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Roadway Lighting on Secondary Roads in Iowa

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Iowa DOT Project HR-251
ERI Project 1603
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report

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DEPARTMENT OF CIVIL ENGINEERING
ENGINEERING RESEARCH INSTITUTE
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EXECUTIVE SUMMARY

There are approximately 800 installations of destination lighting at secondary road intersections in Iowa. Approximately 90% of these have only a single luminaire. The other installations have two luminaires. No warrants currently exist for justifying the use of this type of lighting.

Previous research has examined the safety benefits from full lighting of rural intersections that generally serve substantially higher traffic volumes than secondary road intersections in Iowa. However, the safety benefit of destination lighting at intersections carrying relatively low volumes has not been the subject of previous research.

The research reported here, sponsored by the Iowa Department of Transportation, was undertaken to identify locations where destination lighting could be expected to improve highway safety. If destination lighting were shown to reduce accident frequency, warrants for its use on secondary roads could be developed.

An inventory of secondary road lighting installations in Iowa was assembled. From this inventory, two samples were constituted that would permit two separate comparisons of the accident experience with and without destination lighting. Before-and-after comparisons were made for the same locations if accident records were available for at least one full year both preceding and following the installation of destination lighting. Accident records for this purpose were available from a statewide computerized record system covering the period

from 1977 through 1982. The accident experience at locations having destination lighting installed before 1978 was compared with a sample of comparable locations not having destination lighting.

The sample of secondary road intersections used for the before-and-after comparison included 91 locations. The sample of continuously lighted locations included 102 intersections. Accident experience at these locations was compared with the experience at 102 intersections that were not lighted.

The intersections included in these samples averaged only 0.31 accidents per year. The accident rate at secondary road intersections that had destination lighting did not differ significantly from the accident rate at intersections that were not lighted. This conclusion was derived from both comparisons, the before-and-after experience and the comparison of experience at intersections that were continuously lighted with that at unlighted locations.

Furthermore, no significant differences were noted between lighted and unlighted locations in the proportion of accidents that occurred at night. The distribution of accidents by type also did not differ between unlighted intersections and those having destination lighting. It was not possible to formulate warrants for destination lighting since analyses directed toward identifying specific characteristics of an intersection that could be correlated with highway safety did not yield any useful relationships.

However, it was noted that the average damages for night accidents that occurred at lighted intersections were lower than for accidents at unlighted intersections. Even in the absence of a more definitive demonstration of beneficial effects, destination lighting is perceived by officials in most of the counties having such installations as yielding desirable effects and is recognized as helpful to motorists in performing the guidance function in driving. Given this benefit and a relatively low cost (an average of $74 per year for one luminaire), and given that the subjective criteria that have been used in the past to justify the installation of destination lighting have led to a high degree of public acceptance and satisfaction, it is recommended that the same subjective criteria continue to be used in lieu of definitive warrants.

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CHAPTER I. INTRODUCTION

Background for the Study

Practices vary widely among Iowa counties in their use of roadway lighting. Nearly half of the counties have no lights on roads under their jurisdiction. Several other counties have a few lighting installations only because these were acquired through the transfer of jurisdictional responsibility for particular road segments as a result of functional reclassification of highways in the state. Fewer than half of the counties in Iowa have roadway lighting as a result of deliberate policy decisions to install lights.

The Iowa Department of Transportation has promulgated warrants for roadway lighting based on traffic volumes and sight distances. The type of installation warranted under these conditions normally would consist of three or more lights. On the other hand, directional lighting, usually consisting of only a single light, is installed at hundreds of intersections and at a few other locations in approximately 50 counties in Iowa.

Use of directional lighting is suggested in Volume X of the Action Guide Series issued by the National Association of Counties. The intent of this lighting is "to identify dangerous intersections, railroad crossings, and other dangerous spots" rather than as "an attempt to illuminate the surface" according to this source.

Inherent in this suggestion is the premise that destination lighting will improve safety at "dangerous spots." However, there has not been an assessment of the safety benefits, if any, of this type of lighting installation on secondary roads. The purpose of this research was to determine whether there were quantifiable benefits from the use of destination lighting. Also to be investigated was whether any safety benefits could be correlated with specific characteristics of a location which would suggest that destination lighting would be helpful as a safety measure at a particular location as distinguished from other locations where lighting might not be beneficial.

Project Overview

Research Goal and Objectives

The goal of this research was to improve safety on secondary roads by defining locations at which destination lighting could be expected to exert a beneficial effect on the frequency of highway accidents. To accomplish this goal, those factors were to be identified that could be used to distinguish between locations where roadway lighting had apparently been effective in reducing accidents and those locations where no beneficial effect on accident frequency had been apparent. If practicable, the effect of each such factor was to be quantified and applied in evaluating the cost effectiveness of destination lighting.

Research Approach

The technical literature was reviewed for publications that reported the results of research relating to the installation of destination lighting on roads carrying relatively low traffic volumes. A brief summary of the most relevant reports is included in Chapter II.

Chapter III describes the process of data acquisition that was undertaken as part of this research. It was recognized in advance that any analysis of accident experience at secondary road locations would face the problem of handling small numbers statistically. Since relatively few accidents occur at such locations, two distinctly different comparisons were to be accomplished, as described in Chapter III. These comparisons required the acquisition of accident and traffic volume data for each sample location as well as a field survey that obtained information on the physical characteristics of each location. The sample was constituted following an inventory of the roadway lighting currently under county jurisdiction on secondary roads in Iowa.

An evaluation and analysis of the accident experience at locations with destination lighting followed the acquisition of data and is presented in Chapter IV. The purpose of this step was to assess the effect of roadway lighting on accident experience. A further purpose was to identify any characteristics that were unique to locations where lighting had exerted a beneficial effect on accident frequency and to quantify the relationships involved.

