word	Number of Signs with Key Words	Number of Signs Legibility Distance Were Recorded
Post Oak Rd.	3	2
Richmond Ave.	4	2
Chimney Rock Road	2	2
Bellaire Blvd.	2	2
Houston Baptist Univ.	1	1
Airport Blvd.	3	2
Sugarland	2	2
Williams Trace Blvd.	5	3
West Bellfort Ave.	1	1
Bissonnet Street	3	3
Fondren Road	2	2
Hillcroft Ave.	1	1
San Felipe Rd.	2	1
Washington Ave.	3	3
Scott Street	2	1
Long Drive	5	3
Monroe Drive	4	3
Edgebrook Drive	2	2
Almeda-Genoa Road	5	3
Ellington Field	4	2
El Dorado Blvd.	2	2
Choate Road	3	2
Clearwood Drive	3	2
Broadway Blvd.	3	2
Frontage Road	1	1

Table 2. Factors Used in the Legibility Study

Sign Background Material

a) Opaque

b) Engineer Grade Reflective Sheeting

c) Super Engineer Grade Reflective Sheeting

d) High Specific-Intensity Reflective Sheeting

Sign Copy Material

a) Removable Reflective Button

b) High Specific-Intensity Reflective Stick-On

Weather

a) Clear

b) Rain

c) Fog

Roadway Geometrics

a) Horizontal and/or Vertical Alignments less than 2 degrees

b) Horizontal and/or Vertical Alignments greater than 2 degrees

Sign Mounting

a) Overhead Mounted Sign

b) Ground Mounted Sign

Sign Lighting-This specifically applies to overhead mounted since ground signs are non-illuminated.

a) On

b) Off

Freeway Lighting

a) On

b) Off

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greater than 4°. Curvatures greater than 4° create target value problems as well as legibility problems. This is because the driver must detect and recognize a freeway sign before reading the sign.

Sign Location

The location of the sign is another important factor which affects both the signs target value and legibility distance. The two locations considered in the study were overhead and side (shoulder) ground mounted. The overhead signs consisted of overhead bridge mounts, median mounts, cantilever mounts and elevated T-mounts within the freeway right-of-way. All of these structures are 17.5 feet or higher above the roadway surface. Shoulder ground mounted signs are any signs placed to the right or left of the mainlanes less than 17.5 feet in height. The apparent brightness to the motorist of sign background sheeting is affected by the sign position. Shoulder ground mounted signs reflect more light with less traffic and low-beam light usage. Overhead signs will reflect less light back to the driver under the conditions just described. For overhead signs to reflect sufficient light from the green background back to the driver requires vehicle headlamps to be on high-beam or have sufficient street traffic to illuminate the sign. High ambient illumination will also aid the detection, recognition and legibility of overhead guide signs. Most urban freeway drivers use low beam head lights, but there are normally sufficient traffic to provide the necessary light for reflection and detection.

Illumination

Sign and freeway illumination were also considered in this study. The sign lighting was either on or off. The same freeway lighting conditions were used along the two routes. Both test sections started in highly complex, high ambient illumination areas and continued into the suburbs where freeway lighting was discontinued or nonexistent. In this way the complexity of the background was varied along the route. Shoulder ground mounted signs are not lighted in

Texas. Overhead signs were illuminated along one route and not illuminated along the other route.

Sign Materials

The sign background materials used in this study are those most commonly used. These materials are opaque, engineer grade reflective sheeting, super engineer grade reflective sheeting, and high specific-intensity reflective sheeting. These are the typical types of backgrounds used in the United States.

Legend Materials

And finally, the copy materials used in this study were removable reflective button or high specific-intensity reflective stick-on. The inclusion of the other types of copy material was not considered due to project economic considerations.

Legibility Pilot Study

Prior to conducting the Operational Study a pilot study was conducted to accomplish several objectives. These objectives were to determine (1) whether there was any effect on legibility distance due to the order in which the signs were presented to the subjects, (2) whether there were any differences in test signs on either route which would require selecting new signs or possibly even more routes, (3) whether there was a difference in legibility distances using the experimental approach used in the 1-18-75-222 study and the one to be used in the operational study, (4) the sample size and the degree of accuracy obtained with the new experimental design and (5) to train the test administrators, determine reliability of the test equipment and potential problem areas in the test procedure. The same routes, test equipment and test procedure were used in both the pilot study and the Operational Study. The pilot study was conducted before the full complement of test signs were in place. However, sufficient observations to accomplish the pilot study objectives were achieved. The pilot study indicated that the data collected in the 222 study was valid.

The pilot study also indicated that the order in which the signs were presented had no significant effect on legibility distance and that there was no difference in the same type of signs on either route. The Pilot Study indicated the sample size required for the Operational Study.

Test Subjects

Thirty-seven (37) subjects were used in the pilot study. Seven (7) were subjects previously used in the 1-18-75-222 project. The seven individuals were used to compare legibility distances using the new test procedure to the legibility distances using the old test procedure. By comparing the legibility distances using the two test procedures, the decision could be made as to whether to include the legibility data previously collected to increase the data base for analysis. The distribution of the subjects for the pilot and study was as follows:

Age Group	Male	Female
17-24	3	3
25-34	7	7
35-44	2	5
45-54	2	3
55-64	2	1
Over 65	1	1
Total	17	20

The test drivers were tested for visual acuity, depth perception and color blindness. One individual used in the study passed away before we could obtain his visual characteristics. The visual acuities ranged from 20/17 to 20/25 with a mean visual acuity of 20/20. The individual that passed away had extremely long legibility distance which may indicate that his visual acuity was extremely good. The mean of 20/20 indicated that most test subjects had extremely good eyesight and would therefore result in longer legibility distances than drivers with poorer visual acuities. The individual depth perception ranged from 20/22 to 20/50 with a mean of 20/31. This test indicates the subjects ability to judge position at varying distances. This test was used to indicate the ability of each subject to locate a sign several hundred feet away embedded in a complex background.

And, finally, all test drivers were tested for color blindness. Since all of the drivers were told to read the green destination sign it was imperative that they were not color blind with respect to that color. In all of the subjects none were blind to any one color combination.

Based on the results of the pilot study only seventeen test drivers were required to perform the Operational Study after all the sign material combinations were in place. The same percentage distribution was used for the seventeen additional test drivers in the Operational Study. The color blindness, acuity and other tests on the subjects were again performed.

Test Routes

Two test sections utilizing both loop and arterial freeways in the Houston, Texas area were used. Each test section was approximately 50 miles in length. The length of the sections was of concern to the researchers because of the possibility of fatigue to the drivers. The pilot study indicated that the drivers did not incur any unusual fatigue due to the length of the test sections.

One of the test sections commenced on southbound I-610 (West Loop) and proceeded south on US-59 (Southwest Freeway). The return trip was over the same two routes and a portion of I-10 (Katy Freeway) eastbound. This route covered a total of 48 miles. The second test section began on eastbound I-610 (South Loop) and proceeded southbound on I-45 (Gulf Freeway) to El Dorado Blvd. The return route was over the same two freeways and ended at Texas 288 (South Freeway) where it began. This test section was 54 miles in length. Appendix C documents the two sections and the test signs used in this research project.

Each route contained a full compliment of freeway guide signs according to the experimental design. Both overhead and shoulder mounted guide signs were included on both routes. To avoid a learning effect due to the test drivers being used more than once, the (I-10, I-610, US 59) route had all overhead signs lighted whereas the (I-610, I-45) route had all the overhead signs unlighted. The freeway guide signs were selected randomly on both routes to prevent an ordering effect. Each route contained sixteen (16) test signs, eight (8) shoulder ground mounted and eight (8) were overhead.

Test Signs

The experimental design required eight (8) overhead freeway guide signs and eight (8) shoulder mounted guide signs. The eight (8) overhead and shoulder ground mounted freeway guide signs utilize the following materials:

Background	Legend
Opaque	Removable Reflective Button
Opaque	High Specific-Intensity Reflective Stick-On
Engineer Grade Reflective Sheeting	Removable Reflective Button
Engineer Grade Reflective Sheeting	High Specific-Intensity Reflective Stick-On
Super Engineering Grade Reflective Sheeting	Removable Reflective Button
Super Engineering Grade Reflective Sheeting	High Specific-Intensity Reflective Stick-On
High Specific-Intensity Reflective Sheeting	Removable Reflective Button
High Specific-Intensity Reflective Sheeting	High Specific-Intensity Reflective Stick-On

The new test signs were fabricated in the SDHPT District 12 sign shop. Since the test signs were to be placed on an operating freeway system the legends were kept the same as the signs they replaced. The test signs contained some new signs and some old signs. Some of the old signs were 20 years old. Appendix C, also contains the test and material properties of each test sign. The overhead test signs were paired by having each of the eight material combinations with external lighting and without external lighting. The ground mounted test signs were paired by having each of the eight material combinations on both routes.

Test Equipment

The test equipment used to record the drivers responses and determine legibility distance consisted of (1) a distance measuring instrument (DMI) and (2) a tape recorder. Each of these devices were placed in each test vehicle. The test vehicles used were two 1984 Chevrolet Malibu sedans.

The distance measuring instruments were Numetrics Model K-55. This particular model has a hold and memory feature. When the hold button is depressed the DMI freezes the display and does not continue measuring distance. When the memory button is depressed it continues measuring distance internally. The DMI was reset when the driver first read the sign and then placed on memory, as the test vehicle passed the sign which the driver was reading. This procedure allowed the test administrator to record the legibility distance while not destroying the total distance travelled by the test vehicle in case any unusual event might occur.

A tape recorder was placed in the test vehicle for two purposes. The first was to present the study objectives to the test drivers and present the key words the drivers were to locate. The second function the tape recorder performed was to record the subjects responses to determine the correctness of the responses. The legibility distance began when the driver first started to read each sign.

If a driver started too early and/or incorrectly read the sign, the legibility distance for that sign was not used. There were very few instances where this occurred.

Test Procedure

As the test drivers were travelling along a previously described route a key word(s) was presented to them. The test driver would scan the horizon in a typical search fashion until a sign with the key word(s) was located. They would not know whether this sign would be a shoulder ground mounted or overhead mounted sign. If it was overhead it could be a median, sign bridge, cantilever, raised T-mount or a cantilever or T-mount placed alongside the roadway. After the test drivers located the sign they were required to read the message in its entirety. This process could continue until a different key word was presented.

In order to camouflage the true test signs from the driver, legibility distances for other signs with the same key word were also obtained. Drivers were never sure which signs were being studied. For those signs without numbers, in Appendix D, the legibility distances were not recorded. Those signs with numbers had legibility recorded and those with asterisks were the test signs. The material combination for each test sign was also given.

It should be noted that the tests were conducted using low beam headlights. The headlights on the test vehicles were normal headlights; they were not the halogen type. The headlights were checked for proper aiming.

V. STATISTICAL ANALYSIS AND RESULTS

A large amount of effort was spent to insure that the reported measurements were recorded correctly on the data sheets and in the computer. While this does not appear to be a task worth mentioning, the size of the data set made this a slow and complicated process. This effort insures that the data being analyzed represents the experiment correctly. The data set used in this study is contained in Appendix E. The signs used in this study are listed in Table 3.

All overhead signs along route 1 were lighted and all overhead signs along route 2 were unlighted. Legibility distances of less than 200 feet were unusual and produced large differences in the matched pair of signs. These measurements were often the result of the test vehicle being behind a truck which would obscure the view. These points were removed from the analysis, since they did not represent a true measure of the signs legibility. The differences in legibility were calculated by subtracting the unlighted distance from the lighted distance for each pair of signs. Hence, a negative difference, as in Table 4 indicates the unlighted sign of the pair is more legible than the lighted sign.

An analysis of variance procedure was used to test for the equality of legibility distances under lighted and unlighted conditions for various sign types. The ordered difference in mean legibility distances for each test sign pair are listed in Table 5. The two-way analysis of variance model using distances as the dependent variable and the lighted and unlighted condition as the classification variable, revealed there was a significant difference among these means ($p \leq .001$). The difference of the average distance for each pair (lighted and unlighted) is listed in Table 4 ordered from largest to smallest. That is, the largest difference in legibility distance was found for sign pair number 15 (super-engineer grade reflective sheeting with reflective button copy). This

Table 3. Overhead Sign Pairs on Both Routes and Sign Materials

Pair Number	Material	Route 1 Signs Lighted No.	Route 2 Signs Unlighted No.
1	ENG/SO	4 SB	5 NB
8	ENG/BC	7 NB	14 SB
10	OP/SO	11 NB	14 NB
11	HI/BC	2 SB	7 NB
13	OP/BC	8 SB	11 SB
14	SE/SO	13 SB	12 NB
15	SE/BC	8 NB	1 SB
16	HI/SO	10 NB	7 SB

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

Table 4. Average and Standard Deviations of All Overhead Test Signs and the Differences Between the Lighted and Unlighted Signs on Both Routes

Pair	n	Material	Differences Avg.	Lighted		Unlighted	
				Avg	Std	Avg	Std
1	14	ENG/SO	129	775	189	646	150
8	17	ENG/BC	-39	908	169	947	235
10	13	OP/SO	-69	692	117	761	103
11	13	HI/BC	-217	666	162	883	185
13	16	OP/BC	38	830	117	792	192
14	15	SE/SO	139	835	164	696	156
15	12	SE/BC	165	907	153	742	82
16	14	HI/SO	50	888	119	838	111

n - number of observations

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

Table 5. Ordered Differences in Legibility between Lighted and Unlighted Overhead Signs

Pair Number	Material	Difference of Mean Distances
15	SE/BC	165
14	SE/SO	139
1	ENG/SO	129
16	HI/SO	50
13	OP/BC	38
8	ENG/BC	-39
10	OP/SO	-69
11	HI/BC	-217

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

sign type had a legibility distance, on the average, 165 feet further under lighted conditions than unlighted. At the other extreme, sign pair number 11 (high specific-intensity reflective sheeting with reflective button copy) was detected 217 feet further under unlighted conditions than lighted conditions. A Ducans multiple range test on these means revealed that sign pairs 15 and 14 (super-engineer reflective grade sheeting with stick-on reflective copy and reflective button copy) were significantly better under lighted conditions. Sign pair 11 was detected significantly better under unlighted conditions. There was no significant difference among the other sign pairs. The statistical analysis, Appendix (F), contains plots of this model by subject and sign pair and reveals the amount of variability inherent in this data set. In this study it was determined that the signs background type, legend type and ambient illumination had significant effects on the signs legibility distance. One of the important bits of information that is evident from Table 5 is that some sign material combinations are not greatly affected in legibility distance by the presence or absence of sign lighting (OP/BC, ENG/BC).

The statistical analysis indicates that several parameters which are usually considered as reliable indications of both sign legibility and target value were not reliable in this study. These parameters were (1) background luminance, (2) legend luminance, (3) contrast ratios, and (4) background complexity. Background luminance and legend luminance did not prove to be a reliable indicator because of the variability of the data. It is virtually impossible to obtain the exact background and legend luminance at the instant each test driver read the sign. Without the luminance values for each test driver it is impossible to get a high correlation between the legibility distance and the luminance values. The resultant contrast ratios therefore will also not provide a good correlation. Field data of these parameters will not result in high correlation values as laboratory or controlled field studies. The complexity of the background has an affect on both sign legibility and target value. Several studies have shown this and provided some methodology in trying to understand why this happens. At present there is no methodology which provides numerical values for complexity which can be accurately correlated with legibility and target distance. In some situations the sign is placed in front of a light source whereas in other situations light sources (fixed roadway illumination) are placed in close proximity to the sign face. To study the exact reduction in both legibility distance and target detection, extensive controlled field studies would have to be performed.

VI. FREEWAY GUIDE SIGNS LEGIBILITY STUDY RESULTS

Figure 6 illustrates the differences in legibility distance between lighted and unlighted signs for different sign material combinations. Signs which drivers read at a greater distance with the sign lights turned on have a positive legibility distance difference, whereas those read at a greater distance with the sign lights turned off have a negative legibility distance difference. The two signs which performed extremely well in the lighted condition were super engineer reflective sheeting with reflective button copy and engineer grade reflective sheeting with reflective button copy. High specific-intensity reflective sheeting with reflective button copy performed extremely well in the unlighted condition. This large distance may be the result of this sign being in a rural location. All other combinations performed equally well in the lighted and unlighted conditions.

A study of the signs background and legend material indicate that the sign combination which had the best legibility distance in the unlighted condition was engineer grade reflective sheeting with reflective button copy (947 feet). The variance, however, was extremely large (253 feet). This means that the legibility distances ranged from 712 feet to 1182 feet with a mean of 947 feet. A large proportion of the drivers will be able to read the signs with this combination at 1100 feet while others can read it at 712 feet. High specific-intensity reflective sheeting with reflective button copy had the greatest differential between the lighted and unlighted condition and was seen best in the unlighted condition.