The conclusions and recommendations resulting from the research are presented in Chapter V. The recommendations were formulated following a meeting with an advisory panel that assisted the research team.

CHAPTER II. REPORTED RESULTS OF PREVIOUS RESEARCH

Previous research that has been reported in the literature has been directed toward rural highways that carry relatively high traffic volumes. Furthermore, these studies have concentrated upon what may be described as full lighting where the level of illumination has been a relevant concern. The research team is not aware of any previous studies in which the focus has been upon destination lighting on roads carrying relatively low traffic volumes (the type of installations that are the subject of this research).

1968 Review of Status of Knowledge

Lipinski et al. [1] conducted a review in 1968 of the status of knowledge regarding roadway lighting at rural at-grade intersections and summarized then-current practices. The research included a review of more than 300 references. Survey questionnaires were sent to 49 state highway departments and various other organizations and industries concerned with roadway lighting problems.

This review concluded that very few research studies pertaining to illumination problems at rural at-grade intersections had been conducted. The replies of the states and other organizations to the survey questionnaire, however, indicated considerable interest in such studies.

Relatively few states had established programs for lighting rural at-grade intersections, although such lighting had been installed at some 2,300 intersections in 20 states. It was concluded that only a few states had realized the importance of establishing and implementing lighting programs that were based on specific warrants or design criteria.

This study was concerned with defining the benefits from illumination of rural at-grade intersections. The two principal benefits mentioned were accident reduction and capacity improvement. Another concern was to ascertain the factors being considered in the design of lighting systems. Relatively little information was presented concerning warranting conditions for roadway lighting. Traffic volume counts and number of accidents or accident rates, particularly in permitting comparisons of night accidents with day accidents, were apparently being used by a few states as warrants for the installation of roadway lighting. Certain aspects of intersection design were also suggested as criteria to determine lighting warrants.

Illinois Studies of Lighting on Rural Highways

Studies conducted in Illinois were directed toward determining the safety benefits from illuminating rural at-grade highway intersections and, based on this experience, developing warrants for the use of lighting at such locations [2,3]. Data from these studies indicated no differences in accident severity between lighted and unlighted locations. However, lighting was shown to have a significant and beneficial effect on the frequency of occurrence of accidents at night. Illumination was credited with an average reduction in night accidents of 30%.

The potential reduction in night accidents was suggested from these studies as a condition warranting the installation of lighting. An intersection was to be considered for illumination only if at least one-fourth of the accidents recorded at that location had occurred at night. The anticipated reduction in night accidents was quantified and used to establish priorities among candidate locations.

Study in Iowa of Rural Intersection Lighting

Walker and Roberts compared the accident rates after lighting at 47 rural highway intersections in Iowa with the accident rates before illumination was installed [4]. An average reduction in the night accident rate of 52% occurred after lighting, a change that was highly significant. The 13% reduction in the day accident rate was not statistically significant.

The changes observed in Iowa were significant only at certain types of locations. Channelized intersections experienced a significant reduction in night accidents, whereas the reduction at nonchannelized intersections was not significant. Similarly, greater benefits occurred if the intersection had four legs, involved a route turn, and had average daily traffic volumes greater than 3,500 vehicles. Installations with six or more lights experienced greater improvement than installations with three to five lights, a characteristic that correlated closely with high-volume locations that were channelized.

Before lighting, 29% of the total number of accidents recorded at these 47 intersections occurred at night. This was reduced to 18% following the installation of lights. Of 30 intersections where the proportion of night accidents was 25% or more (consistent with the Illinois warrant of a day-to-night ratio of three to one), 26 experienced a reduction in accidents occurring at night. The proportion of night accidents at these locations declined from 39% to 17% following the installation of lighting. On the other hand, the proportion of accidents occurring at night increased sharply at the 17 intersections in this sample where the ratio of day-to-night accidents exceeded three before the installation of lighting.

Summary Comments

The previous research summarized above tends to indicate that significant safety benefits will occur from the installation of lighting at rural intersections that carry high traffic volumes and are channelized. Although the numbers of accidents occurring at the 47 intersections in Iowa were quite low, thus enhancing the likelihood that changes in before-and-after accident experience would be subject to a regression-to-the-mean effect, the changes experienced were significant. These changes also tended to substantiate the conclusions from the Illinois studies that a beneficial effect on safety would be most likely to result if more than one-fourth of the accidents at a location had occurred at night. None of these research results may be related directly to the experience that may be expected from the use of destination lighting on secondary roads, however. Secondary road locations are characterized by low traffic volumes, simple intersection layouts, and only one or two lights at a location.

References

1. Lipinski, M. E., et al., "Summary of Current Status of Knowledge on Rural Intersection Illumination," Highway Research Record 336, 1970, pp. 33-62.
2. Wortman, R. H., et al., "Development of Warrants for Rural At-Grade Intersection Illumination," Civil Engineering Studies, Transportation Engineering Series No. 3, Illinois Cooperative Highway Research Program Series No. 135, Urbana, Illinois: University of Illinois, Nov. 1972.
3. Wortman, R. H. and M. E. Lipinski, "Rural At-Grade Intersection Illumination," Civil Engineering Studies, Transportation Engineering Series No. 12, Illinois Cooperative Highway Research Program Series No. 153, Urbana, Illinois: University of Illinois, May 1974.
4. Walker, Fred W. and Stephan E. Roberts, "Influence of Lighting on Accident Frequency at Highway Intersections," Transportation Research Record 562, 1976, pp. 73-78.

CHAPTER III. DATA ACQUISITION

An initial step in this research was to compile an inventory of the roadway lighting currently installed on secondary roads in Iowa. From this inventory, two samples were constituted. The first sample was used subsequently for a before-and-after comparison of accident experience. The second sample was used for a comparison of accident experience at lighted locations with the experience at selected control locations. For each lighted location included in either sample and the control locations, the following additional data were collected:

1. Accident records for the period 1977 through 1982
2. General physical characteristics of each location
3. Traffic volume data

Inventory of Secondary Road Lighting

In order to establish a complete inventory of the roadway lighting currently installed on secondary roads in Iowa, a survey in two stages was utilized. Initially, a telephone contact was made with each County Engineer in Iowa to establish whether there were any secondary road lighting installations for which that county was responsible. Those counties having responsibility for secondary roadway lighting were then sent questionnaires to obtain the following information:

- Locations of lighting installations (indicated on a map) that are the responsibility of the county
- The number of luminaires in place at each lighted location

- The type of luminaires in use at each lighted location
- The source of electricity for each installation
- The costs of installation, maintenance (both wear-and-tear and vandalism), and energy for each location
- The type of each location (intersection, railroad crossing, etc.)
- The type of installation for each location
- Significant changes that had occurred at each location since 1976
- Objective information to provide insight into the acceptance of lighting by County Supervisors, property owners, and motorists

Copies of the questionnaire and its accompanying letter are included in Appendix A. This questionnaire was developed following the pretest of a slightly different questionnaire sent to four County Engineers in Iowa. The pretest questionnaire was evaluated for its clarity and its effectiveness in obtaining the required information and was then revised accordingly.

The telephone survey indicated that 56 of the 99 Iowa counties had secondary roadway lighting installations under county jurisdiction. In December 1982, questionnaires were mailed to the 55 County Engineers who had indicated that there was at least one secondary road lighting installation under county jurisdiction in each of their counties. An annual report on lighting installations in Polk County served in lieu of a questionnaire response from that county.

All 55 questionnaires were received from the County Engineers by April 1983. Two of these questionnaires indicated no secondary roadway lighting installations under county jurisdiction (after the telephone contact had indicated at least one). This resulted in a total of 54 counties having secondary roadway lighting installations under their jurisdiction. A frequency distribution of the number of secondary roadway lighting installations in each county is shown in Table 1. A summary of the number of lighting installations by county is provided in Table 2.

Constituting the Sample for Detailed Analysis

Relatively few accidents typically occur at the rural secondary road locations where destination lighting has been installed; thus, it was anticipated that statistical analyses involving the use of accident data would encounter the problem of dealing with small numbers of accidents. As a consequence, an objective in structuring a sample for analysis was to include as many locations for analysis as the project budget would permit.

In an effort to enhance further the validity of the analyses of data from this research, two distinctly different comparisons were to be accomplished. In one comparison, the accident experience following the installation of destination lighting was to be compared with the accident experience before lighting was installed.

The second comparison was to include locations that had destination lighting throughout the period of analysis. The accident experience

Table 1. Frequency distribution of light installations

Number of Lighting Installations	Number of Counties
0	45
1	8
2-3	7
4-5	8
6-10	5
11-15	6
16-20	4
21-30	8
31-50	5
Over 50	3

Table 2. Inventory of secondary road lighting

County	No.	County	No.	County	No.
Adair	7	Franklin	24	O'Brien	12
Adams	1	Greene	3	Osceola	2
Appanoose	2	Grundy	5	Palo Alto	2
Audubon	1	Hamilton	16	Pocahontas	31
Benton	18	Hancock	14	Polk	100
Black Hawk	28	Henry	4	Pottawattamie	6
Bremer	29	Humboldt	49	Poweshiek	7
Butler	41	Jackson	3	Ringgold	1
Calhoun	28	Jefferson	1	Sac	1
Carroll	4	Jones	15	Scott	14
Cerro Gordo	15	Kossuth	91	Shelby	8
Clay	12	Lee	3	Sioux	21
Clinton	19	Linn	26	Story	5
Crawford	2	Louisa	5	Tama	33
Des Moines	1	Lyon	22	Warren	1
Dubuque	7	Marshall	4	Washington	1
Emmet	18	Mills	4	Webster	56
Floyd	30	Monona	4	Wright	39

The total number of secondary road lighting installations in Iowa in 1982 is 896.

at these locations was to be compared with a sample of comparable locations that had no lighting.

In constituting both samples, installations were excluded if a significant change had occurred since 1976 in traffic control, surface type, or any other factor that would tend to invalidate a before-and-after comparison. Installations effected after 1980 were excluded since it was not known at the time the research commenced whether accident data would become available for all of 1982. Because of the relatively small number of installations at bridges or railroad grade crossings, only installations at intersections were included in the sample for detailed study. Similarly, installations that had more than two luminaires were excluded from the sample. By excluding locations having three or more luminaires, the sole focus of the research was on installations that properly may be described as destination lighting, as distinct from full lighting. The total number of locations available for the two samples for detailed study is summarized in Table 3.