Table 7 presents the sign material combinations with their associated legibility distance in the lighted and unlighted conditions, and variance. In the lighted condition super engineer grade reflective background with reflective button copy and engineer grade reflective sheeting with reflective button copy

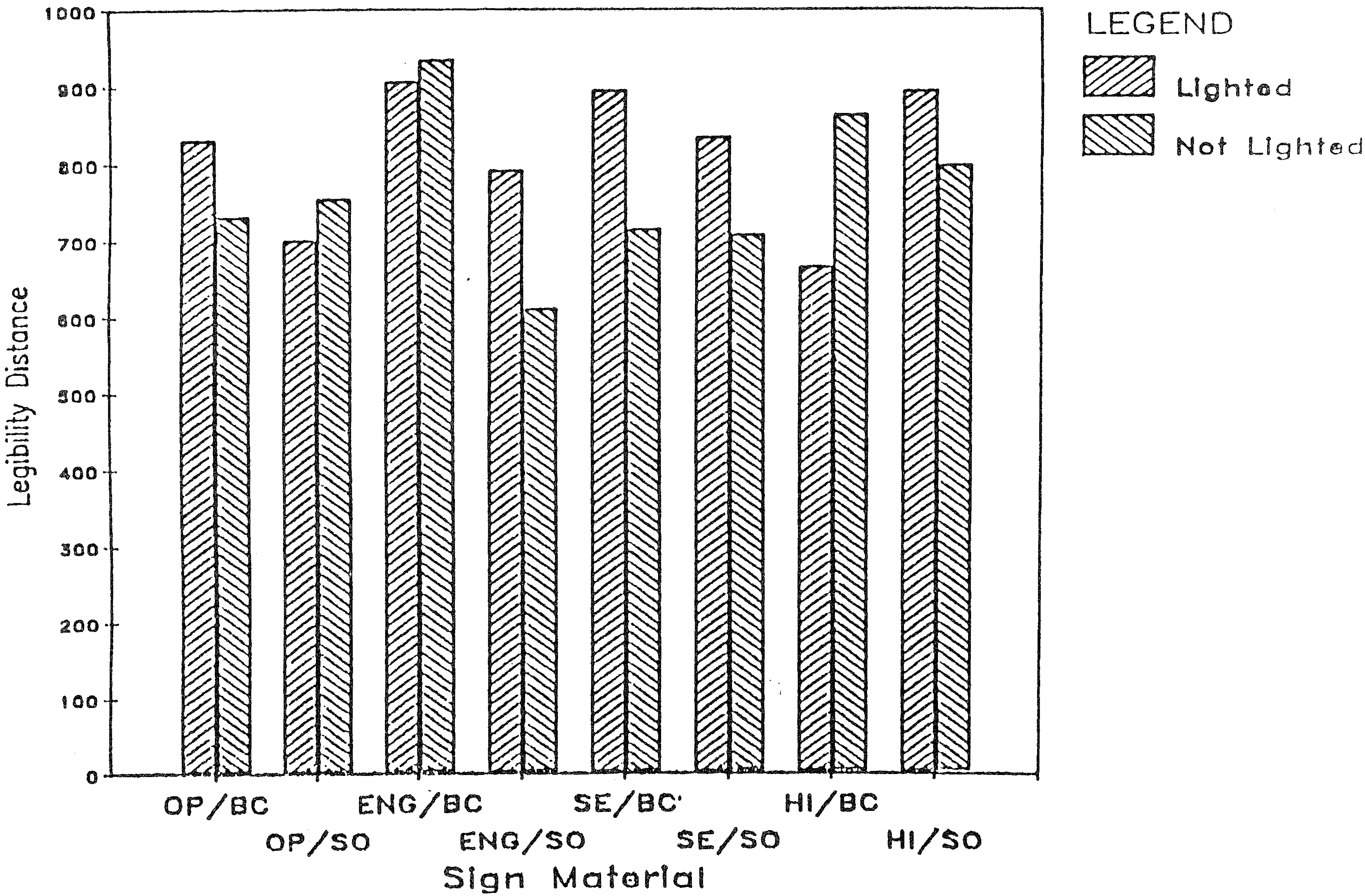

Figure 6. Legibility Distance of Lighted and Unlighted Signs by Materials.

had the longest legibility distance. High specific-intensity reflective sheeting with high specific-intensity grade reflective stick-on copy, opaque with reflective button copy and engineer grade reflective sheeting with stick-on reflective copy, high specific-intensity grade reflective sheeting with reflective button copy and super engineer reflective sheeting with stick-on copy had the poorest legibility distances in the lighted condition, all having less than 700 feet. The lighted condition resulted in more uniform variances than the unlighted condition.

In the unlighted condition engineer grade reflective sheeting with reflective button copy was the only combination resulting in a legibility distance greater than 900 linear feet. The 947 linear feet is longer than the 907 linear feet in the lighted condition. High specific-intensity reflective sheeting with reflective button copy, high specific-intensity reflective sheeting with reflective stick-on copy, opaque with reflective button copy, opaque with high specific-intensity grade reflective stick-on copy and super engineer grade reflective sheeting with reflective button copy had legibility distances ranging from 742 linear feet to 883 linear feet. Super engineer grade reflective sheeting with high specific-intensity grade reflective stick-on copy and engineer grade reflective sheeting with high specific-intensity grade reflective stick-on copy had legibility distances less that 700 linear feet. The unlighted condition resulted in a wider variance range (82 linear feet - 235 linear feet) than the lighted condition (116 feet - 189 feet).

Table 8, presents the different sign combinations ranked in order by legibility distance. Engineer grade reflective sheeting with reflective button copy was legible over 900 linear feet in both the lighted and unlighted conditions. This sign material combination has excellent legibility distance and provides over eleven (11) seconds of travel time for the motorist to change lanes. On

Table 7. Legibility Distance and Standard Deviation for Lighted and Unlighted Overhead Signs, by Sign Materials Combinations

Sign Material	Distance (Ft.)		Standard Deviation	
	Lighted	Unlighted	Lighted	Unlighted
SE/BC	907	742	153	82
SE/SO	635	696	164	156
ENG/SO	775	646	189	150
HI/SO	888	838	119	111
OP/BC	830	792	117	192
ENG/BC	908	947	169	235
OP/SO	692	761	117	103
HI/BC	666	883	162	185

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

Table 8. Sign Materials Legibility, Distance for Lighted and Unlighted Overhead Sign Conditions Ranked by Legibility Distance

Rank Order	Sign Pair Number	Sign Material	Lighted Distance (Ft.)	Sign Pair Number	Sign Material	Unlighted
1	8	ENG/BC	908	8	ENG/BC	947
2	15	SE/BC	907	11	HI/BC	883
3	16	HI/SO	888	16	HI/SO	838
4	14	SE/SO	835	13	OP/BC	792
5	13	OP/BC	830	10	OP/SO	761
6	1	ENG/SO	775	15	SE/BC	742
7	10	OP/SO	692	14	SE/SO	696
8	11	HI/BC	666	1	ENG/BC	646

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

most large freeways with 3 to 4 lanes the driver would require between 900 - 1300 linear feet depending on the freeway level of service and number of lanes (11). This sign combination would provide sufficient distance if it were placed as close as 353 linear feet upstream from the exit.

Table 9 presents the legibility distances for each sign combination in the standard feet per inch of letter height. In this study all signs used sixteen (16) inch upper case with twelve (12) inch lower case letters. The lighted signs ranged from 37 feet/inch for high specific-intensity reflective sheeting with reflective button copy to 57 feet/inch for engineer grade reflective sheeting with reflective button copy and super engineer grade reflective sheeting with reflective button copy. For the unlighted overhead signs the signs ranged from 38 feet/inch for engineer grade reflective sheeting with high specific-intensity reflective grade stick-on copy to 59 feet/inch for engineer grade reflective sheeting with reflective button copy. For the ground mounted signs, the signs ranged from 38 feet/inch with engineer grade reflective sheeting with high-specific-intensity grade reflective stick-on copy to 51 feet/inch for super engineer grade reflective sheeting with reflective button and high specific-intensity reflective grade stick-on copy and opaque with high specific-intensity grade reflective stick-on copy. This analysis points out the non-significant differences with respect to sign lighting and sign location. One comment should be made at this time with respect to the legibility distance of the signs using high specific-intensity reflective sheeting with reflective button copy in the lighted condition. The legibility distance indicates that in the lighted condition specular glare reduced the distance the drivers were able to read the sign. This condition did not occur with signs using engineer grade reflective sheeting with reflective button copy and super engineer grade reflective sheeting with reflective button copy. All other sign combinations were legible

Table 9. Legibility Distance in Feet Per Inch of Letter Height for 16 Inch Letters, Lighted and Unlighted by Sign Material and Location

Material	Sign Location	Legibility Distance (Ft.) Lighted	Unlighted
HI/BC	OVH	42	55
	GND	--	47
HI/SO	OVH	56	52
	GND	--	50
SE/BC	OVH	57	46
	GND	--	52
SE/SO	OVH	52	44
	GND	--	51
ENG/BC	OVH	57	59
	GND	--	50
ENG/SO	OVH	48	40
	GND	--	38
OP/BC	OVH	52	50
	GND	--	50
OP/SO	OVH	43	48
	GND	--	51

Background Materials

ENG - Engineer Grade Reflective Sheeting
OP - Opaque
HI - High Specific-Intensity Reflective Sheeting
SE - Super-Engineer Grade Reflective Sheeting

Legend Materials

BC - Reflective Button Removable
SO - High Specific-Intensity Reflective Sheeting

Sign Locations

OVH - Overhead
GND - Ground mounted

farther with both reflective button and high specific-intensity grade reflective stick-on copy and the opaque background with stick-on copy were legible farther on ground-mounted signs than overhead. All other combinations were legible farther on overhead than ground-mounted signs.

Background Luminance, Legend Luminance and Ambient Light

One basic factor of sign design which contributes to the signs target value and to a lesser degree to the legibility of the sign is the background retroreflective property. Many studies have pointed out that as the amount of retroreflectivity increases, the signs conspicuity increases. Additional factors which may contribute to the signs conspicuity are (1) the sign location (overhead or shoulder mounted), (2) the presence of freeway illumination, (3) the presence of sufficient traffic volumes to increase illumination on the signs (traffic stream illumination), and (4) the presence of sign lighting.

The legibility distance of a sign is dependent to a large extent on the contrast ratio between the background and legend luminance.

In an attempt to correlate the legibility distances of the test signs to background luminance, legend luminance and ambient light, photometric readings were taken in the field to measure these items for each test sign. The measurements were made with a Pritchard photometer, using a 6' aperture at a distance of 300 feet. Five readings were taken at each location. The variation in the readings due to changes in the amount of light from vehicle headlights indicated that under field conditions, photometric data is of questionable value and any one reading could not be duplicated. It was determined that no valid conclusions could be obtained from the photometric data collected under actual field conditions without some control over the traffic stream which was impossible in our study sections.

Sign Lighting

Sign lighting effects were determined by averaging the legibility distance for all lighted overhead guide signs and comparing that to the average legibility distance for all unlighted overhead guide signs. The average legibility distance for the lighted signs was 813 linear feet and the average legibility distance for the unlighted signs was 788 linear feet. This twenty-five (25) foot difference is not statistically significant. The legibility distance had a range of 242 linear feet (908-666) on the lighted signs and the unlighted signs had a range of 301 linear feet (947-646). This indicates that the variability of the legibility distance is reduced by sign lighting.

Sign Mounting

In analyzing the effect of sign mounting (overhead vs. ground), legibility distances for the ground mounted signs on both routes were combined and compared to the legibility distance of unlighted overhead signs. This analysis compared all unlighted signs by mounting type. The overhead unlighted signs had an average legibility distance of 788 linear feet and the ground mounted signs had an average legibility distance of 787 linear feet. The unlighted overhead guide signs had a range of 301 linear feet compared to the ground mounted range of 222 linear feet (878-656). The variability of the ground mounted signs is less than the overhead signs.

Age Group

The test drivers were grouped according to age and classified as young (less than 40) and old (over 40). The legibility distances for all test signs were averaged and also tested by sign mount. It was found that for both overhead and ground mounted the younger drivers performed consistently better than the older drivers. The younger drivers had an average legibility distance of 29 feet longer.

APPENDIX A. LUMINANCE VALUES OF OVERHEAD AND SHOULDER-MOUNTED SIGNS (YOUNG-BLOOD AND WOLTMAN)

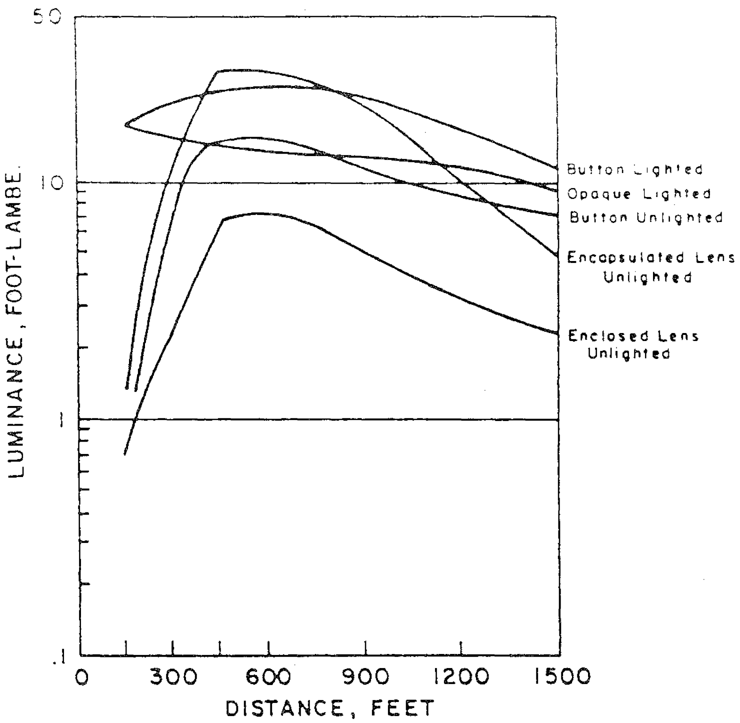

Figure A-1. Nighttime Luminance of Sign legends Versus Distance for Overhead Signs, High Beams.

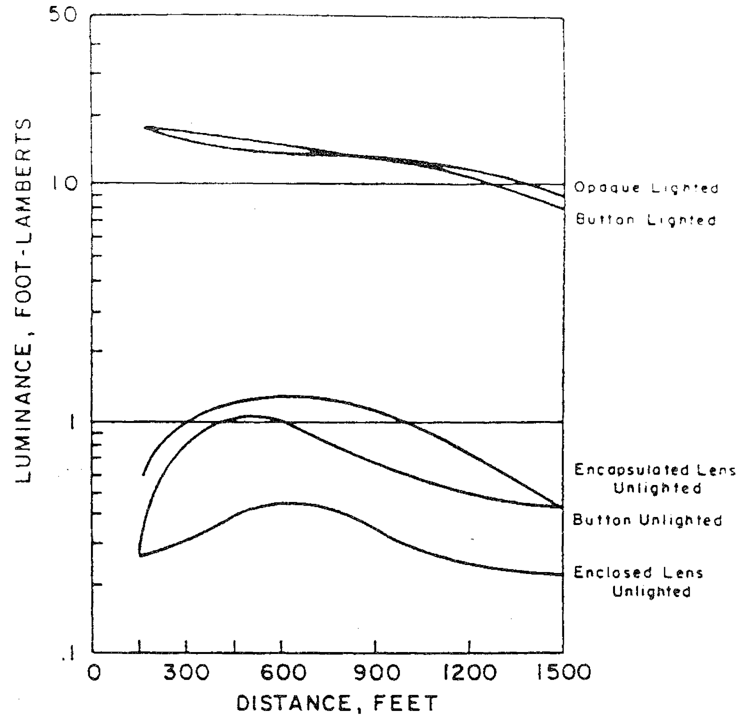

Figure A-2. Nighttime Luminance of Sign Legends Versus Distance for Overhead Signs, Low Beams.

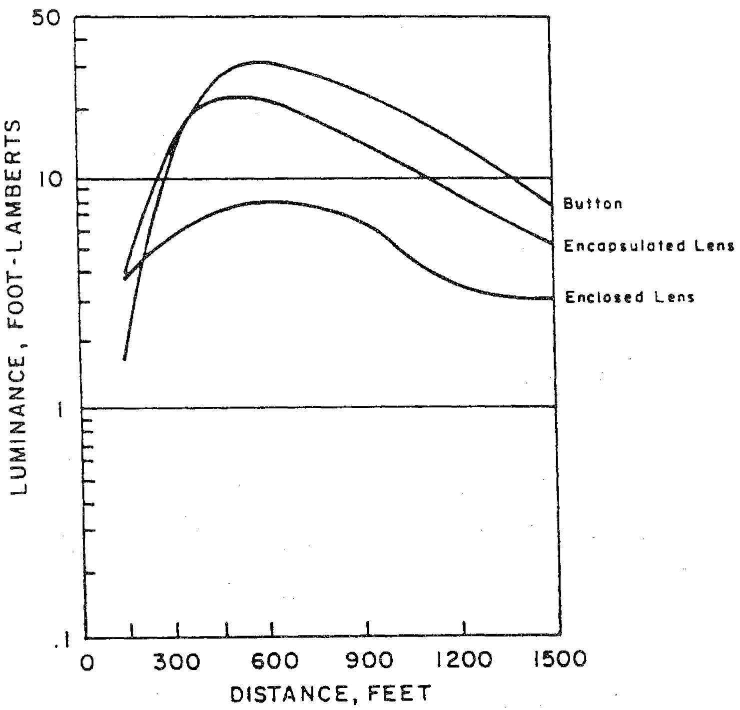

Figure A-3. Nighttime Luminance of Sign Legends Versus Distance for Shoulder-Mounted Signs, High Beams.

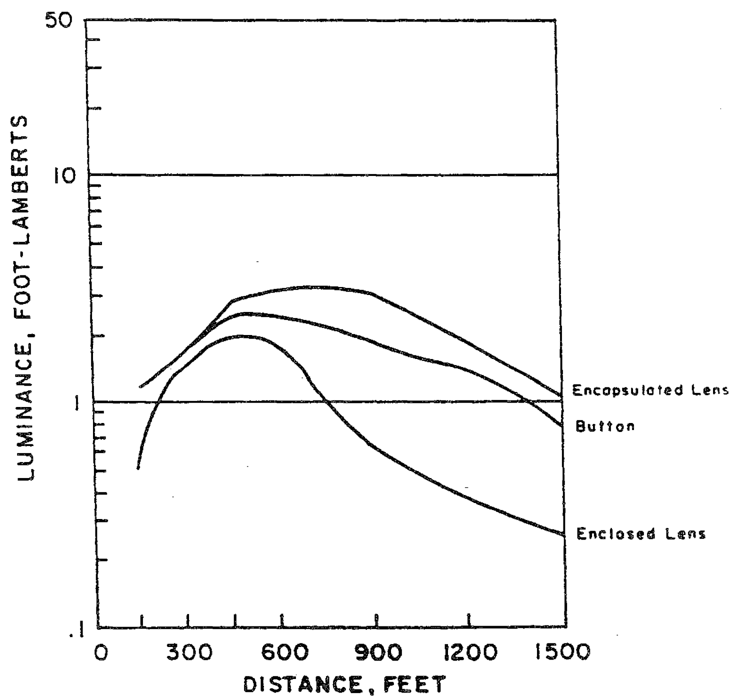

Figure A-4. Nighttime Luminance of Sign Legends Versus Distance for Shoulder-Mounted Signs, Low Beams.

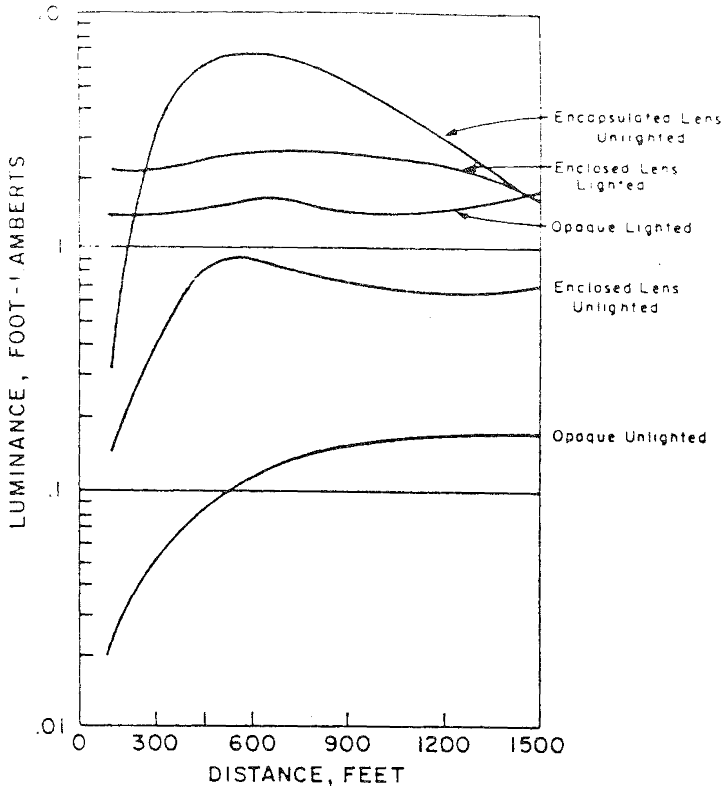

Figure A-5. Nighttime Luminance of Sign Backgrounds Versus Distance for Overhead Signs, High Beams.

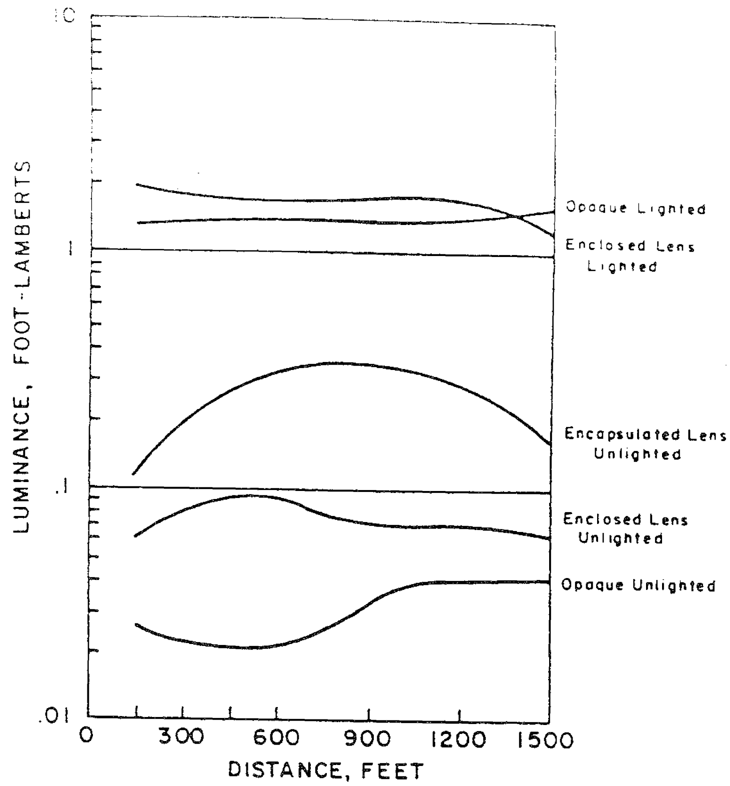

Figure A-6. Nighttime Luminance of Sign Backgrounds Versus Distance for Overhead Signs, Low Beams.

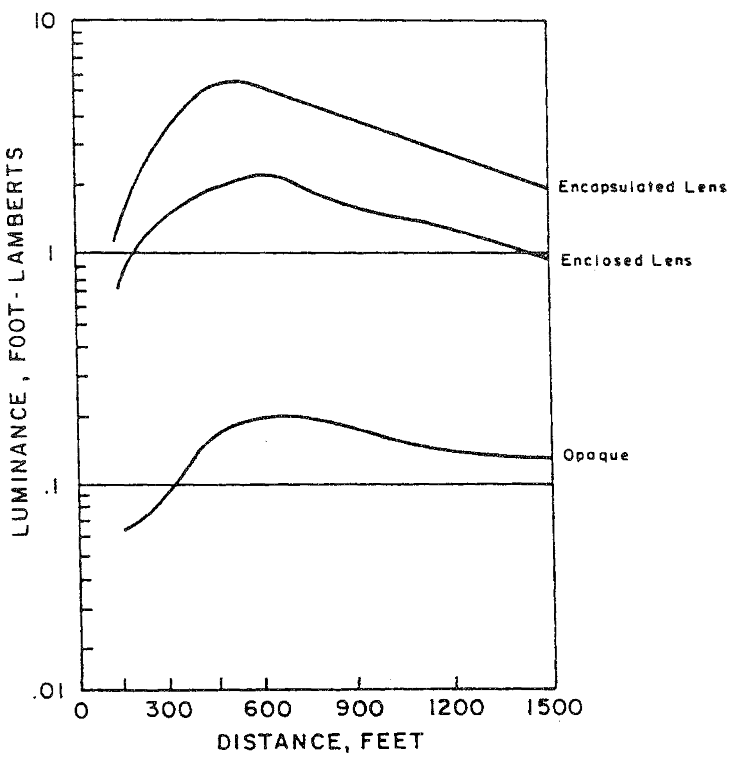

Figure A-6. Nighttime Luminance of Signs Backgrounds Versus Distance for Shoudler-Mounted Signs, High Beams.

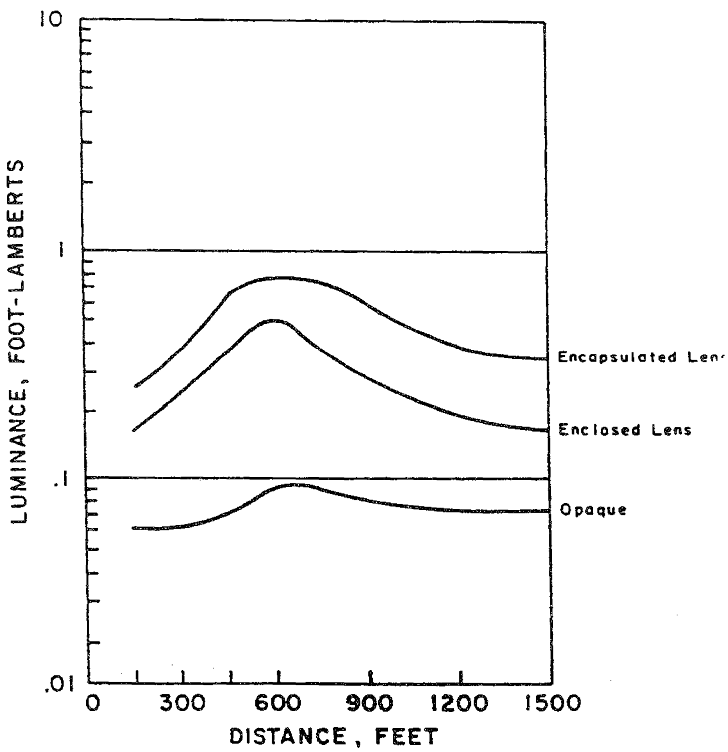

Figure A-7. Nighttime Luminance of Sign Backgrounds Versus Distance for Shoulder-Mounted Signs, Low Beams.

APPENDIX B. STANDARD SPECIFICATIONS FOR CONSTRUCTION OF ROADS AND BRIDGES ON FEDERAL HIGHWAY PROJECTS FP-79-1979 SECTION 633.06--SHEET REFLECTIVE MATERIALS

Standard Specifications for Construction of Roads and Bridges on Federal Highway Projects FP-79 1979 Section 633.06 – Sheet Reflective Materials

633.06 Sheet Reflective Materials. Type I, Type II, Type III, and Type IV reflective sheeting.

(a) *Description*

Reflective sheeting shall consist of a retroreflective lens system having a smooth outer surface. When adhesive backing is used the sheeting shall have a precoated adhesive on the backside protected by an easily removable liner. Types I — IV refer to levels of performance in terms of reflective intensity.

(b) *Color Requirements*

(1) The colors specified shall be matched visually and shall be within the color tolerance limits shown on the appropriate Highway Color Tolerance Charts issued by the Federal Highway Administration utilizing the instructions thereon. Certification as to conformance with this requirement may be accepted by the purchaser.

(or)

(2) Through instrumental color testing the diffuse day color of the reflective material shall conform to the requirements of Table I or II and shall be determined in accordance with ASTM E 97, "Standard Method of Test for 45-Degree, 0-Degree Directional Reflectance of Opaque Specimens by Filter Photometry." (Geometric characteristics must be confined to illumination within 10 degrees of, and centered about, a direction of 45 degrees from the perpendicular to the test surface; viewing is within 15 degrees of, and center about, the perpendicular to the test surface. Conditions of illumination and observation must not be interchanged.) The standards to be used for reference shall be the MUNSELL PAPERS designated in Table I and II. The papers must be recently calibrated on a spectrophotometer. The test instrument shall be one of the following or approved equal:

1. *GARDNER Multipurpose Reflectometer or Model XL20 Color Difference Meter.*
2. *GARDNER Model AC-2a Color Difference Meter or Model XL30 Color Difference Meters.*
3. *MEECO Model V Colormaster*
4. *HUNTERLAB D25 Color Difference Meter*

(c) *Reflective Intensity*

The reflective sheeting shall have minimum Specific Intensity per unit area (SIA) as shown in Tables III, IV, V, or VI expressed as "candelas per footcandle per square foot" [(C d fc $^{-1}$) ft. $^{-2}$]. Four levels of performance relative to SIA are available to be selected by the purchaser for specific uses. Measurement of SIA shall be conducted in accordance with the method detailed in Section 718.

(d) *Specular Gloss*

The reflective sheeting shall have an 85 degree specular gloss of not less than 40 for types I and II, and not less than 50 for III– IV, when tested in accordance with ASTM D 523.

(e) *Color Processing*

The sheeting shall permit cutting and color processing with compatible transparent and opaque process inks in accordance with the Manufacturers recommendation at temperatures of 60°F to 100°F and relative humidity R.H. at 20 to 80 percent. The sheeting shall be heat resistant and permit force curing without staining of applied or unapplied sheeting at temperatures as recommended by the manufacturer. Color processing for Type III material shall be restricted to sheeting with heat activated adhesive backing unless otherwise recommended by the manufacturer.

(f) *Shrinkage*

A 9 inch by 9 inch reflective sheeting specimen with liner shall be conditioned a minimum of 1 hour at 72°F and 50 percent relative humidity. The liner shall be removed and the specimen placed on a flat surface with the adhesive side up. Ten minutes after liner is removed and again after 24 hours, the specimen shall be measured to determine the amount of dimensional change. The reflective sheeting shall not shrink in any dimension more than 1/32 inch in 10 minutes nor more than 1/8 inch in 24 hours.

(g) *Flexibility*

Types I and II Sheeting Material: The sheeting, applied according to the manufacturer's recommendations to a clean, etched 0.020 inch by 2 inch by 8 inch aluminum panel of alloy 6061-T6 conditioned a minimum of 48 hours and tested at 72°F and 50 percent relative humidity shall be sufficiently flexible to show no cracking when bent around a 3/4 inch mandrel.

633.06

TABLE I
Color Specification Limits and Reference Standards
Types I and II Sheeting

Color	Chromaticity Coordinates* (Corner points) 1 x	1 y	2 x	2 y	3 x	3 y	4 x	4 y	Reflectance Limits (%Y) Y Min.	Max	Reference Standard*** (Munsell Papers)
White**	.305	.290	.350	.342	.321	.361	.276	.308	35	--	6.3GY 6.77/0.8
Red	.602	.317	.664	.336	.644	.356	.575	.356	8	12	8.2R 3.78/14.0
Orange	.535	.375	.607	.393	.582	.417	.635	.399	18	30	2.5YR 5.5/14.0
Brown	.445	.353	.604	.396	.556	.443	.445	.386	4	9	5.0YR 3/6
Yellow	.482	.450	.532	.465	.506	.494	.475	.485	29	45	1.25Y 6/12
Green	.130	.369	.180	.391	.155	.460	.107	.439	3.5	9	0.65BG 2.84/8.45
Blue	.147	.075	.176	.091	.176	.151	.106	.113	1.0	4	5.8PB 1.32/6.8

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illumination source C.

**Silver white is an acceptable color designation.

***Available from Munsell Color Company; 2441 Calvert St., Baltimore, MD, 21218.

TABLE II
Color Specification Limits and Reference Standards
Types III and IV Sheeting

Color	Chromaticity Coordinates* (Corner points) 1 x	1 y	2 x	2 y	3 x	3 y	4 x	4 y	Reflectance Limits (%Y) Y Min.	Max	Ref. Std.*** (Munsell Papers)
White**	.303	.287	.368	.353	.340	.380	.274	.316	27	—	5.0PB 7/1
Red	.613	.297	.708	.292	.636	.364	.558	.352	2.5	11	7.5R 3/12
Orange	.550	.360	.630	.370	.581	.418	.516	.394	14	30	2.5YR 5.5/14
Yellow	.498	.412	.557	.442	.479	.520	.438	.472	15	40	1.25Y 6/12
Green	.030	.380	.166	.346	.286	.428	.201	.776	3	8	10G 3/8
Blue	.144	.030	.244	.202	.190	.247	.066	.208	1	10	5.8PB 1.32/6.8

*The four pairs of chromaticity coordinates determine the acceptable color in terms of the CIE 1931 standard colorimetric system measured with standard illumination source C.

**Silver white is an acceptable color designation.

***Available from Munsell Color Company, 2441 Calvert St., Baltimore, MD, 21218.

TABLE III
Minimum Specific Intensity Per Unit Area (SIA)
(Candelas Per Footcandle Per Square Foot)
Type I Sheeting

Observation Angle (°)	Entrance Angle (°)	White	Red	Orange	Brown	Yellow	Green	Blue
0.2	−4	50	10	13.0	1.0	25	5	3.8
0.2	+30	12	3	4.0	0.3	7	2	1.0
0.5	−4	15	5	6.5	0.3	10	3	2.0
0.5	+30	6	1	2.5	0.2	3	1	0.8

TABLE IV
Minimum Specific Intensity Per Unit Area (SIA)
(Candelas Per Footcandle Per Square Foot)
Type II Sheeting

Observation Angle (°)	Entrance Angle (°)	White	Red	Orange	Brown	Yellow	Green	Blue
0.2	−4	70	14.5	25.0	1.0	50	9.0	4.0
0.2	+30	30	6.0	7.0	0.3	22	3.5	1.7
0.5	−4	30	7.5	13.5	0.3	25	4.5	2.0
0.5	+30	15	3.0	4.0	0.2	13	2.2	0.8

TABLE V

Minimum Specific Intensity Per Unit Area (SIA)
(Candelas Per Footcandle Per Square Foot)
Type III Sheeting

A — Glass Bead Retro-Reflective Element Material

Observation Angle (°)	Entrance Angle (°)	White	Red	Orange	Yellow	Green	Blue
0.2	−4	250	45	100	170	45	20.0
0.2	+30	150	25	60	100	25	11.0
0.5	−4	95	15	30	62	15	7.5
0.5	+30	65	10	25	45	10	5.0

B—Prismatic Retro-Reflective Element Material

Observation Angle (°)	Entrance Angle (°)	White	Red	Orange	Yellow	Green	Blue
0.2	−4	250	45.0	100	170	45.0	20.0
0.2	+30	95	13.3	26	64	11.4	7.6
0.5	−4	200	28.0	56	136	24.0	18.0
0.5	+30	65	10.0	25	45	10.0	5.0

TABLE VI

Minimum Specific Intensity Per Unit Area (SIA)
(Candelas Per Foot Candle Per Square Foot)
Type IV Sheeting*

Observation Angle (°)	Entrance Angle (°)	White	Red	Orange	Yellow	Green	Blue
0.2	−4	250	35.0	70	170	30.0	20.0
0.2	+30	95	13.3	26	64	11.4	7.6
0.5	−4	200	28.0	56	136	24.0	18.0
0.5	+30	60	8.4	17	40	7.2	4.8

*Test samples are to be mounted in accordance with manufacturer's recommendation.

Type III and IV Sheeting Material: The sheeting, with the liner removed and conditioned for 24 hours at 72°F and 50 percent R. H., shall be sufficiently flexible to show no cracking when slowly bent, in one second's time, around a 1/8 inch mandrel with adhesive contacting the mandrel. NOTE: For ease of testing, spread talcum powder on adhesive to prevent sticking to the mandrel.

Non-adhesive sheetings shall show no signs of cracking or crazing when flexed repeatedly over a 1/16 inch mandrel to 180° at 72°F.

(h) *Adhesive*

The reflective sheeting shall include a pre-coated pressure sensitive adhesive backing (Class 1) or a tack-free heat activited adhesive backing (Class 2) either of which may be applied without necessity of additional adhesive coats on either the reflective sheeting or application surface.

The Class 1 adhesive shall be a pressure sensitive adhesive of the aggressive tack type requiring no heat solvent or other preparation for adhesion to smooth clean surfaces. The Class 2 adhesive backing shall be a tack-free adhesive activated by applying heat in excess of 175°F to the material as in the heat-vacuum process of sign fabrication.

The protective liner attached to the adhesive shall be removed by peeling without soaking in water or other solvents without breaking, tearing or removing any adhesive from the backing. The protective liner shall be easily removed following accelerated storage for 4 hours at 160°F under a weight of 2.5 pounds per square inch.

The adhesive backing of the reflective sheeting shall produce a bond to support a 1 3/4 pound weight for 5 minutes, without the bond peeling for a distance of more than 2.0 inches when applied to a smooth aluminum surface and tested as specified in Section 718.