The sample for before-and-after comparisons of accident experience was constituted from those intersection locations at which lighting was installed in 1978, 1979, or 1980. Choice of these three years reflects the fact that accident data were available only for the period 1977 through 1982. By excluding accidents occurring during the year that lighting was installed, the accident experience used in the before-and-after comparison is summarized as follows:

Table 3. Types of secondary road lighting installations

- Total number of secondary road lighting installations = 896
  - Total number unsuitable for analysis = 255
  - Total number suitable for analysis = 641
    - Suitable locations requiring controls = 549
      - Primary to secondary = 199
        - Installed before 1977 = 163
          - One luminaire = 149
          - Two luminaires = 14
        - Installed in 1977 = 36
          - One luminaire = 26
          - Two luminaires = 10
      - Secondary to secondary = 350
        - Installed before 1977 = 329
          - One luminaire = 295
          - Two luminaires = 34
        - Installed in 1977 = 21
          - One luminaire = 18
          - Two luminaires = 3
    - Suitable before-and-after locations = 92
      - Primary to secondary = 53
        - Installed in 1978 = 11
          - One luminaire = 9
          - Two luminaires = 2
        - Installed in 1979 = 18
          - One luminaire = 14
          - Two luminaires = 4
        - Installed in 1980 = 24
          - One luminaire = 23
          - Two luminaires = 1
      - Secondary to secondary = 39
        - Installed in 1978 = 11
          - One luminaire = 11
          - Two luminaires = 0
        - Installed in 1979 = 14
          - One luminaire = 13
          - Two luminaires = 1
        - Installed in 1980 = 14
          - One luminaire = 14
          - Two luminaires = 0

Year of Installation	"Before" Experience	"After" Experience
1978	1977 (1 year)	1979-1982 (4 years)
1979	1977-1978 (2 years)	1980-1982 (3 years)
1980	1977-1979 (3 years)	1981-1982 (2 years)

All of the 92 locations in this category were included in the sample for before-and-after comparison.

The second sample was drawn from those 549 locations at which lighting was installed before 1978. An objective in constituting this sample was to limit the number of locations to be surveyed in the field to approximately 300, suggesting the need for about 104 locations in this category plus the same number of control locations. This sample size was achieved by selecting a nominal 25% sample with a maximum of six locations in any county.

The 54 counties with secondary road lighting were placed in 16 groups of from one to six counties each. Installations were selected for inclusion in the sample by generating random numbers. These random numbers designated a county and grid coordinates placed on that county map. Installations nearest the randomly-generated point locations were selected. This process continued in each county until a nominal 25% sample was reached or until six installations were selected in that county.

Accident comparisons for the locations that were lighted throughout the period 1977 through 1982 were with a sample of comparable locations that were not lighted. A control location was selected to correspond with each location in the sample that was continuously lighted, using the following criteria:

- Located in the same county as the lighted location or in an adjacent county
- Had the same geometric configuration as the lighted location (such as four-leg intersection or T-intersection)
- Had the same type of traffic control (such as two-way stop or four-way stop)

These samples were reduced even further in size for several other reasons. Many locations requiring controls that were initially selected for analysis were discovered to be "odd" locations when field surveys were conducted. An odd location is one where an unusual configuration or other physical feature makes it difficult, if not impossible, to find a comparable control location. For this reason, the location is excluded from the analysis sample. Two locations (one of them a before-and-after location) were excluded because traffic volume data necessary for analysis of these locations were unobtainable. These exclusions resulted in the final sample that was the subject of accident analysis, field inventories, and traffic volume data collection, as follows:

- Installations for before-and-after study 91
- Installations requiring controls 102
- Control locations 102
- Total for detailed analysis 295

Accident Data

An additional data set collected was the accident data for each location in the sample for detailed analysis. Accident information was obtained from the Office of Safety Programs, Iowa Department of Transportation. A computer printout from the Accident Location and Analysis System (ALAS) was requested for each location in the sample. Information was available from 1977 to 1982 inclusive. The information obtained and used in this research included:

- The number of accidents at each location
- The time and date of occurrence of each accident
- The lighting condition for each accident (day, night, dawn, dusk, or lighted)
- The type of each accident
- The driver/vehicle contributing circumstances for each accident
- The approximate dollar cost of each accident

Field Survey Data

After a complete inventory of secondary roadway lighting installations was established, field surveys were conducted by research personnel at those locations selected for inclusion in the sample for analysis. A field survey crew, consisting of two persons, traveled to all of the locations in the analysis sample and gathered the following information where applicable on the physical characteristics of each:

- The type of configuration (+, T, Y, etc.)
- The angle of intersection between the roadways

- The type of controls present (stop signs, yield signs, etc.)
- The presence of channelization
- The number of luminaires present
- The mounting height(s) of the luminaire(s)
- The type of mounting used for the luminaires
- The distance(s) of the luminaire(s) from the center of the intersection
- The color of the luminaire(s)
- The presence and number of farm security lights in the vicinity of the intersection
- The surface type of the intersection approach legs (paved surface or loose surface)
- The pavement width of each paved approach leg
- The number of access points (driveways, field entrances, or roads) on the approach legs near each intersection
- The types of signing present on each approach
- The speed limits on each approach
- The night sight distances for stop signs (or yield signs) for each approach with these traffic controls present
- The distance from the intersection on each approach when the lighting becomes visible and acquires significant target value at night
- The level of illumination at the center of the intersection

A copy of the field survey form is shown in Appendix B.

Traffic Volume Data

The final data set collected was traffic volumes at each location in the analysis sample. These traffic volumes were obtained from traffic volume maps supplied by the Iowa Department of Transportation. Secondary road traffic volumes from several different years (1973-1982) were adjusted, using conversion factors, to reflect traffic volumes in the base year, 1980. The conversion factor for each year was a multiplier equal to the vehicle-miles of travel on secondary roads for 1980 divided by the vehicle-miles of travel on secondary roads for the year of the traffic count. Multiplying the traffic volume entering an intersection in a given year by the corresponding conversion factor for that year yields an estimate of the traffic volume entering that intersection in 1980. Table 4 gives the values of these conversion factors.

Table 4. Traffic volume conversion factors for secondary roads

Year	Factor (Multiplier)
1973	1.047
1974	1.025
1975	1.000
1976	0.986
1977	0.974
1978	0.955
1979	0.934
1980	1.000 = Base Year
1981	0.958
1982	0.874

CHAPTER IV. EVALUATION AND ANALYSIS

The objective of evaluating and analyzing the data obtained in this research was to quantify the effect of destination lighting on accident frequency. This was accomplished by comparing the accident experience at lighted locations (the "after" experience at 91 before-and-after locations and the experience at 102 locations that were continuously lighted) with the accident experience at locations without lights (the "before" experience at 91 before-and-after locations and the experience at 102 control locations).

Ideally, the conclusions reached from the two comparisons would be consistent. For example, if accident rates declined following the installation of destination lighting at the locations in the before-and-after sample, it would be expected that accident rates would be lower at the locations with destination lights than at the comparable unlighted control locations. Such a finding would support the conclusion that the installation of destination lighting may be expected to lead to a reduction in accidents. An array of possible results from the two comparisons is shown as Figure 1. The possible conclusions from these results are displayed in Table 5.

Only conclusions 3, 5, and 7 shown in Table 5 are consistent. The other six conclusions have been interpreted to indicate that the short-run results as indicated from the before-and-after sample differ from the long-run results indicated by comparing accident rates at continuously lighted locations with the rates at unlighted locations.

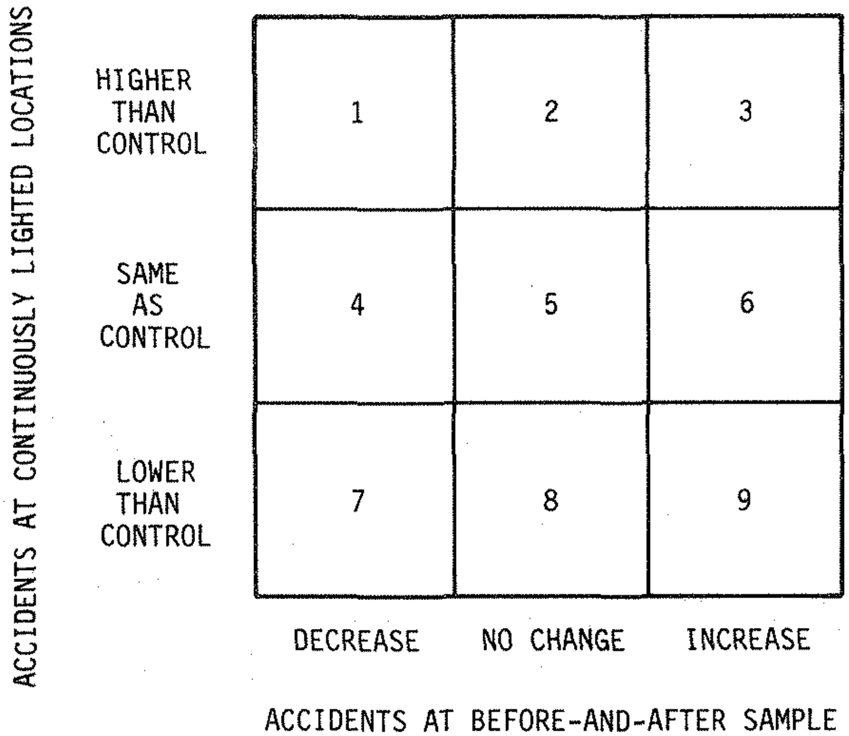

Figure 1. Possible results from comparisons of accident experience.

Table 5. Interpretation of results displayed in Figure 1

	Conclusions	
Result	Short-run Effect	Long-run Effect
1	Accidents decrease	Accidents increase
2	No effect	Accidents increase
3	Accidents increase	Accidents increase
4	Accidents decrease	No effect
5	No effect	No effect
6	Accidents increase	No effect
7	Accidents decrease	Accidents decrease
8	No effect	Accidents decrease
9	Accidents increase	Accidents decrease

It should be recognized that these inconsistent conclusions may also result because of the instability inherent in any statistical analysis involving small numbers.

Accident Rate Comparisons

Comparisons of accident rates were made using a t-test at a 5% level of significance. The implication of this significance level is that there is a 95% probability that any differences noted occurred because of actual differences in the results of destination lighting and only a 5% probability that there were no actual differences but that the apparent difference in results was a chance occurrence. A "t" statistic of 1.96 or greater indicates a significant difference at this significance level.

Three different accident rates were calculated for each comparison as follows:

1. The total accident rate (equal to the total number of accidents at the intersection during the exposure period divided by the total traffic volume entering the intersection during the exposure period);
2. The day accident rate (equal to the number of accidents occurring during the day divided by two-thirds of the total traffic volume entering the intersection); and
3. The night accident rate (equal to the number of accidents occurring at night divided by one-third of the total traffic volume entering the intersection).

All rates were expressed in accidents per million entering vehicles (accidents/MEV).

These calculations were based on an assumption that two-thirds of the traffic volume occurred during the day and one-third occurred at night. This breakdown between day and night traffic was reported in Illinois in the study of rural at-grade intersection lighting referred to previously (Ref. 3, Chapter II). The accuracy of this assumption is not critical to the analyses for which it was used since all of the values compared were based on the use of the same assumed breakdown. The relative magnitude of the accident rates being compared would be the same if the proportion of traffic occurring at night were more or less than one-third.

A summary of the accident rate comparison for the before-and-after data subset is shown in Table 6. The average day accident rate under unlighted conditions was 0.588 accidents/MEV. The average day accident rate under lighted conditions was 0.517 accidents/MEV. This difference is not statistically significant at the 5% level. A t statistic greater than or equal to 1.96 is needed for significance. The t statistic for this analysis was only 0.43. Destination lighting, however, was not expected to have a beneficial effect on reducing day accidents.