(i) *Impact Resistance*

Types I, II and III reflective sheeting material, applied according to the manufacturer's recommendations to a cleaned, etched aluminum panel of alloy 6061-T6, 0.04 inches by 3.0 inches by 5 inches and conditioned for 24 hours at 72°F and 50 percent R.H., shall show no cracking when the face of the panel is subjected to an impact of a 2.0 pound weight with a 5/8 inch rounded tip dropped from a 10 inch pound setting on a Gardner Variable Impact Tester, 1G-1120. For Type IV material a 100-inch-pound setting should be used.

(j) *Accelerated Weathering*

When applied in accordance with recommended procedures, the reflective material shall be weather resistant and, following cleaning in accordance with manufacturers recommendations, shall show no appreciable discoloration, cracking, blistering or dimensional change. Following exposure, the panels shall be washed with a 5% HCl solution for 45 seconds, rinsed thoroughly with clean water, blotted with a soft clean cloth, brought to equilibrium at standard conditions and tested. It shall have not less than the percent of the minimum SIA specified in the table below when subjected to accelerated weathering in accordance with ASTM G23, Type E or EH Weatherometer with the humidifier off.

Type of Material	Hours Tested	Minimum Specific Intensity Per Unit Area
I	1000	50% of Table III
II	1000	50% of Table IV
III	2200 *	80% of Table V
IV	250	50% of Table VI

*For orange material having glass bead retro-reflective elements, the hours tested shall be 600.

(k) *Intended Use*

The reflective sheeting specified herein is intended for use on surfaces of highway signs and other traffic control devices to assure their optimum visibility by day and at night when exposed to a light source and whether dry or totally wet by rain.

Purchasers should select colors and preferred options permitted herein and specify (1) the desired level of SIA (Type I, Type II, Type III or Type IV) as appropriate for anticipated use and durability, and (2) the type of adhesive backing (class 1, precoated pressure sensitive adhesive or class 2, heat activated adhesive) or other type of non-adhesive backing as required.

APPENDIX C. TEST ROUTES AND TEST SIGN LOCATIONS AND TEXT

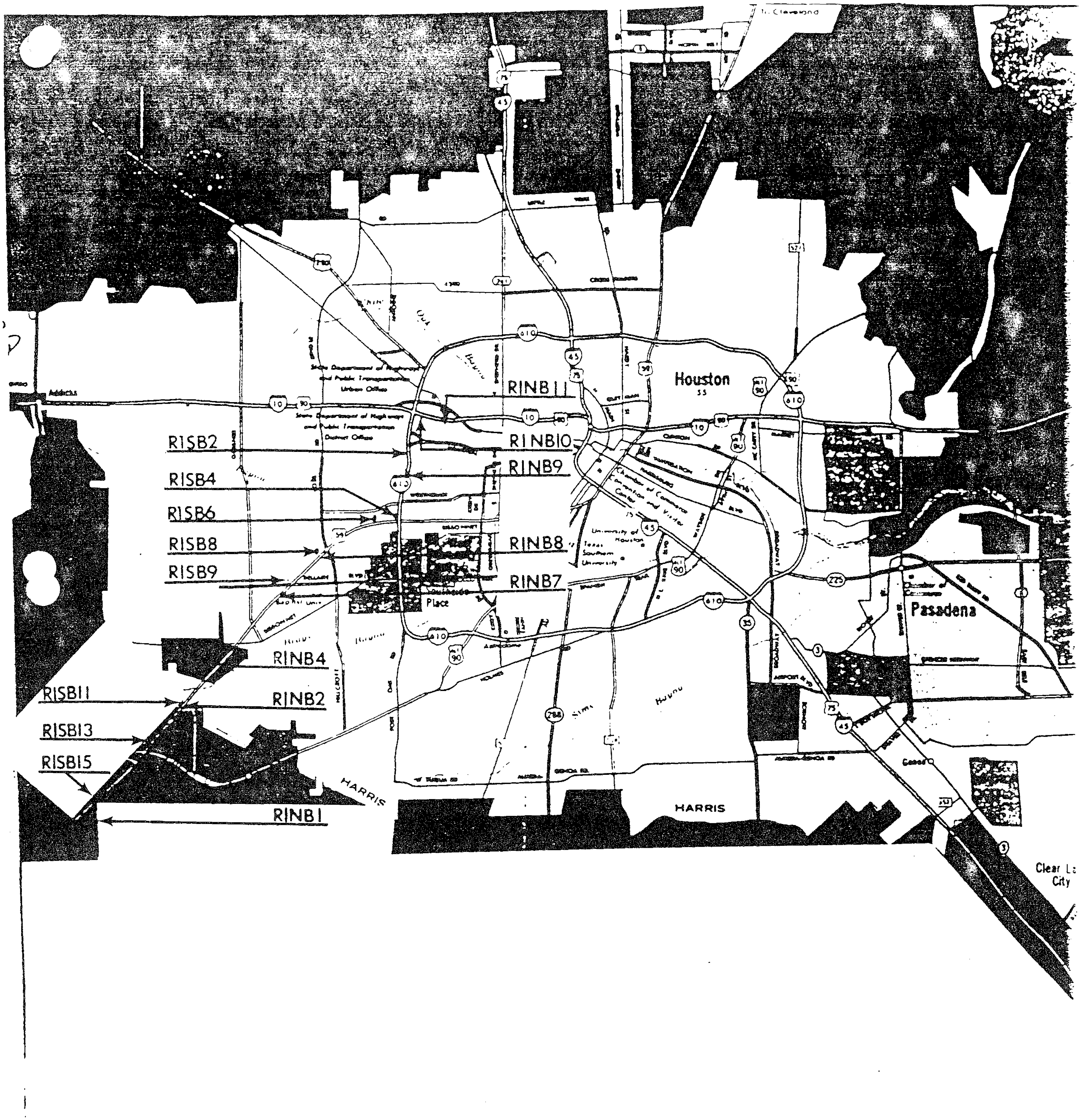

Figure C-1. Map of Houston With Location of Signs on US 59--Lighted Route.

Table C-1. Listing of Test Signs with Messages, Location of Sign, Types of Material Construction Sign and Code Number for the Lighted Route in the Southbound Direction

SIGN	LOCATION	MOUNT	TYPE	CODE
Post Oak Blvd 1/4 San Felipe Rd 3/4 Westhiemer Rd 3/4	I-610 WEST	OVH	HI/BC	R1SB2
Richmond Ave ↗	I-610 WEST	OVH	EG/SO	R1SB4
Chimney Rock Rd City of Bellaire ↗	US-59 SOUTH	GND	HI/BC	R1SB6
Bellaire Blvd EXIT 1 MILE	US-59 SOUTH	OVH	OP/BC	R1SB8
Houston Baptist University NEXT RIGHT	US-59 SOUTH	GND	SE/BC	R1SB9
Airport Blvd Kirkwood Rd EXIT 1/2 MILE	US-59 SOUTH	GND	OP/SO	R1SB11
ALT SPUR 90 41 Sugar Land ↓ EXIT ONL	US-59 SOUTH	OHV	SE/SO	R1SB13
Williams Trace Blvd ↗	US-59 SOUTH	GND	EG/BC	R1SB15

All Ground Mounted Signs (GND) are unlighted.
All Overhead Mounted Signs (OVH) are lighted.

Table C-2. Listing of Test Signs with Messages, Location of Sign, Types of Sign Construction Materials and Code Number for the Lighted Route in the Northbound Direction

SIGN	LOCATION	MOUNT	TYPE	CODE
Williams Trace Blvd ↗	US-59 SOUTH	GND	EG/SO	R1NB1
W Bellfort Ave NEXT RIGHT	US-59 SOUTH	GND	HI/SO	R1NB2
Bissonnet St EXIT 3/4 MILE	US-59 SOUTH	GND	SE/SO	R1NB4
Fondren Rd Bellaire Blvd ↗	US-59 SOUTH	OVH	EG/BC	R1NB7
Hillcroft Ave ↗	US-59 SOUTH	OVH	SE/BC	R1NB8
San Felipe Rd NEXT RIGHT	I-610 WEST	GND	OP/BC	R1NB9
Westcott St Washington Ave 1 MILE	I-10 EAST	OVH	HI/SO	R1NB10
Westcott St 1/2 Washington Ave 1/2 T C Jester Blvd 1 1/4	I-10 EAST	OVH	OP/SO	R1NB11

All Ground Mounted Signs (GND) are unlighted.
All Overhead Mounted Signs (OVH) are lighted.

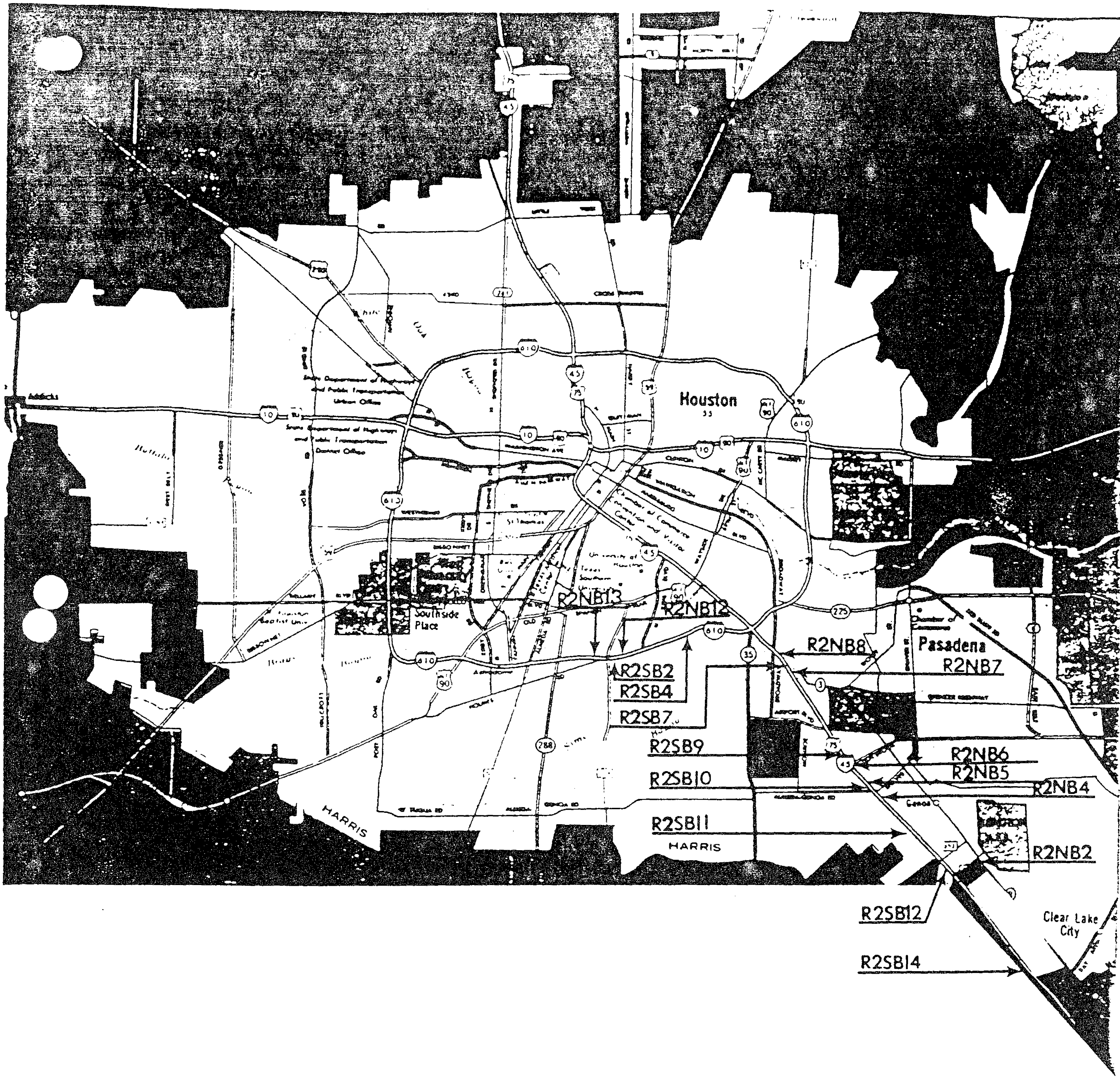

Figure C-2. Map of Houston With Location of Signs on US 59--Unlighted Route.

Table C-3. Listing of Test Signs with Messages, Location of Sign, Sign Construction Materials and Code Number for the Unlighted Route in the Southbound Direction

SIGN	LOCATION	MOUNT	TYPE	CODE
Scott St EXIT 3/4 MI	I-610 SOUTH	OVH	SE/BC	R2SB2
Long Dr S Wayside Dr	I-610 SOUTH	GND	HI/SO	R2SB4
TEXAS 3 Monroe Dr	I-45 SOUTH	OVH	HI/SO	R2SB7
Edgebrook Dr Clearwood Dr RIGHT LANE	I-45 SOUTH	GND	SE/SO	R2SB9
South Shaver Rd Almeda Genoa Rd RIGHT LANE	I-45 SOUTH	GND	OP/SO	R2SB10
FM 1959 Ellington Field Choate Rd EXIT 1 7/10 MI	I-45 SOUTH	OVH	OP/BC	R2SB11
FM 1959 Ellington Field Choate Rd RIGHT LANE	I-45 SOUTH	GND	EG/BC	R2SB12
El Dorado Blvd	I-45 SOUTH	OVH	EG/BC	R2SB14

All Ground Mounted Signs (GND) are unlighted.
All Overhead Mounted Signs (OVH) are unlighted.

Table C-4. Listing of Test Signs with Messages, Location of Sign, Sign Construction Materials, and Code Number for the Unlighted Route in the Northbound Direction

SIGN	LOCATION	MOUNT	TYPE	CODE
FM 1959 Ellington Field Choate Rd RIGHT LANE	I-45 SOUTH	GND	EG/SO	R2NB2
Almeda-Genoa Rd NEXT RIGHT	I-45 SOUTH	GND	OP/BC	R2NB4
Clearwood Dr Edgebrook Dr EXIT ↓ 3/4 MILE	I-45 SOUTH	OVH	EG/SO	R2NB5
Clearwood Dr Edgebrook Dr RIGHT LANE	I-45 SOUTH	GND	SE/BC	R2NB6
Park Place Blvd Broadway Blvd 1 MILE	I-45 SOUTH	OVH	HI/BC	R2NB7
Park Place Blvd Broadway Blvd NEXT RIGHT	I-45 SOUTH	GND	HI/BC	R2NB8
Calais Rd Holmes Rd EXIT MILE	I-610 SOUTH	OVH	SE/SO	R2NB12
Scott St 1 1/4 MILE	I-610 SOUTH	OVH	OP/SO	R2NB13

All Ground Mounted Signs (GND) are unlighted.
All Overhead Mounted signs (OVH) are unlighted.

APPENDIX D. DATA ACQUISITION FORM

NAME ______________ TAPE COUNT ______________

GROUP ______________ FILE NAME ______________

* = Test Sign

Route 1

South Bound

Legend	Location	Comments

KEY: Post Oak//

1. Post Oak Blvd. Exit 8/10 Mi — Overhead, 2nd of 3 panels

---

*2. Post Oak Blvd. 3/10 / San Felipe Rd. 7/10 / Westheimer Rd. 7/10 — Overhead, Median

---

Post Oak Blvd. — Overhead

KEY: Richmond//

San Felipe / Westheimer / Richmond Ave. — Overhead, Median

---

3. Richmond Ave. Exit 1 1/2 Mi — Overhead, 3rd of 3 panels

Richmond Ave. Exit 1/3 Mi — Overhead, 3rd of 3 panels

---

*4. Richmond Ave. — Overhead

ROUTE 1

South Bound

Legend	Location	Comments
KEY: Chimney Rd.		
5. Chimney Road Rd. Exit 1/2 Mi Exit Only	Overhead on side	
*6. Chimney Rock Rd. City of Bellaire	Ground	
KEY: Bellaire Blvd		
7. Westpark Dr. 1/2 Hillcroft Ave. 1 Bellaire Blvd. 1 3/4	Overhead Median	
*8. Bellaire Blvd. Exit 1 Mi	Overhead 1st of 2 panels	
KEY: Houston Baptist University		
9. Houston Baptist University Next Right	Ground	

ROUTE 1

South Bound

	Legend	Location	Comments
KEY: Airport Blvd///			
10.	Airport Blvd. Kirkwood Rd. Eixt 1 1/2 Mi	Overhead 1st of 2 panels	
*11.	Airport Blvd. Kirkwood Rd. Exit 1/2 Mi	Ground	
	Airport Blvd. Kirkwood Rd.	Overhead 2nd of 2 panels	
KEY: Sugar Land//			
12.	Alt Spur 90 41 SugarLand Exit 1 Mi	Overhead 1st of 2 panels	
*13.	Alt Spur 90 41 Sugar Land Exit Only	Overhead Cantilever	

ROUTE 1

South Bound

	Legend	Location	Comments
KEY: Williams Trace Blvd			
14.	Williams Trace Blvd. Exit 1 1/4 Mi	Overhead 2nd of 3 panels	
	Williams Trace Blvd. Exit 1/2 Mi	Ground	
*15.	Williams Trace Blvd.	Ground	

END OF FIRST HALF

(Take the Flannigan Exit to turn around)

NAME ______________ TAPE COUNT ______________

GROUP ______________ FILE NAME ______________

ROUTE 1

North Bound

	Legend	Location	Comments
KEY: Williams			
	WilliamsTrace Blvd. Exit 1/2 Mi	Ground	
*1.	Williams Trace Blvd.	Ground	
KEY: West Bellfort Ave			
*2.	W. Bellfort NEXT RIGHT	Ground	
KEY: Bissonnet St			
*3.	Bissonnet St. Exit 1 1/4 Mi	Overhead 1st of 2 panels	
4.	Bissonet Exit 3/4 Mi.	Ground	
5.	Bissonnet St.	Overhead 2nd of 2 panels	
KEY: Fondren Rd			
6.	Fondren Rd. Bellaire Blvd. Exit 1 1/4 Mi	Overhead 1st of 2 panels	

ROUTE 1

North Bound

	Legend	Location	Comments
7.	Fondren Rd. Bellaire Blvd.		

KEY: Hillcroft Ave//

*8.	Hillcroft Ave. Ave.	Overhead	

KEY: San Felipe//

	San Felipe Exit 4/10 Mi	Overhead 1st of 2 panels	
*9.	San Felipe NEXT RIGHT	Overhead	

KEY: Washington Ave//

*10.	Westcott St. Washington Ave. 1 Mi.	Overhead	
*11.	Westcott St. 1/2 Washington Ave. 1/2 TC Jester Blvd. 1 1/4	Overhead	
12.	Exit 764 Westcott St. Washington Ave.	Overhead 3rd of 3p panels	

EXIT AT WASHINGTON AVE.