The average night accident rate under unlighted conditions was 0.395 accidents/MEV. Under lighted conditions, the average night accident rate was 0.626 accidents/MEV. The difference is in the opposite direction of what was expected. Again, however, the difference is not statistically significant at the 5% level, i.e., destination lighting did not have a statistically significant

Table 6. Accident rates before and after lighting

Day Accident Rate	Mean	Standard Deviation
Unlighted	0.588	1.253
Lighted	0.517	0.964

The value of the t statistic is 0.43.

Night Accident Rate	Mean	Standard Deviation
Unlighted	0.395	1.230
Lighted	0.626	1.643

The value of the t statistic is -1.07.

effect in increasing the night accident rate. The hypothesis that the average night accident rates from the two populations are equal cannot be rejected at the 95% confidence level.

A summary of the accident rate comparison for the lighted and control location data subset is shown in Table 7. The average total accident rate for unlighted control locations is 0.674 accidents/MEV. For lighted locations, the average total accident rate is 0.532 accidents/MEV. The t statistic equals 1.32.

The average day accident rate for unlighted control locations is 0.683 accidents/MEV. Lighted locations had an average day accident rate of 0.538 accidents/MEV. The t statistic is 1.23.

For unlighted control locations, the average night accident rate is 0.656 accidents/MEV. Lighted locations had an average night accident rate of 0.520 accidents/MEV. The t statistic is 0.73.

For all three accident rates (even the day rate), the difference was in the direction expected, i.e., lower for lighted locations. None of the differences, however, was statistically significant at the 5% level. None of the t statistics exceeded 1.96, and the night accident rate, which was most expected to be reduced by destination lighting, had the lowest t statistic of the three.

Correlation Coefficients

Even in the absence of any evidence that the installation of destination lighting could be expected to lead to a reduction in accidents, an analysis was undertaken to quantify the relationship

Table 7. Accident rates for lighted and control locations

Total Accident Rate	Mean	Standard Deviation
Lighted	0.532	0.589
Control	0.674	0.912

The t statistic is equal to 1.32.

Day Accident Rate	Mean	Standard Deviation
Lighted	0.538	0.682
Control	0.683	0.973

The t statistic is equal to 1.23.

Night Accident Rate	Mean	Standard Deviation
Lighted	0.520	1.006
Control	0.656	1.584

The t statistic is equal to 0.73.

between the accident rate and certain independent variables that could be quantified numerically. This analysis was intended to identify warranting conditions to distinguish between locations where destination lighting was shown to be effective in reducing accidents and those locations where no beneficial effect on accident frequency was apparent.

Different types of statistical analyses were undertaken including multiple linear regression and discriminant analysis. Three different dependent variables were used, as follows:

1. TACCRATE = total accident rate (a decrease indicates a safety benefit).
2. PRCTDIFF = difference between the percentage of total accidents occurring at night under unlighted conditions and the same percentage under lighted conditions (an increase indicates a safety benefit).
3. RATEDIFF = difference in the ratio of night-to-day accident rates under unlighted conditions and the same ratio under lighted conditions (an increase indicates a safety benefit).

Since use of these variables is valid only if lighting is installed at a previously unlighted location, the data for the before-and-after sample were used for this analysis. The independent variables used in the analysis are displayed in Table 8. No combination of variables, however, led to a significant relationship. It was not possible from this analysis to identify specific factors that would tend to suggest that the installation of destination lighting would reduce accident frequency at a given location.

Table 8. Variables describing intersection characteristics

Variable	Description
ANGLE	The angle of intersection between the intersecting roadway centerlines.
INTERSEC	The type of intersection configuration (a dummy variable having only two values).
ISLAND 1	The channelization present at the intersection (a dummy variable).
ISLAND 2	The channelization present at the intersection (a dummy variable).
NUMBER	The number of luminaires present at the intersection.
LIGHT 1	The distance from the first luminaire to the center of the intersection.
LIGHT 2	The distance from the second luminaire (if present) to the center of the intersection.
TYPELUM 1	The type of the first luminaire present at the intersection (a dummy variable).
TYPELUM 2	The type of the second luminaire (if present) (a dummy variable).
HEIGHT 1	The height of the first luminaire above the center of the intersection.
HEIGHT 2	The height of the second luminaire (if present) above the center of the intersection.
COLOUR 1	The color of the first luminaire (a dummy variable).
COLOUR 2	The color of the second luminaire (a dummy variable).
COLOUR 3	The color of the third luminaire (a dummy variable).
COLOUR 4	The color of the fourth luminaire (a dummy variable).
COLOUR 5	The color of the fifth luminaire (a dummy variable).
LEVEL 1	The illumination level at the center of the intersection with the light meter horizontal.

Table 8. Continued

Variable	Description
LEVEL 2	The illumination level at the center of the intersection with the light meter directed at the light source.
FARMLITE	The presence of farm security lights near the intersection (a dummy variable).
QUADRANT	The location and number of farm security lights present.
AVGSURF	The average surface type of all approaches (a dummy variable).
MINSURF	The minimum surface type of the approaches (a dummy variable).
AVGWIDTH	The average width of the paved approaches.
MINWIDTH	The minimum width of the paved approaches.
AVGELEV	Average difference in elevation 200 feet from the intersection for all approaches.
MAXELEV	Maximum elevation difference on an approach.
AVGDRIVE (AVGFIELD) [AVGROAD] {AVGACCES}	Average number of driveways (field entrances) [roads] {total access points} in ¼-mile approach length for all approaches to the intersection.
MAXDRIVE (MAXFIELD) [MAXROAD] {MAXACCESS}	Maximum number of driveways (field entrances) [roads] {total access points} in ¼-mile approach length on any of the approaches to the intersection.
SIGNSX	The level of signing found on the intersection approaches.
SIGNST	The level of signing found on the approaches to T-intersections.
AVGSPEED	The average speed limit on all approaches.
MINSPEED	The minimum speed limit of all the approaches.
AVGVISIB	Average distance the stop sign is visible at night.
MINVISIB	Minimum distance the stop sign is visible at night.

Table 8. Continued

Variable	Description
AVGTARGT	Average distance that the lighting becomes visible and acquires significant target value.
MINTARGT	Minimum distance that the lighting becomes visible and acquires significant target value.

Correlation coefficients were calculated for each independent variable. These indicate the extent to which an independent variable is associated with a particular dependent variable. A correlation coefficient with an absolute value between 0.00 and 0.20 indicates a very weak relationship. A value between 0.20 and 0.40 indicates a weak relationship. A moderately strong relationship is indicated by a value between 0.40 and 0.60. With a coefficient between 0.60 and 0.80, the relationship is strong. A very strong relationship is indicated by a value between 0.80 and 1.00.

The largest correlations obtained are displayed in Table 9. It may be noted that only one relationship (MINWIDTH with PRCTDIFF) may be characterized as strong.

Cost Effectiveness

Because destination lighting was apparently ineffective in providing safety benefits and because no significant correlations could be established between the accident experience and certain independent varibles, the cost effectiveness of destination lighting installations could not be determined. Information that would have been used for this calculation will still be presented, however, for its possible value to future research and for its general interest to the reader.

Accident Costs

An average cost per accident was calculated for several accident categories. These costs were developed from the accident data using

Table 9. Values of largest correlation coefficients

TACCRATE		PRCTDIFF		RATEDIFF	
NUMBER	0.30	MINWIDTH	-0.65	MINWIDTH	-0.45
		AVGWIDTH	-0.58	NUMBER	0.38
		AVGROAD	-0.40	ANGLE	-0.32
		AVGSURF	-0.36		
		NUMBER	0.35		

the cost estimates provided in the ALAS computer printout. Table 10 shows these average accident costs.

Costs for Destination Lighting

The typical destination lighting installation in Iowa is owned by an electric utility or a rural electric cooperative. The owner of the installation has incurred the costs for construction and assumes responsibility for maintaining the lighting installation. Consequently, the charge to a county includes the cost of electric energy, a charge for maintenance, and a contribution toward amortizing the original cost for construction. The data available do not make it possible to segregate the charges for construction, maintenance, and energy. Variations occur in some counties in which the county is responsible for costs resulting from vandalism but not for routine maintenance costs. In other cases, a county has constructed a lighting installation, retains full responsibility for maintenance, and simply purchases electrical energy.

Because of the considerable variation in the methods used to install, maintain, and operate destination lighting, average costs are not meaningful. However, displayed in Table 11 are median values for the annual costs of a typical installation, broken down by Iowa Department of Transportation Highway Division Districts. In this typical case, the monthly or quarterly charge includes all costs for construction, maintenance, and electric energy. It may be seen that the average costs are relatively low; approximately $6.17 per month for an installation including one luminaire and $10.58 per month if two luminaires are present.

Table 10. Average accident cost vs. lighting condition

Type of Accident	Average Cost
An accident at any time	$10,739
A day accident	$11,009
A night accident	$10,020
A night unlighted accident	$11,261
A night lighted accident	$ 9,163

Table 11. Median annual costs of destination lighting in Iowa

Location	For One Light	For Two Lights
District 1	$108	$134
District 2	60	101
District 3	87	121
District 4	88	224
District 5	97	250
District 6	134	224
Iowa	$ 74	$127

Attitudes Toward Roadway Lighting

Thirty-four County Engineers answered the question on the survey questionnaire concerning the response by the public and their Boards of Supervisors to lighting on secondary roads. The responses of 31 County Engineers were favorable, indicating that lighting was well received by the public and was perceived as being beneficial. One County Engineer gave a neutral response indicating only that no complaints had been received concerning roadway lighting. Two County Engineers indicated that their counties were not considering any more lighting installations, a response that was considered to be negative.

It should be pointed out that these responses were from a biased sample. The questionnaire was directed only to County Engineers in counties that have secondary road lighting installed. Counties without roadway lighting obviously may not view lighting favorably. County Engineers in these counties commonly indicated to research personnel that the Boards of Supervisors do not support expenditures for this purpose. Other comments indicated a lack of conviction that there are benefits from roadway lighting and a concern for problems resulting from vandalism of lighting installations.

Several counties reported programs to replace mercury vapor luminaires with the sodium vapor type. This change can result in lower energy costs for the same level of illumination. A number of County Engineers favor the sodium vapor lighting because its distinctive yellow color is easily distinguished from the blue color of mercury vapor lamps. This color difference helps to identify roadway lighting and prevent confusing these installations with farm lights, which typically use mercury vapor lamps. Other County Engineers reported that the same goal is being accomplished using mercury vapor lamps with a color-correcting yellow lens on the luminaire.

Only a few County Engineers perceive vandalism of luminaires as a significant problem. One County Engineer reported that the public was prompt in notifying authorities when a light was out.

CHAPTER V. CONCLUSIONS AND RECOMMENDATIONS

Conclusions

The results of this research show that the installation of destination lighting will not result in a decrease in accident frequency. No significant differences were noted in the accident rates at lighted and unlighted locations.

Similarly, the results of this research indicate that the proportion of accidents occurring at night will not be affected favorably by the installation of destination lighting on secondary roads. The proportion of accidents occurring at night increased from 24% to 31% after lighting was installed at the 91 intersections included in the before-and-after sample. The 102 locations that were continuously lighted experienced 27% of all accidents at night. This compares with experience at the 102 control locations that were not lighted, at which 26% of all accidents occurred at night.