NAME ______________________ TAPE COUNT ______________________

GROUP ______________________ FILE NAME ______________________

* = Test Sign

ROUTE 2

South Bound

Legend	Location	Comments
KEY: Scott St.		
*1. Scott St Exit 2/10 Mi	Overhead Side Mount	
Scott St	Overhead 3rd of 3 panels	
KEY: Long Dr		
2. Crestmount St. 7/10 Mykawa Rd. 7/10 Long Dr. 1 1/2	Overhead Median	
3. Long Dr. S. Wayside Dr. Exit 8/10 Mi	Overhead 2nd of 3 panels	
Long Dr. 1/2 S. Wayside Dr. 1/2 Telephone Rd. 1 8/10	Overhead Median tee	
*4. Long Dr. S. Wayside Dr.	Ground	
Long Dr. S. Wayside Dr.	Overhead	

ROUTE 2

South Bound

Legend	Location	Comments
KEY: Monroe Rd		
5. Texas 3 Monroe Rd. 1 Mi	Overhead 1st of 2 panels	
6. Texas 3 Monroe Rd. 1/2 Mi	Overhead	
Texas 3 Monroe Rd. NEXT RIGHT	Ground	
*7. Texas 3 Monroe Rd.	Overhead Raised tee Side Mount	
KEY: Edgebrook Dr.		
8. Edgebrook Dr. Clearwood Dr. 1 Mi	Overhead Raised tee on side	
*9. Edgebrook Dr. Clearwood Dr. RIGHT LANE	Ground	

South Bound

Legend	Location	Comments
KEY: Almeda-Genoa Rd		
South Shaver Rd Almeda-Genoa Rd. Exit 1 1/10 Mi	Overhead 2nd of 3 panels	
*10. South Shaver Rd. Almeda-Genoa Rd. RIGHT LANE	Ground	
South Shaver Rd. Almeda-Genoa Rd.	Overhead 3rd of 3 panels	
KEY: Ellington AFB		
*11. FM 1959 Ellington AFB Choate Rd. Exit 1 7/10 Mi	Overhead	
FM 1959 Ellington AFB Choate Rd. RIGHT LANE	Ground	
*12. FM 1959 Ellington AFB Choate Rd. RIGHT LANE	Ground	
FM 1959 Ellington AFB Choate Rd	Overhead 3rd of 3 panels	

KEY: El Dorado Blvd//

13.	El Dorado Blvd. Exit 1 1/2 Mi	Overhead 2nd of 2 panels
*14.	El Dorado Blvd.	Overhead

NAME ______________ TAPE COUNT ______________

GROUP ______________ FILE NAME ______________

* = Test Sign

ROUTE 2

North Bound

	Legend	Location	Comments
KEY: Choate Rd			
1.	FM 1959 Ellington AFB Choate Rd. Exit 1 1/10 Mi	Overhead 2nd of 3 panels	
*2.	FM 1959 Ellington AFB Choate Rd. RIGHT LANE	Ground	
	FM 1959 Ellington AFB Choate Rd.	Overhead 3rd of 3 panels	
KEY: Almeda-Genoa Rd			
3.	Almeda-Genoa Rd South Shaver Rd. Exit 1 1/10 Mi	Overhead	
*4.	Almeda-Genoa Rd NEXT RIGHT	Ground	

North Bound

	Legend	Location	Comments
KEY: Clearwood Dr			
*5.	Clearwood Dr Edgebrook Dr. Exit 8/10 Mi	Overhead	
6.	Clearwood Dr. Edgebrook Dr. RIGHT LANE	Ground	
	Clearwood Dr. Edgebrook Dr.	Overhead 3rd of 3 panels	
KEY: Broadway Rd			
*7.	Exit 39 Broadway Blvd. 1 Mi	Overhead Raised tee	
8.	Park Place Blvd. Broadway Blvd NEXT RIGHT	Ground	
9.	Park Place Blvd Broadway Blvd.	Overhead 3rd of 3 panels	
KEY: Frontage Rd			
10.	Frontage Rd NEXT RIGHT	Raised tee	

	Legend	Location	Comments
KEY: Calais Rd			
11.	Crestmont Dr. 7/10 M L King 7/10 Calais Rd. 1 7/10	Overhead Median	
*12.	Calais Rd Holmes Rd. Exit 1 Mi	Overhead 2nd of 3 panels	
	Calais Rd. 8/10 Holmes Rd/ 8/10 Scott St. 2 1/10	Overhead Median	
KEY: Scott St			
*13.	Scott St 1 1/4 Mi	Overhead 3rd of 4 panels	
14.	Scott St Exit 2/10 Mi	Overhead Sidemount tee	
	Scott St.	Overhead 3rd of 3 panels	

APPENDIX E. LEGIBILITY DATA BASE

SAS

OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
1	V	AM	R1	SB	1	1	N	1	0	584	1	21
2	V	AM	R1	SB	1	1	N	3	0	617	3	23
3	V	AM	R1	SB	1	1	N	5	0	528	5	25
4	V	AM	R1	SB	1	1	N	10	0	787	10	30
5	V	AM	R1	SB	1	1	N	12	0	771	12	32
6	V	AM	R1	SB	1	1	N	14	0	674	14	34
7	V	AM	R1	NB	1	1	N	5	0	535	18	5
8	V	AM	R1	NB	1	1	N	6	0	744	19	6
9	V	AM	R1	NB	1	1	N	12	0	685	25	12
10	IV	EJ	R1	SB	1	0	N	1	0	1200	54	21
11	IV	EJ	R1	SB	1	0	N	3	0	733	55	23
12	IV	EJ	R1	SB	1	0	N	5	0	837	56	25
13	IV	EJ	R1	SB	1	0	N	7	0	865	60	27
14	IV	EJ	R1	SB	1	0	N	10	0	833	62	30
15	IV	EJ	R1	SB	1	0	N	12	0	898	65	32
16	IV	EJ	R1	SB	1	0	N	14	0	749	67	34
17	IV	EJ	R1	NB	1	0	N	5	0	1137	72	5
18	IV	EJ	R1	NB	1	0	N	6	0	1068	73	6
19	IV	EJ	R1	NB	1	0	N	12	0	1093	78	12
20	III	MA	R1	SB	1	0	N	3	0	845	102	23
21	III	MA	R1	SB	1	0	N	5	0	523	104	25
22	III	MA	R1	SB	1	0	N	7	0	488	195	27
23	III	MA	R1	SB	1	0	N	10	0	835	199	30
24	III	MA	R1	SB	1	0	N	12	0	732	201	32
25	III	MA	R1	SB	1	0	N	14	0	637	203	34
26	III	MA	R1	NB	1	0	N	4	0	864	207	4
27	III	MA	R1	NB	1	0	N	5	0	1108	208	5
28	III	MA	R1	NB	1	0	N	6	0	774	209	6
29	III	MA	R1	NB	1	0	N	12	0	1040	215	12
30	III	MJ	R1	SB	2	0	N	1	0	358	244	21
31	III	MJ	R1	SB	2	0	N	3	0	768	246	23
32	III	MJ	R1	SB	2	0	N	5	0	808	248	25
33	III	MJ	R1	SB	2	0	N	7	0	298	250	27
34	III	MJ	R1	SB	2	0	N	10	0	880	253	30
35	III	MJ	R1	SB	2	0	N	12	0	648	255	32
36	III	MJ	R1	SB	2	0	N	14	0	858	257	34
37	III	MJ	R1	NB	2	0	N	3	0	565	258	3
38	III	MJ	R1	NB	2	0	N	12	0	871	267	12
39	VI	EV	R1	SB	1	1	N	1	0	540	295	21
40	VI	EV	R1	SB	1	1	N	3	0	887	298	23
41	VI	EV	R1	SB	1	1	N	5	0	611	300	25
42	VI	EV	R1	SB	1	1	N	7	0	242	302	27
43	VI	EV	R1	SB	1	1	N	10	0	870	305	30
44	VI	EV	R1	SB	1	1	N	14	0	453	309	34
45	VI	EV	R1	NB	1	1	N	5	0	334	314	5
46	VI	EV	R1	NB	1	1	N	6	0	487	315	6
47	VI	EV	R1	NB	1	1	N	12	0	785	321	12
48	VI	PT	R1	SB	4	1	N	1	0	721	350	21
49	VI	PT	R1	SB	4	1	N	3	0	657	352	23
50	VI	PT	R1	SB	4	1	N	5	0	565	354	25
51	VI	PT	R1	SB	4	1	N	7	0	414	358	27
52	VI	PT	R1	SB	4	1	N	10	0	865	359	30
53	VI	PT	R1	SB	4	1	N	12	0	887	361	32
54	VI	PT	R1	SB	4	1	N	14	0	502	363	34
55	VI	PT	R1	NB	4	1	N	5	0	528	369	5
56	VI	PT	R1	NB	4	1	N	12	0	579	375	12

SAS

OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
57	V	CL	R1	SB	2	1	N	1	0	789	404	21
58	V	CL	R1	SB	2	1	N	3	0	806	405	23
59	V	CL	R1	SB	2	1	N	5	0	705	408	25
60	V	CL	R1	SB	2	1	N	7	0	585	410	27
61	V	CL	R1	SB	2	1	N	12	0	792	415	32
62	V	CL	R1	SB	2	1	N	14	0	572	417	34
63	V	CL	R1	NB	2	1	N	5	0	538	422	5
64	V	CL	R1	NB	2	1	N	6	0	805	423	6
65	V	CL	R1	NB	2	1	N	12	0	853	429	12
66	V	EW	R1	SB	9	0	N	1	0	1044	512	21
67	V	EW	R1	SB	9	0	N	3	0	858	514	23
68	V	EW	R1	SB	9	0	N	5	0	780	516	25
69	V	EW	R1	SB	9	0	N	7	0	815	518	27
70	V	EW	R1	SB	9	0	N	10	0	1074	521	30
71	V	EW	R1	SB	9	0	N	12	0	1043	523	32
72	V	EW	R1	SB	9	0	N	14	0	784	525	34
73	V	EW	R1	NB	9	0	N	5	0	800	530	5
74	V	EW	R1	NB	9	0	N	6	0	892	531	6
75	V	EW	R1	NB	9	0	N	12	0	1044	537	12
76	VI	DW	R1	SB	8	0	N	3	0	854	567	23
77	VI	DW	R1	SB	8	0	N	5	0	831	569	25
78	VI	DW	R1	SB	8	0	N	7	0	809	571	27
79	VI	DW	R1	SB	8	0	N	10	0	871	574	30
80	VI	DW	R1	SB	8	0	N	12	0	1002	575	32
81	VI	DW	R1	SB	8	0	N	14	0	805	578	34
82	VI	DW	R1	NB	8	0	N	6	0	1127	583	6
83	VI	DW	R1	NB	8	0	N	12	0	1172	588	12
84	VI	AW	R1	SB	2	1	N	1	0	1147	617	21
85	VI	AW	R1	SB	2	1	N	3	0	873	619	23
86	VI	AW	R1	SB	2	1	N	5	0	821	621	25
87	VI	AW	R1	SB	2	1	N	7	0	810	623	27
88	VI	AW	R1	SB	2	1	N	10	0	1025	626	30
89	VI	AW	R1	SB	2	1	N	12	0	1153	628	32
90	VI	AW	R1	SB	2	1	N	14	0	484	630	34
91	VI	AW	R1	NB	2	1	N	5	0	560	635	5
92	VI	AW	R1	NB	2	1	N	6	0	914	636	6
93	VI	AW	R1	NB	2	1	N	12	0	968	642	12
94	IV	CC	R1	SB	4	0	N	1	0	826	816	21
95	IV	CC	R1	SB	4	0	N	3	0	692	821	23
96	IV	CC	R1	SB	4	0	N	5	0	586	823	25
97	IV	CC	R1	SB	4	0	N	7	0	681	825	27
98	IV	CC	R1	SB	4	0	N	10	0	783	828	30
99	IV	CC	R1	SB	4	0	N	12	0	882	830	32
100	IV	CC	R1	SB	4	0	N	14	0	833	832	34
101	IV	CC	R1	NB	4	0	N	5	0	829	837	5
102	IV	CC	R1	NB	4	0	N	6	0	744	838	6
103	IV	CC	R1	NB	4	0	N	12	0	897	844	12
104	V	JM	R1	SB	3	1	N	3	0	682	874	23
105	V	JM	R1	SB	3	1	N	5	0	679	876	25
106	V	JM	R1	SB	3	1	N	7	0	771	878	27
107	V	JM	R1	SB	3	1	N	10	0	826	881	30
108	V	JM	R1	SB	3	1	N	12	0	565	883	32
109	V	JM	R1	SB	3	1	N	14	0	850	885	34
110	V	JM	R1	NB	3	1	N	5	0	1026	890	5
111	V	JM	R1	NB	3	1	N	6	0	865	891	6
112	V	JM	R1	NB	3	1	N	12	0	1132	897	12

SAS

OBS	SUBJ_CR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
225	VI	EV	R1	NB	1	1	N	2	1	829	312	2
226	VI	EV	R1	NB	1	1	N	4	1	871	313	4
227	VI	EV	R1	NB	1	1	N	7	1	647	316	7
228	VI	EV	R1	NB	1	1	N	8	1	865	317	8
229	VI	EV	R1	NB	1	1	N	9	1	479	318	9
230	VI	EV	R1	NB	1	1	N	10	1	481	319	10
231	VI	EV	R1	NB	1	1	N	11	1	881	320	11
232	VI	PT	R1	SB	4	1	N	2	1	828	351	22
233	VI	PT	R1	SB	4	1	N	4	1	864	353	24
234	VI	PT	R1	SB	4	1	N	6	1	1020	355	26
235	VI	PT	R1	SB	4	1	N	8	1	828	357	28
236	VI	PT	R1	SB	4	1	N	9	1	759	358	29
237	VI	PT	R1	SB	4	1	N	11	1	654	360	31
238	VI	PT	R1	SB	4	1	N	13	1	895	362	33
239	VI	PT	R1	SB	4	1	N	15	1	701	364	35
240	VI	PT	R1	NB	4	1	N	1	1	820	365	1
241	VI	PT	R1	NB	4	1	N	4	1	818	367	4
242	VI	PT	R1	NB	4	1	N	7	1	711	370	7
243	VI	PT	R1	NB	4	1	N	8	1	788	371	8
244	VI	PT	R1	NB	4	1	N	9	1	450	372	9
245	VI	PT	R1	NB	4	1	N	10	1	870	373	10
246	V	CL	R1	SB	2	1	N	2	1	754	405	22
247	V	CL	R1	SB	2	1	N	4	1	817	407	24
248	V	CL	R1	SB	2	1	N	6	1	760	408	26
249	V	CL	R1	SB	2	1	N	8	1	857	412	28
250	V	CL	R1	SB	2	1	N	11	1	713	414	31
251	V	CL	R1	SB	2	1	N	13	1	830	416	33
252	V	CL	R1	SB	2	1	N	15	1	447	418	35
253	V	CL	R1	NB	2	1	N	1	1	850	419	1
254	V	CL	R1	NB	2	1	N	2	1	472	420	2
255	V	CL	R1	NB	2	1	N	4	1	857	421	4
256	V	CL	R1	NB	2	1	N	7	1	914	424	7
257	V	CL	R1	NB	2	1	N	8	1	1146	425	8
258	V	CL	R1	NB	2	1	N	9	1	452	426	9
259	V	CL	R1	NB	2	1	N	10	1	927	427	10
260	V	CL	R1	NB	2	1	N	11	1	758	428	11
261	V	EW	R1	SB	9	0	N	4	1	851	515	24
262	V	EW	R1	SB	9	0	N	6	1	887	517	26
263	V	EW	R1	SB	9	0	N	8	1	820	519	28
264	V	EW	R1	SB	9	0	N	9	1	1061	520	29
265	V	EW	R1	SB	9	0	N	11	1	881	522	31
266	V	EW	R1	SB	9	0	N	13	1	829	524	33
267	V	EW	R1	SB	9	0	N	15	1	686	525	35
268	V	EW	R1	NB	9	0	N	1	1	881	527	1
269	V	EW	R1	NB	9	0	N	2	1	728	528	2
270	V	EW	R1	NB	9	0	N	4	1	791	529	4
271	V	EW	R1	NB	9	0	N	7	1	808	532	7
272	V	EW	R1	NB	9	0	N	8	1	819	533	8
273	V	EW	R1	NB	9	0	N	9	1	744	534	9
274	V	EW	R1	NB	9	0	N	10	1	883	535	10
275	V	EW	R1	NB	9	0	N	11	1	773	536	11
276	VI	DW	R1	SB	8	0	N	2	1	782	566	22
277	VI	DW	R1	SB	8	0	N	4	1	1057	568	24
278	VI	DW	R1	SB	8	0	N	6	1	928	570	26
279	VI	DW	R1	SB	8	0	N	8	1	835	572	28
280	VI	DW	R1	SB	8	0	N	9	1	1009	573	29

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OBS	SUBJ_CR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
281	VI	DW	R1	SB	8	0	N	11	1	812	575	31
282	VI	DW	R1	SB	8	0	N	13	1	1024	577	33
283	VI	DW	R1	SB	8	0	N	15	1	829	579	35
284	VI	DW	R1	NB	8	0	N	1	1	852	580	1
285	VI	DW	R1	NB	8	0	N	2	1	1003	581	2
286	VI	DW	R1	NB	8	0	N	4	1	842	582	4
287	VI	DW	R1	NB	8	0	N	7	1	1128	584	7
288	VI	DW	R1	NB	8	0	N	8	1	972	585	8
289	VI	DW	R1	NB	8	0	N	9	1	864	586	9
290	VI	DW	R1	NB	8	0	N	10	1	1044	587	10
291	VI	DW	R1	NB	8	0	N	11	1	785	588	11
292	VI	AW	R1	SB	2	1	N	2	1	856	618	22
293	VI	AW	R1	SB	2	1	N	4	1	877	620	24
294	VI	AW	R1	SB	2	1	N	6	1	1042	622	26
295	VI	AW	R1	SB	2	1	N	8	1	939	624	28
296	VI	AW	R1	SB	2	1	N	9	1	1024	625	29
297	VI	AW	R1	SB	2	1	N	11	1	1058	627	31
298	VI	AW	R1	SB	2	1	N	13	1	1099	628	33
299	VI	AW	R1	SB	2	1	N	15	1	862	631	35
300	VI	AW	R1	NB	2	1	N	1	1	897	632	1
301	VI	AW	R1	NB	2	1	N	2	1	885	633	2
302	VI	AW	R1	NB	2	1	N	4	1	824	634	4
303	VI	AW	R1	NB	2	1	N	7	1	940	637	7
304	VI	AW	R1	NB	2	1	N	8	1	785	638	8
305	VI	AW	R1	NB	2	1	N	9	1	835	639	9
306	VI	AW	R1	NB	2	1	N	10	1	843	640	10
307	VI	AW	R1	NB	2	1	N	11	1	854	641	11
308	IV	CC	R1	SB	4	0	N	2	1	523	820	22
309	IV	CC	R1	SB	4	0	N	4	1	892	822	24
310	IV	CC	R1	SB	4	0	N	6	1	808	824	26
311	IV	CC	R1	SB	4	0	N	8	1	855	826	28
312	IV	CC	R1	SB	4	0	N	9	1	843	827	29
313	IV	CC	R1	SB	4	0	N	11	1	837	829	31
314	IV	CC	R1	SB	4	0	N	13	1	963	831	33
315	IV	CC	R1	SB	4	0	N	15	1	783	833	35
316	IV	CC	R1	NB	4	0	N	1	1	822	834	1
317	IV	CC	R1	NB	4	0	N	2	1	803	835	2
318	IV	CC	R1	NB	4	0	N	4	1	821	836	4
319	IV	CC	R1	NB	4	0	N	7	1	958	839	7
320	IV	CC	R1	NB	4	0	N	8	1	1039	840	8
321	IV	CC	R1	NB	4	0	N	9	1	881	841	9
322	IV	CC	R1	NB	4	0	N	10	1	928	842	10
323	IV	CC	R1	NB	4	0	N	11	1	763	843	11
324	V	JM	R1	SB	3	1	N	2	1	880	873	22
325	V	JM	R1	SB	3	1	N	4	1	828	875	24
326	V	JM	R1	SB	3	1	N	6	1	875	877	26
327	V	JM	R1	SB	3	1	N	8	1	1009	879	28
328	V	JM	R1	SB	3	1	N	9	1	1075	880	29
329	V	JM	R1	SB	3	1	N	11	1	1036	882	31
330	V	JM	R1	SB	3	1	N	13	1	933	884	33
331	V	JM	R1	SB	3	1	N	15	1	881	886	35
332	V	JM	R1	NB	3	1	N	1	1	820	887	1
333	V	JM	R1	NB	3	1	N	2	1	760	888	2
334	V	JM	R1	NB	3	1	N	7	1	1164	892	7
335	V	JM	R1	NB	3	1	N	8	1	1157	893	8
336	V	JM	R1	NB	3	1	N	9	1	1060	894	9

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OBS	SUBJ_CR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
449	III	MJ	R2	SB	2	0	N	2	0	763	217	22
450	III	MJ	R2	SB	2	0	N	3	0	732	218	23
451	III	MJ	R2	SB	2	0	N	8	0	727	222	28
452	III	MJ	R2	SB	2	0	N	13	0	745	228	33
453	III	MJ	R2	NB	2	0	N	1	0	638	230	1
454	III	MJ	R2	NB	2	0	N	3	0	811	232	3
455	III	MJ	R2	NB	2	0	N	9	0	614	238	9
456	III	MJ	R2	NB	2	0	N	10	0	613	239	10
457	III	MJ	R2	NB	2	0	N	11	0	565	240	11
458	III	MJ	R2	NB	2	0	N	14	0	661	243	14
459	VI	EV	R2	SB	1	1	N	2	0	671	259	22
460	VI	EV	R2	SB	1	1	N	13	0	484	260	33
461	VI	EV	R2	NB	1	1	N	1	0	374	262	1
462	VI	EV	R2	NB	1	1	N	9	0	599	290	9
463	VI	PT	R2	SB	4	1	N	2	0	599	323	22
464	VI	PT	R2	SB	4	1	N	3	0	623	324	23
465	VI	PT	R2	SB	4	1	N	5	0	585	326	25
466	VI	PT	R2	SB	4	1	N	6	0	657	327	26
467	VI	PT	R2	SB	4	1	N	8	0	657	329	28
468	VI	PT	R2	SB	4	1	N	13	0	745	334	33
469	VI	PT	R2	NB	4	1	N	.	0	633	335	1
470	VI	PT	R2	NB	4	1	N	3	0	600	336	3
471	VI	PT	R2	NB	4	1	N	9	0	603	344	9
472	VI	PT	R2	NB	4	1	N	10	0	693	345	10
473	VI	PT	R2	NB	4	1	N	11	0	721	346	11
474	VI	PT	R2	NB	4	1	N	14	0	629	348	14
475	V	CL	R2	SB	2	1	N	2	0	634	377	22
476	V	CL	R2	SB	2	1	N	3	0	658	378	23
477	V	CL	R2	SB	2	1	N	5	0	595	380	25
478	V	CL	R2	SB	2	1	N	6	0	610	381	26
479	V	CL	R2	SB	2	1	N	8	0	1008	383	28
480	V	CL	R2	SB	2	1	N	13	0	612	386	33
481	V	CL	R2	NB	2	1	N	1	0	756	390	1
482	V	CL	R2	NB	2	1	N	3	0	681	392	3
483	V	CL	R2	NB	2	1	N	9	0	623	396	9
484	V	CL	R2	NB	2	1	N	10	0	611	399	10
485	V	CL	R2	NB	2	1	N	11	0	533	400	11
486	V	CL	R2	NB	2	1	N	14	0	488	403	14
487	V	EW	R2	SB	9	0	N	2	0	623	485	22
488	V	EW	R2	SB	9	0	N	3	0	684	486	23
489	V	EW	R2	SB	9	0	N	6	0	646	489	26
490	V	EW	R2	SB	9	0	N	8	0	590	491	28
491	V	EW	R2	SB	9	0	N	13	0	756	494	33
492	V	EW	R2	NB	9	0	N	1	0	610	498	1
493	V	EW	R2	NB	9	0	N	3	0	642	500	3
494	V	EW	R2	NB	9	0	N	10	0	652	507	10
495	V	EW	R2	NB	9	0	N	11	0	695	508	11
496	V	EW	R2	NB	9	0	N	14	0	637	511	14
497	VI	DW	R2	SB	6	0	N	2	0	603	538	22
498	VI	DW	R2	SB	6	0	N	3	0	1028	540	23
499	VI	DW	R2	SB	6	0	N	5	0	718	542	25
500	VI	DW	R2	SB	6	0	N	6	0	655	543	26
501	VI	DW	R2	SB	6	0	N	8	0	696	545	28
502	VI	DW	R2	SB	6	0	N	13	0	659	550	33
503	VI	DW	R2	NB	6	0	N	1	0	744	552	1
504	VI	DW	R2	NB	6	0	N	3	0	1301	554	3

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OBS	SUBJ_CR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
505	VI	DW	R2	NB	6	0	N	9	0	771	550	9
506	VI	DW	R2	NB	6	0	N	10	0	1236	551	10
507	VI	DW	R2	NB	6	0	N	11	0	771	552	11
508	VI	DW	R2	NB	6	0	N	14	0	884	555	14
509	VI	AW	R2	SB	2	1	N	2	0	609	581	22
510	VI	AW	R2	SB	2	1	N	3	0	1335	592	23
511	VI	AW	R2	SB	2	1	N	5	0	618	594	25
512	VI	AW	R2	SB	2	1	N	6	0	1035	595	26
513	VI	AW	R2	SB	2	1	N	8	0	1011	597	28
514	VI	AW	R2	NB	2	1	N	1	0	851	603	1
515	VI	AW	R2	NB	2	1	N	3	0	1101	605	3
516	VI	AW	R2	NB	2	1	N	9	0	1027	611	9
517	VI	AW	R2	NB	2	1	N	10	0	861	612	10
518	VI	AW	R2	NB	2	1	N	11	0	657	613	11
519	VI	AW	R2	NB	2	1	N	14	0	621	616	14
520	IV	CC	R2	SB	4	0	N	2	0	746	792	22
521	IV	CC	R2	SB	4	0	N	3	0	881	793	23
522	IV	CC	R2	SB	4	0	N	5	0	889	795	25
523	IV	CC	R2	SB	4	0	N	6	0	777	796	26
524	IV	CC	R2	SB	4	0	N	8	0	851	798	28
525	IV	CC	R2	SB	4	0	N	13	0	714	803	33
526	IV	CC	R2	NB	4	0	N	1	0	611	806	1
527	IV	CC	R2	NB	4	0	N	3	0	885	807	3
528	IV	CC	R2	NB	4	0	N	9	0	962	813	9
529	IV	CC	R2	NB	4	0	N	10	0	655	814	10
530	IV	CC	R2	NB	4	0	N	11	0	897	815	11
531	IV	CC	R2	NB	4	0	N	14	0	811	818	14
532	V	JM	R2	SB	3	1	N	2	0	736	846	22
533	V	JM	R2	SB	3	1	N	3	0	1177	847	23
534	V	JM	R2	SB	3	1	N	5	0	643	849	25
535	V	JM	R2	SB	3	1	N	6	0	748	850	26
536	V	JM	R2	SB	3	1	N	8	0	775	852	28
537	V	JM	R2	SB	3	1	N	13	0	1191	857	33
538	V	JM	R2	NB	3	1	N	3	0	1000	861	3
539	V	JM	R2	NB	3	1	N	9	0	868	867	9
540	V	JM	R2	NB	3	1	N	10	0	577	868	10
541	V	JM	R2	NB	3	1	N	11	0	749	869	11
542	V	JM	R2	NB	3	1	N	14	0	836	872	14
543	I	DB	R2	SB	3	0	N	2	0	884	878	22
544	I	DB	R2	SB	3	0	N	5	0	708	880	25
545	I	DB	R2	SB	3	0	N	6	0	752	881	26
546	I	DB	R2	SB	3	0	N	8	0	773	883	28
547	I	DB	R2	SB	3	0	N	13	0	876	888	33
548	I	DB	R2	NB	3	0	N	1	0	814	890	1
549	I	DB	R2	NB	3	0	N	3	0	859	892	3
550	I	DB	R2	NB	3	0	N	9	0	733	898	9
551	I	DB	R2	NB	3	0	N	10	0	631	899	10
552	I	DB	R2	NB	3	0	N	11	0	555	1000	11
553	I	DB	R2	NB	3	0	N	14	0	659	1003	14
554	IV	SM	R2	SB	5	0	N	2	0	991	1005	22
555	IV	SM	R2	SB	5	0	N	3	0	783	1006	23
556	IV	SM	R2	SB	5	0	N	5	0	532	1008	25
557	IV	SM	R2	SB	5	0	N	6	0	1073	1009	26
558	IV	SM	R2	SB	5	0	N	8	0	680	1011	28
559	IV	SM	R2	SB	5	0	-	13	0	640	1016	33
560	IV	SM	R2	NB	5	0		1	0	802	1018	1

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OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
673	VI	PT	R2	NB	4	1	N	7	1	661	342	7
674	VI	PT	R2	NB	4	1	N	12	1	444	347	12
675	VI	PT	R2	NB	4	1	N	13	1	603	348	13
676	V	CL	R2	SB	2	1	N	1	1	657	376	21
677	V	CL	R2	SB	2	1	N	4	1	726	379	24
678	V	CL	R2	SB	2	1	N	7	1	685	382	27
679	V	CL	R2	SB	2	1	N	9	1	965	384	29
680	V	CL	R2	SB	2	1	N	10	1	959	385	30
681	V	CL	R2	SB	2	1	N	11	1	976	386	31
682	V	CL	R2	SB	2	1	N	12	1	832	387	32
683	V	CL	R2	SB	2	1	N	14	1	1069	388	34
684	V	CL	R2	NB	2	1	N	2	1	820	391	2
685	V	CL	R2	NB	2	1	N	4	1	907	393	4
686	V	CL	R2	NB	2	1	N	5	1	907	394	5
687	V	CL	R2	NB	2	1	N	6	1	701	395	6
688	V	CL	R2	NB	2	1	N	7	1	693	396	7
689	V	CL	R2	NB	2	1	N	8	1	643	397	8
690	V	CL	R2	NB	2	1	N	12	1	836	401	12
691	V	CL	R2	NB	2	1	N	13	1	821	402	13
692	V	EW	R2	SB	9	0	N	1	1	828	484	21
693	V	EW	R2	SB	9	0	N	4	1	767	487	24
694	V	EW	R2	SB	9	0	N	7	1	615	490	27
695	V	EW	R2	SB	9	0	N	9	1	832	492	29
696	V	EW	R2	SB	9	0	N	10	1	818	493	30
697	V	EW	R2	SB	9	0	N	11	1	867	494	31
698	V	EW	R2	SB	9	0	N	12	1	838	495	32
699	V	EW	R2	SB	9	0	N	14	1	619	497	34
700	V	EW	R2	NB	9	0	N	2	1	825	499	2
701	V	EW	R2	NB	9	0	N	4	1	846	501	4
702	V	EW	R2	NB	9	0	N	5	1	606	502	5
703	V	EW	R2	NB	9	0	N	6	1	465	503	6
704	V	EW	R2	NB	9	0	N	7	1	624	504	7
705	V	EW	R2	NB	9	0	N	8	1	662	505	8
706	V	EW	R2	NB	9	0	N	12	1	637	509	12
707	V	EW	R2	NB	9	0	N	13	1	743	510	13
708	VI	DW	R2	SB	8	0	N	1	1	758	538	21
709	VI	DW	R2	SB	8	0	N	4	1	1072	541	24
710	VI	DW	R2	SB	8	0	N	7	1	1043	544	27
711	VI	DW	R2	SB	8	0	N	9	1	966	546	29
712	VI	DW	R2	SB	8	0	N	10	1	633	547	30
713	VI	DW	R2	SB	8	0	N	11	1	726	548	31
714	VI	DW	R2	SB	8	0	N	12	1	640	549	32
715	VI	DW	R2	SB	8	0	N	14	1	1051	551	34
716	VI	DW	R2	NB	8	0	N	2	1	1116	553	2
717	VI	DW	R2	NB	8	0	N	4	1	989	555	4
718	VI	DW	R2	NB	8	0	N	5	1	610	556	5
719	VI	DW	R2	NB	8	0	N	6	1	1010	557	6
720	VI	DW	R2	NB	8	0	N	7	1	1093	558	7
721	VI	DW	R2	NB	8	0	N	8	1	785	559	8
722	VI	DW	R2	NB	8	0	N	12	1	770	563	12
723	VI	DW	R2	NB	8	0	N	13	1	714	564	13
724	VI	AW	R2	SB	2	1	N	1	1	667	590	21
725	VI	AW	R2	SB	2	1	N	4	1	1035	593	24
726	VI	AW	R2	SB	2	1	N	7	1	684	596	27
727	VI	AW	R2	SB	2	1	N	9	1	1021	598	29
728	VI	AW	R2	SB	2	1	N	10	1	1101	589	30

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OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
729	VI	AW	R2	SB	2	1	N	11	1	1015	600	31
730	VI	AW	R2	SB	2	1	N	12	1	1066	601	32
731	VI	AW	R2	SB	2	1	N	14	1	928	602	34
732	VI	AW	R2	NB	2	1	N	2	1	622	604	2
733	VI	AW	R2	NB	2	1	N	4	1	937	606	4
734	VI	AW	R2	NB	2	1	N	5	1	586	607	5
735	VI	AW	R2	NB	2	1	N	6	1	940	608	6
736	VI	AW	R2	NB	2	1	N	7	1	1064	609	7
737	VI	AW	R2	NB	2	1	N	8	1	814	610	8
738	VI	AW	R2	NB	2	1	N	12	1	894	614	12
739	IV	CC	R2	SB	4	0	N	1	1	756	781	21
740	IV	CC	R2	SB	4	0	N	4	1	928	784	24
741	IV	CC	R2	SB	4	0	N	7	1	761	797	27
742	IV	CC	R2	SB	4	0	N	9	1	833	799	29
743	IV	CC	R2	SB	4	0	N	10	1	882	800	30
744	IV	CC	R2	SB	4	0	N	11	1	850	801	31
745	IV	CC	R2	SB	4	0	N	12	1	787	802	32
746	IV	CC	R2	SB	4	0	N	14	1	867	804	34
747	IV	CC	R2	NB	4	0	N	2	1	912	805	2
748	IV	CC	R2	NB	4	0	N	4	1	810	808	4
749	IV	CC	R2	NB	4	0	N	5	1	567	809	5
750	IV	CC	R2	NB	4	0	N	6	1	885	810	6
751	IV	CC	R2	NB	4	0	N	7	1	715	811	7
752	IV	CC	R2	NB	4	0	N	8	1	787	812	8
753	IV	CC	R2	NB	4	0	N	12	1	843	816	12
754	IV	CC	R2	NB	4	0	N	13	1	839	817	13
755	V	JM	R2	SB	3	1	N	1	1	703	845	21
756	V	JM	R2	SB	3	1	N	4	1	768	848	24
757	V	JM	R2	SB	3	1	N	7	1	912	851	27
758	V	JM	R2	SB	3	1	N	9	1	817	853	29
759	V	JM	R2	SB	3	1	N	10	1	855	854	30
760	V	JM	R2	SB	3	1	N	11	1	875	855	31
761	V	JM	R2	SB	3	1	N	12	1	1168	856	32
762	V	JM	R2	SB	3	1	N	14	1	1272	858	34
763	V	JM	R2	NB	3	1	N	2	1	882	860	2
764	V	JM	R2	NB	3	1	N	5	1	468	863	5
765	V	JM	R2	NB	3	1	N	6	1	628	864	6
766	V	JM	R2	NB	3	1	N	7	1	1047	865	7
767	V	JM	R2	NB	3	1	N	8	1	558	866	8
768	V	JM	R2	NB	3	1	N	12	1	784	870	12
769	V	JM	R2	NB	3	1	N	13	1	810	871	13
770	I	DB	R2	SB	3	0	N	1	1	681	877	21
771	I	DB	R2	SB	3	0	N	4	1	428	879	24
772	I	DB	R2	SB	3	0	N	7	1	932	882	27
773	I	DB	R2	SB	3	0	N	9	1	857	884	29
774	I	DB	R2	SB	3	0	N	10	1	638	885	30
775	I	DB	R2	SB	3	0	N	11	1	822	886	31
776	I	DB	R2	SB	3	0	N	12	1	722	887	32
777	I	DB	R2	SB	3	0	N	14	1	871	889	34
778	I	DB	R2	NB	3	0	N	2	1	891	891	2
779	I	DB	R2	NB	3	0	N	4	1	662	893	4
780	I	DB	R2	NB	3	0	N	5	1	731	894	5
781	I	DB	R2	NB	3	0	N	6	1	854	895	6
782	I	DB	R2	NB	3	0	N	7	1	931	896	7
783	I	DB	R2	NB	3	0	N	8	1	716	897	8
784	I	DB	R2	NB	3	0	N	12	1	783	1001	12

SAS

OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
673	VI	PT	R2	NB	6	1	N	7	1	861	342	7
674	VI	PT	R2	NB	6	1	N	12	1	448	347	12
675	VI	PT	R2	NB	6	1	N	13	1	603	348	13
676	V	CL	R2	SB	2	1	N	1	1	852	376	21
677	V	CL	R2	SB	2	1	N	4	1	728	379	24
678	V	CL	R2	SB	2	1	N	7	1	885	382	27
679	V	CL	R2	SB	2	1	N	8	1	955	384	29
680	V	CL	R2	SB	2	1	N	10	1	959	385	30
681	V	CL	R2	SB	2	1	N	11	1	974	386	31
682	V	CL	R2	SB	2	1	N	12	1	832	387	32
683	V	CL	R2	SB	2	1	N	14	1	1069	388	34
684	V	CL	R2	NB	2	1	N	2	1	820	391	2
685	V	CL	R2	NB	2	1	N	4	1	807	393	4
686	V	CL	R2	NB	2	1	N	5	1	807	394	5
687	V	CL	R2	NB	2	1	N	6	1	701	395	6
688	V	CL	R2	NB	2	1	N	7	1	883	396	7
689	V	CL	R2	NB	2	1	N	8	1	843	397	8
690	V	CL	R2	NB	2	1	N	12	1	836	401	12
691	V	CL	R2	NB	2	1	N	13	1	821	402	13
692	V	EW	R2	SB	9	0	N	1	1	828	484	21
693	V	EW	R2	SB	9	0	N	4	1	787	487	24
694	V	EW	R2	SB	9	0	N	7	1	815	490	27
695	V	EW	R2	SB	9	0	N	8	1	832	492	29
696	V	EW	R2	SB	9	0	N	10	1	818	493	30
697	V	EW	R2	SB	9	0	N	11	1	887	494	31
698	V	EW	R2	SB	9	0	N	12	1	838	495	32
699	V	EW	R2	SB	9	0	N	14	1	419	497	34
700	V	EW	R2	NB	9	0	N	2	1	825	499	2
701	V	EW	R2	NB	9	0	N	4	1	846	501	4
702	V	EW	R2	NB	9	0	N	5	1	806	502	5
703	V	EW	R2	NB	9	0	N	6	1	465	503	6
704	V	EW	R2	NB	9	0	N	7	1	824	504	7
705	V	EW	R2	NB	9	0	N	8	1	842	505	8
706	V	EW	R2	NB	9	0	N	12	1	837	509	12
707	V	EW	R2	NB	9	0	N	13	1	743	510	13
708	VI	DW	R2	SB	8	0	N	1	1	759	538	21
709	VI	DW	R2	SB	8	0	N	4	1	1072	541	24
710	VI	DW	R2	SB	8	0	N	7	1	1043	544	27
711	VI	DW	R2	SB	8	0	N	8	1	988	546	29
712	VI	DW	R2	SB	8	0	N	10	1	833	547	30
713	VI	DW	R2	SB	8	0	N	11	1	728	548	31
714	VI	DW	R2	SB	8	0	N	12	1	840	549	32
715	VI	DW	R2	SB	8	0	N	14	1	1051	551	34
716	VI	DW	R2	NB	8	0	N	2	1	1116	553	2
717	VI	DW	R2	NB	8	0	N	4	1	899	555	4
718	VI	DW	R2	NB	8	0	N	5	1	810	556	5
719	VI	DW	R2	NB	8	0	N	6	1	1010	557	6
720	VI	DW	R2	NB	8	0	N	7	1	1093	558	7
721	VI	DW	R2	NB	8	0	N	8	1	788	559	8
722	VI	DW	R2	NB	8	0	N	12	1	770	563	12
723	VI	DW	R2	NB	8	0	N	13	1	714	564	13
724	VI	AW	R2	SB	2	1	N	1	1	867	590	21
725	VI	AW	R2	SB	2	1	N	4	1	1035	593	24
726	VI	AW	R2	SB	2	1	N	7	1	884	596	27
727	VI	AW	R2	SB	2	1	N	8	1	1021	598	29
728	VI	AW	R2	SB	2	1	N	10	1	1101	599	30

SAS

OBS	SUBJ_GR	SUBJ_INT	ROUTE	DIRECTN	SUBJ_NO	PREV_STD	TIME	SIGN_NO	TESTSIGN	DISTANCE	OBS_ID	CSIGN_NO
729	VI	AW	R2	SB	2	1	N	11	1	1015	600	31
730	VI	AW	R2	SB	2	1	N	12	1	1088	601	32
731	VI	AW	R2	SB	2	1	N	14	1	925	602	34
732	VI	AW	R2	NB	2	1	N	2	1	822	604	2
733	VI	AW	R2	NB	2	1	N	4	1	837	606	4
734	VI	AW	R2	NB	2	1	N	5	1	588	607	5
735	VI	AW	R2	NB	2	1	N	6	1	940	608	6
736	VI	AW	R2	NB	2	1	N	7	1	1054	609	7
737	VI	AW	R2	NB	2	1	N	8	1	814	610	8
738	VI	AW	R2	NB	2	1	N	12	1	894	614	12
739	IV	CC	R2	SB	4	0	N	1	1	756	781	21
740	IV	CC	R2	SB	4	0	N	4	1	828	794	24
741	IV	CC	R2	SB	4	0	N	7	1	781	797	27
742	IV	CC	R2	SB	4	0	N	8	1	833	799	29
743	IV	CC	R2	SB	4	0	N	10	1	882	800	30
744	IV	CC	R2	SB	4	0	N	11	1	850	801	31
745	IV	CC	R2	SB	4	0	N	12	1	787	802	32
746	IV	CC	R2	SB	4	0	N	14	1	857	804	34
747	IV	CC	R2	NB	4	0	N	2	1	912	806	2
748	IV	CC	R2	NB	4	0	N	4	1	810	808	4
749	IV	CC	R2	NB	4	0	N	5	1	857	809	5
750	IV	CC	R2	NB	4	0	N	6	1	595	810	6
751	IV	CC	R2	NB	4	0	N	7	1	718	811	7
752	IV	CC	R2	NB	4	0	N	8	1	787	812	8
753	IV	CC	R2	NB	4	0	N	12	1	843	816	12
754	IV	CC	R2	NB	4	0	N	13	1	839	817	13
755	V	JM	R2	SB	3	1	N	1	1	703	845	21
756	V	JM	R2	SB	3	1	N	4	1	768	848	24
757	V	JM	R2	SB	3	1	N	7	1	912	851	27
758	V	JM	R2	SB	3	1	N	8	1	817	853	29
759	V	JM	R2	SB	3	1	N	10	1	855	854	30
760	V	JM	R2	SB	3	1	N	11	1	675	855	31
761	V	JM	R2	SB	3	1	N	12	1	1188	856	32
762	V	JM	R2	SB	3	1	N	14	1	1272	858	34
763	V	JM	R2	NB	3	1	N	2	1	897	860	2
764	V	JM	R2	NB	3	1	N	5	1	488	863	5
765	V	JM	R2	NB	3	1	N	6	1	828	864	6
766	V	JM	R2	NB	3	1	N	7	1	1047	865	7
767	V	JM	R2	NB	3	1	N	8	1	555	866	8
768	V	JM	R2	NB	3	1	N	12	1	784	870	12
769	V	JM	R2	NB	3	1	N	13	1	810	871	13
770	I	DB	R2	SB	3	0	N	1	1	881	977	21
771	I	DB	R2	SB	3	0	N	4	1	425	979	24
772	I	DB	R2	SB	3	0	N	7	1	932	982	27
773	I	DB	R2	SB	3	0	N	8	1	857	984	29
774	I	DB	R2	SB	3	0	N	10	1	829	985	30
775	I	DB	R2	SB	3	0	N	11	1	922	986	31
776	I	DB	R2	SB	3	0	N	12	1	722	987	32
777	I	DB	R2	SB	3	0	N	14	1	871	989	34
778	I	DB	R2	NB	3	0	N	2	1	991	991	2
779	I	DB	R2	NB	3	0	N	4	1	862	993	4
780	I	DB	R2	NB	3	0	N	5	1	731	994	5
781	I	DB	R2	NB	3	0	N	6	1	864	995	6
782	I	DB	R2	NB	3	0	N	7	1	931	996	7
783	I	DB	R2	NB	3	0	N	8	1	718	997	8
784	I	DB	R2	NB	3	0	N	12	1	783	1001	12

APPENDIX F. STATISTICAL ANALYSIS

There was significant interaction among mean legibility distances between routes (lighted versus unlighted) and sign material. The mean distances were not consistent for the different sign background materials on both routes. Plots of these means (Figures F-1 and F-2) reveal the source of the interaction. The high specific-intensity grade reflective sheeting with high specific-intensity grade reflective stick-on letters sign on US-59 could be read at longer distances than the high specific-intensity grade reflective sheeting with reflective button copy sign. This is inconsistent with the other types of signs along both routes. Except for the high specific-intensity grade reflective sheeting on the unlighted route, the reflective button copy was read uniformly at longer distances regardless of background material.

When the routes were analyzed separately, it was found that the reflective button copy signs had significantly longer legibility distances (p=.0003) with the average distance of 851 linear feet compared to 731 linear feet for the high specific-intensity grade reflective stick-on copy (220 linear feet difference). The largest difference in mean legibility distance was for engineer grade reflective sheeting with reflective button copy being legible at 304 linear feet further than the engineer grade reflective sheeting with high specific-intensity grade reflective stick-on copy. These were the causes of the significant interaction.

On the unlighted route, as noted there was a strong interaction caused by the reversal of legibility distances for the high specific-intensity grade reflective sheeting signs. Omitting these signs, the results were similar to US-59 with the reflective button copy performing uniformly better than the high specific-intensity grade reflective stick-on copy. Thus it would appear that reflective button copy legends are significantly more legible under both lighted and unlighted conditions for all backgrounds except high specific-intensity grade reflective sheeting when unlighted. It is strongly suggested that the high specific-intensity grade reflective sheeting sign lighted route may be atypical because of the visual clutter in the background. This sign is located on the loop I-61C with 40 foot mounting height fixed roadway lighting. Due to the lighting and the clutter the test sign was not able to perform as well as its counterpart in its present environment.

With regard to background, there was only a marginally significant difference for the unlighted route (p=.045) with the high specific-intensity grade reflective sheeting being ranked highest followed by engineer grade, opaque, and super engineer grade reflective sheetings (Tables F-1 and F-2) respectively. The lighted route rankings differed with super engineer grade reflective sheeting the highest, followed by super engineer, and high specific-intensity grade reflective sheetings and opaque backgrounds (Table F-3 and F-4). These rankings are average over both legends, however, and since there was a significant interaction caused by a reversal in legibility distance on US-59 these rankings should be used with caution. When the high specific-intensity grade reflective sheeting sign was omitted the background materials relationship with legibility distance was more significant (p=.039) as presented in Table F-5. With the high specific-intensity grade reflective sheeting sign removed the signs were ranked with super engineer grade reflective sheeting being the highest followed by engineer grade reflective sheeting and opaque background signs. The difference in legibility distance between super engineer grade and engineer grade reflective sheetings was minimal (868 versus 854). This analysis is present in Table F-6.

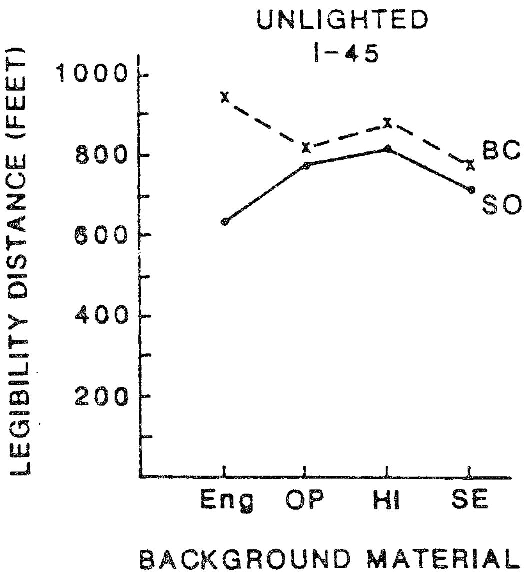

Figure F-1. Legibility Distance by Background and Legend Materials on I-45 Unlighted.

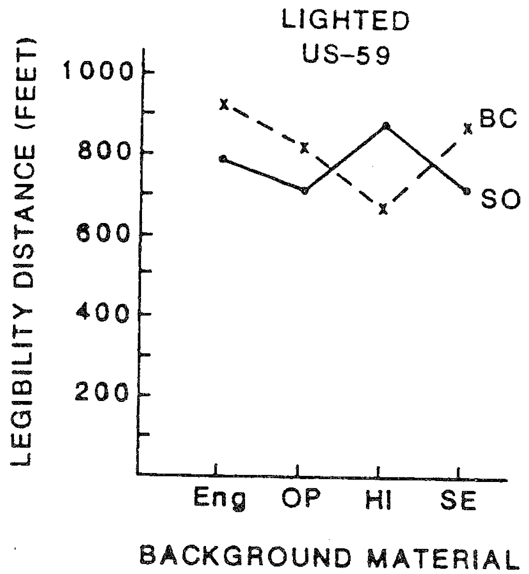

Figure F-2. Legibility Distance by Background and Legend Materials on US-59 Lighted

Note: Interaction Effect for the High-Specific-Intensity Grade Reflective Sheeting.

Table F-1. Analysis of Variance of Background and Legend on I-45

DEPENDENT VARIABLE: Distance

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	7	1066505.73055813	152367.96150830	5.62	0.0001
ERROR	119	3228411.68676471	27129.50997281		
CORRECTED TOTAL	126	4294917.41732284			

ROOT MSE	DIST MEAN	C.V.	R-SQUARE
164.71038210	790.44881890	20.8376	0.248318

SOURCE	DF	TYPE I SS	F VALUE	PR > F
BACKGRD	3	2495067.6778970	2.77	0.449
LEGEND	1	381158.17399559	14.05	0.0003*
BACKGRD*LEGEND	3	410508.11393293	5.04	0.0025*

Table F-2. Mean legibility Distance for Background and Legend on I-45

MEANS

BACKGRD	N	DISTANCE (Ft.)	LEGEND	N	DISTANCE (Ft.)
1	33	300			
2	33	784	1	64	731
3	32	849	2	63	851
4	29	722			

BACKGRD	LEGEND	N	DISTANCE (Ft.)
ENG - 1	SO - 1	16	643
ENG - 1	BC - 2	17	947
OP - 2	1	16	764
OP - 2	2	17	803
HI - 3	1	15	815
HI - 3	2	17	880
SE - 4	1	17	709
SE - 4	2	12	742

Table F-3. Analysis of Variance of Background and Legend on US-59

DEPENDENT VARIABLE: Distance

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	7	880242.31979642	125748.90282806	4.70	0.0001
ERROR	119	3180942.12114847	26730.6060607		
CORRECTED TOTAL	126	4061184.44094489			

ROOT MSE	DIST MEAN (Ft.)	CV	R-SQUARES
163.49497248	818	19.9954	0.216745

SOURCE	DF	TYPE II SS	F VALUE	PR > F
BACKGRD	3	248024.30997942	3.09	0.0297
LEGEND	1	14377.761410921	0.54	0.4648
BACKGRD*LEGEND	3	620128.28039047	7.73	0.0001*

Table F-4. Mean Legibility Distance of Background and Legend on US-59

MEANS

BACKGRD	N	DISTANCE (Ft.)	LEGEND	N	DISTANCE (Ft.)
1	32	854	1	61	807
2	30	771	2	66	827
3	32	715			
4	33	867			

BACKGRD	LEGEND	N	DISTANCE (Ft.)
1	1	15	793
1	2	17	908
2	1	14	703
2	2	16	830
3	1	16	883
3	2	16	666
4	1	16	835
4	2	17	897

Table F-5. Analysis of Variance of Background and Legend on US-59 with High Specific Intensity Reflective Sheeting Omitted

DEPENDENT VARIABLE: Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	5	423429.51043049	846815.90208610	3.23	0.0100
ERROR	89	2335161.12114846	26237.76540616		
CORRECTED TOTAL	94	2758590.631557895			

ROOT MSE	DIST MEAN	C.V.	R-SQUARE
161.98075628	832.15789474	19.4651	0.153495

PARAMETER ESTIMATES

SOURCE	DF	TYPE II SS	F VALUE	PR > F
BACKGRD	2	176399.37777170	3.36	0.0391
LEGEND	1	240372.61033598	9.16	0.0032
BACKGRD*LEGEND	2	18848.29385646	0.36	0.6993

Table F-6. Mean Legibility Distance for Background and Legend on US 59 with High Specific-Intensity Reflective Sheeting Omitted

BACKGRD	N	DISTANCE (Ft.)	LEGEND	N	DISTANCE (Ft.)
1	32	854	1	45	780
2	30	771	2	50	879
4	33	867			

BACKGRD	LEGEND	N	DISTANCE (Ft.)
1	1	15	793
1	2	17	908
2	1	14	703
2	2	16	830
4	1	16	835
4	2	17	897

APPENDIX G. REGRESSION ANALYSIS

REGRESSION ANALYSIS

Regression analyses were performed on legibility distance and sign parameters legend, background, and ambient light. Each variable was run separately and a multiple regression using all variables was also run. The regressions were run on I-45 and US-59 separately and on the two routes combined. Contrast ratios [$CR = \frac{L_b - L_1}{L_b}$] and luminance ratio [$LR = L_t/L_b$] were also computed. None of these regressions yielded a significant relationship, the largest R^2 value being 0.12.

One statistical problem with this data set is that the variability in both legibility distance and sign parameters is extremely high. The legibility distance variability is due to the presence or absence of sign lighting and the complexity of the surround. The legend, background and ambient lighting parameters exhibited a large variation due to the influence of freeway traffic mixes and the type of lighting and commercial signing on the freeway. The reflective properties of the different types of sheeting resulted in the large variation in readings because of the extremely low ambient light levels. If the data could be paired at the exact time the drivers read the test sign the resultant statistical procedures would have resulted in a higher R^2.

Multiple readings of legibility and sign parameter data were taken hoping that the increased sample size would result in a better estimate of the mean. Thus, regressions were attempted using only the mean values of legibility, legend, background and ambient light. This practice is not generally recommended as the estimate of the variability is not correct and seriously biased or deflated. Hence, the resulting models cannot be used in a predictive sense. The intent of this analysis was purely to identify general trends in this data.

There was still no relationship with the contrast ratio or ambient light variables on either route. The most interesting phenomenon is that the trends for the legend and background variables differed for the two routes. There was a moderate negative relationship between mean legibility distances and the average luminance of the legend on I-45 (slope -12.24, R^2 = .222, $p \leq 0.07$) as presented in Table F-7. The I-45 was the unlighted route. A negative slope means that as the legend brightness increases the legibility distance decreases. An inspection of Figure F-3, leads to a conclusion that the two data points at the extreme end of the legend (9.75 and 10.95 ft-lamberts) could indicate one of two possibilities. The first being that these two readings are not representative of the true readings and are unduly influencing the relationship resulting in a negative slope (*) and secondly the true relationship is not a decreasing relationship but a quadratic, meaning that as the legend increases the legibility distance increases and at some point the relationship becomes negatively correlated (+). The second relationship would appear to be more accurate than the first. As legend luminance increases legibility distance should increase. However, legend luminance could increase to a level at which the contrast ratio becomes extremely large resulting in a decrease of legibility distance. This is the same relationship that explains contrast ratio with legibility distance, and since legend luminance is one critical element of the contrast ratio it would seem to justify this conclusion. On US-59 the legend luminance has a positive slope (+11.70) which is approximately the same as that on the I-45 route with a negative slope. The correlation coefficient is larger on US-59 (.38) than on I-45 (.22) as referenced in Table F-8. The legend on US-59 also has a significant effect ($p \leq .01$) on legibility distance. Figure F-4 illustrates this relationship.

The same was true for background, on I-45 (slope -44.2 R^2 = .25, and $p \leq$

0.05) as referenced in Table F-9 and on US-59 (slope 33.6, R^2 - .29, and $P \leq 0.05$) as referenced in Table F-10. The relationships existing for the legend and distance are identical to that of the background with the exception of the magnitude of the slope. On I-45, the unlighted route, both the legend and background materials have negative slopes which indicate that as the reflectivity increases the legibility decreases. On the US-59 route, the lighted route has a positive slope indicating that as the reflectivity increases the legibility distance increases. Figure F-5 and F-6 illustrate the linear relationships between background brightness and legibility distance on both routes.

Tables F-11 and F-12 present the analysis of variance and regression analysis for ambient light. Both of these tables indicate that ambient light has a statistically significant effect on I-45 ($p \leq .02$) whereas on US-59 ambient light did not have a statistically significant effect ($p \leq .56$). This is to be expected since I-45 was the route without sign lights and US 59 had sign lights. The presence of sign lighting takes away any effect ambient light might have. Figures F-7 and F-8 indicate that ambient light had a negative slope on both routes. As ambient light increases legibility distance decreases.

Table F-7. Regression Analysis of Legend Brightness on I-45

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	19779.32585	19779.32585	3.994	0.0655
ERROR	14	69335.25984	4952.51856		
CORRECTED TOTAL	15	89114.58569			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
70.37413	794.7982	8.854339	0.2220	0.1664

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	846.29178	31.20030805	27.124	0.0001	INTERCEPT
AVG-LD	1	-12.24326209	6.12638746	-1.998	0.0655	LEGEND MEAN

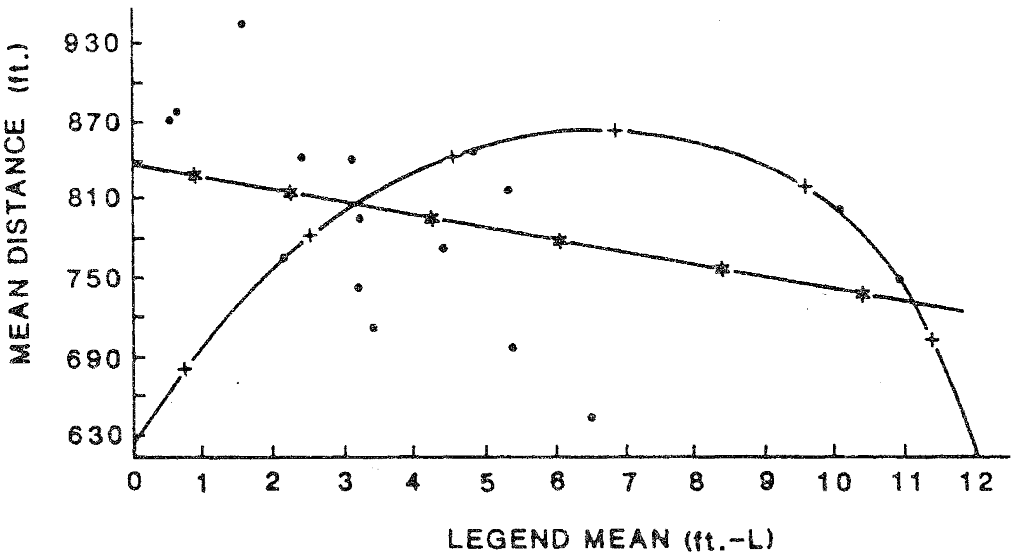

Figure F-3. Relationships Between Mean Legibility Distance and Legend Photometrics on I-45 Unlighted

Table F-8. Regression Analysis of Legend Brightness on US-59

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	29481.57526	19481.57526	7.338	0.0190
ERROR	12	48209.66614	4017.47218		
CORRECTED TOTAL	13	77691.24140			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
63.38353	776.3999	8.163773	0.3795	0.3278

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	723.70982	25.79309147	28.058	0.0001	INTERCEPT
AVG-LD	1	11.70169485	4.31966298	2.709	0.0190	LEGEND MEAN

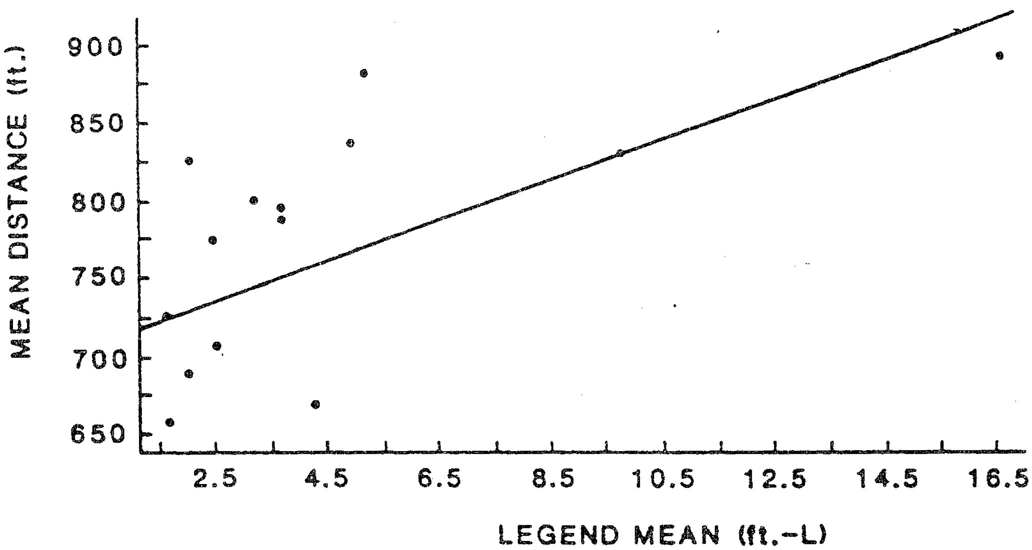

Figure F-4. Relationships Between Mean Legibility Distance and Legend Photometrics on US-59 Lighted

Table F-9. Regression Analysis of Background Brightness on US-59

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	22423.23978	22423.23978	4.707	0.0477
ERROR	14	66691.34591	4763.66757		
CORRECTED TOTAL	15	89114.58569			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
60.01933	794.7982	8.68388	0.2516	0.1982

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	857.26047	33.5641571	25.541	0.0001	INTERCEPT
AVG-BG	1	-44.20032157	20.3726409	-2.170	0.0477	BACKGROUND MEAN

Table F-10. Regression Analysis of Background Brightness on US-59

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	22687.96758	22687.96758	4.950	0.0460
ERROR	12	55003.27382	4583.60615		
CORRECTED TOTAL	13	77691.24140			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
67.70233	776.3999	8.720033	0.2920	0.2330

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	727.30362	28.5372587	25.486	0.0001	INTERCEPT
AVG-BG	1	33.58907098	15.09745843	2.225	0.0460	BACKGROUND MEAN

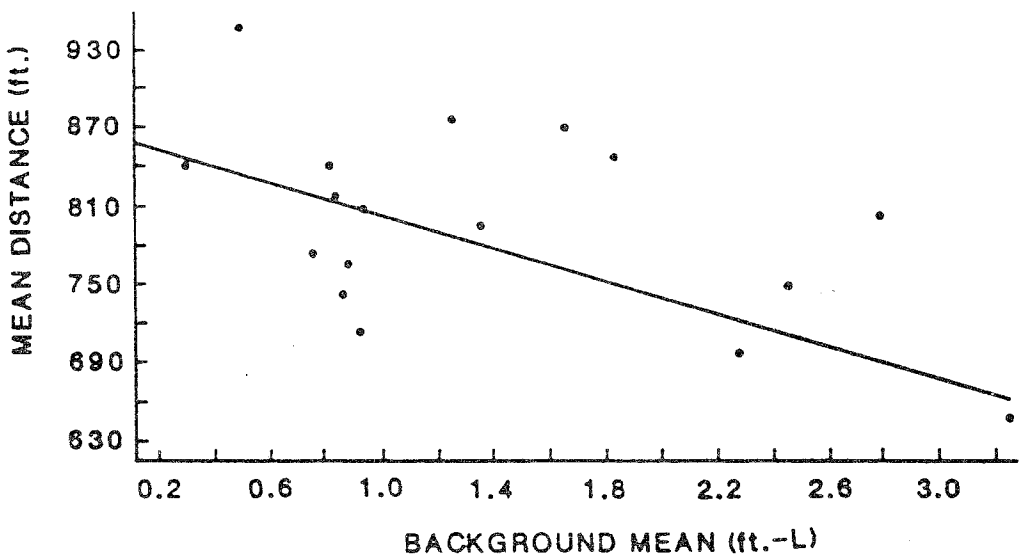

Figure F-5. Relationships Between Mean Legibility Distance and Background Photometric Values on I-45

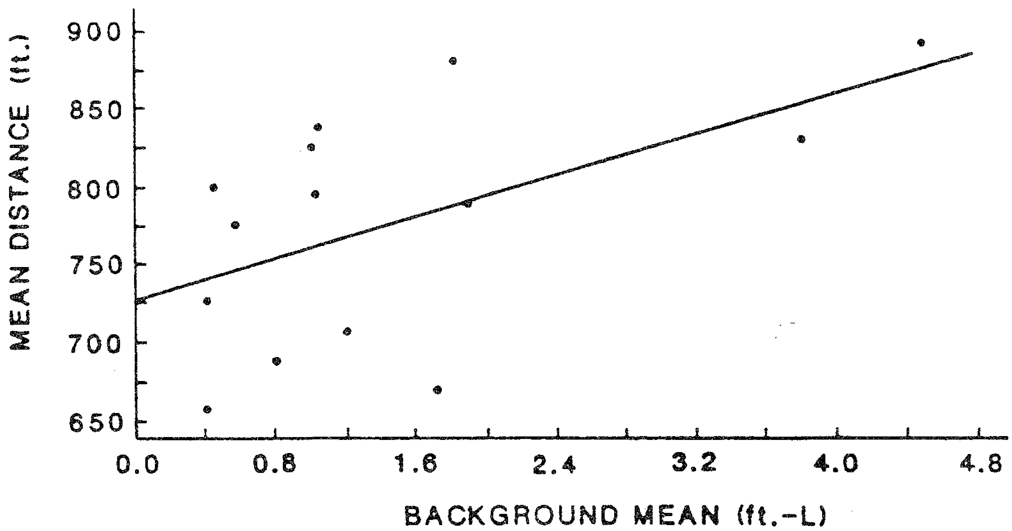

Figure F-6. Relationship Between Mean Legibility Distance and Background Photometric on US-59

Table F-11. Regression Analysis of Ambient Light on I-45

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	28900.92306	28900.92306	6.477	0.0244
	13	58004.99569	4461.92277		
CORRECTED TOTAL	14	86905.91903			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
66.78763	797.8318	8.372394	0.3326	0.2812

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	836.68208	23.03223509	36.327	0.0001	INTERCEPT
AVG-AM	1	-53.74235810	21.11649752	-2.545	0.0244	AMBIENT MEAN

Table F-12. Regression Analysis of Ambient Light on US-59

DEPENDENT VARIABLE: Average-Distance Mean Distance

ANALYSIS OF VARIABLE

SOURCE	DF	SUM OF SQUARES	MEAN SQUARE	F VALUE	PROB>F
MODEL	1	2269.58104	2269.58104	0.361	0.5591
ERROR	12	75421.66036	6285.13836		
CORRECTED TOTAL	13	77691.24140			

ROOT MSE	DEP MEAN	C.V.	R-SQUARE	ADJ. R-SQUARE
79.27886	776.3999	10.21109	0.0292	-0.0517

PARAMETER ESTIMATES

VARIABLE	DF	PARAMETER ESTIMATE	STANDARD ERROR	T FOR HO: PARAMETER=0	PROB> T	VARIABLE LABEL
INTERCEPT	1	801.52114	46.86757098	17.102	0.0001	INTERCEPT
AVG-LD	1	-53.64501311	89.27172572	-0.501	0.601	AMBIENT MEAN

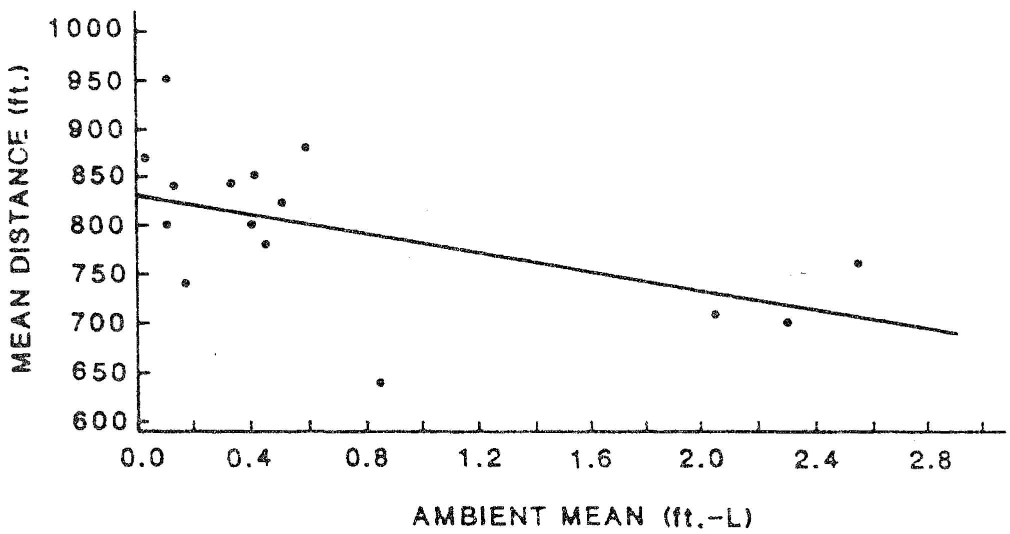

Figure F-7. Relationship Between Mean Legibility Distance and Ambient Light on I-45

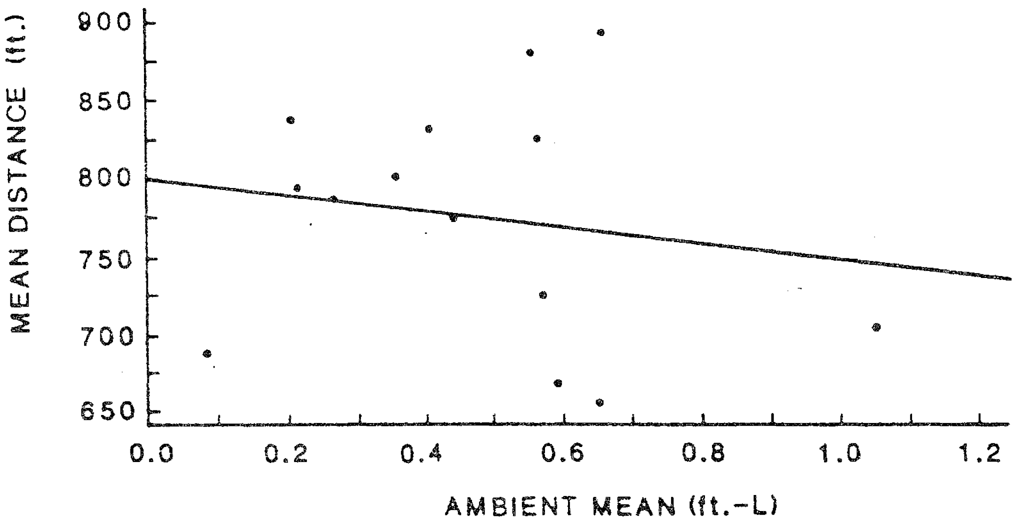

Figure F-8. Relationship Between Mean Legibility Distance and Ambient Light on US-59

APPENDIX H. BIBLIOGRAPHY

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