Although the differences in the proportions of accidents occurring at night between lighted and unlighted locations are not statistically significant, a hypothesis that destination lighting will reduce night accidents must be rejected. Nevertheless, the effects of dealing with very low numbers of accidents must be considered in interpreting any of the results from this research. The sample from which accident rates was derived included 295 secondary road intersections, including the control locations. Accident data for a six-year period were utilized; thus, the total sample included the exposure for 1,770 intersection-years, seemingly a very large sample. Even so, there were no accidents during 1,365 intersection years, 77% of the total. The average frequency was 0.32 accidents per intersection-year, approximately 1.9 accidents per intersection for the entire six-year analysis period. Even though the sample size seemed large and a total of 567 accidents was recorded at all of the sample locations, the analyses for this research were dealing with very small numbers of accidents at each location. This factor largely accounts for the fact that it was not possible from this research to identify specific characteristics of a location that were correlated with beneficial effects on accident frequency.

The analysis of possible differential effects of destination lighting on different types of accidents produced the following results:

- Single-vehicle accidents: Night rates were substantially higher than day rates. Differences between lighted and unlighted rates were inconsistent; single-vehicle accidents increased at night after lighting at the before-and-after locations, but there were fewer night single-vehicle accidents at continuously lighted locations than at the control locations.
- Stop-sign-violation accidents: Night rates were substantially lower than day rates. Differences between lighted and unlighted rates were slight and were inconsistent between the two samples.
- Turning accidents: Day and night rates differed very little. Differences between lighted and unlighted rates were slight and were inconsistent between the two samples.

It is not possible to conclude from this comparison that there are benefits from the installation of destination lighting that are reflected by changes in the types of accidents that will occur.

Because of the small number of accidents involved and the possibility of results being distorted by random occurrences, no effort was made to differentiate among accidents by severity. It may be recalled that the Illinois study found no differences in accident severity between lighted and unlighted locations (Ref. 2, Chapter II). However, the average cost displayed in Table 10 for night accidents that occurred at lighted locations included in this study was only 81% as high as for night accidents at an unlighted location. This difference, although not highly significant, indicates a possible safety benefit from destination lighting that is not reflected in the number of accidents. Based on the data from this study, a night accident typically would occur at a secondary road intersection about once every 12 years. By contrast, the difference in costs of $2,098 per night accident is sufficient to offset the cost of a single destination light ($74 per year) for more than 28 years.

Recommendations

There was no evidence from this research that the number of accidents is reduced by the installation of destination lighting. Hence, the installation of destination lighting cannot be recommended based on safety benefits.

Instead, destination lighting must continue to be viewed as a measure that benefits motorists by providing a target to assist in the guidance task in driving. Since this benefit is not readily quantified in monetary terms, it does not lend itself to consideration in terms of cost effectiveness. In effect, the recommendation resulting from this research is that the decision to install destination lighting should be based on the same subjective criteria used in the past. These criteria seem to have worked quite well. Counties with destination lighting seem satisfied with these installations. The results are satisfactory to the public and to the county officials who made the decisions. Counties without destination lighting also seem to be content with that status. Since the benefits from destination lighting cannot be suitably quantified and the costs are so low, the use of subjective criteria for decisions as to its use seems entirely suitable.

ACKNOWLEDGMENTS

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Valuable assistance during portions of the research effort was provided by Richard Yun-Hao Woo, Graduate Research Assistant. His help is gratefully acknowledged.

Each County Engineer in Iowa assisted in this research by responding to a telephone inquiry and, in many cases, also returning a questionnaire that provided much of the input for this research. Their assistance and support is sincerely appreciated.

An Advisory Panel provided the necessary perspective for the interpretation of the findings from this research. Research personnel wish to express their appreciation to the following persons who provided this essential service:

Royce J. Fichtner, Marshall County Engineer

Craig Gregersen, Assistant Attorney General, General Counsel Division, Iowa Department of Transportation

Robert L. Gumbert, Tama County Engineer

Richard E. Mull, Assistant Attorney General, General Counsel Division, Iowa Department of Transportation

Stanley L. Ring, Professor of Civil Engineering, Iowa State University

The authors, however, are solely responsible for the interpretation of the findings resulting from this research and for the conclusions and recommendations that are based on these findings.

APPENDIX A

QUESTIONNAIRE SENT TO COUNTY ENGINEERS

Iowa State University of Science and Technology Ames, Iowa 50010

December 17, 1982

Engineering Research Institute
College of Engineering
104 Marston Hall
Telephone: 515-294-2336

The Iowa Highway Research Board recently approved the award of a research contract to the Engineering Research Institute, Iowa State University, to study lighting on secondary roads. The objective of this research is to define locations at which destination lighting, in particular, may be expected to exert a beneficial effect on the frequency of occurrence of highway accidents.

In this connection, we need to establish a complete inventory of lighting installations on secondary highways. Our concern is with all of those installations that are under county control, as distinct from those belonging to the Iowa DOT. The enclosed survey form is directed to that end. Please indicate on the form the few items of information requested for each such installation in your county. Also please send me a county highway map on which the location of each installation is circled and numbered so that the numbers correspond with those on the lighting survey form.

We shall be using the ALAS computerized record for accident data that will be correlated with the characteristics of lighted locations. Since the ALAS file includes accident records for the period beginning in 1977, the year that lights were installed is important to us if this occurred after 1976.

A sample of lighted locations will be selected randomly from throughout the state. This will be followed by a field study of those locations, and some number of control locations not having lights, to include measurements of sight distances and other physical characteristics.

Please contact me (phone 515-294-6777) if you have any question about the survey or just wish to chat about lighting on secondary roads. Thank you for your assistance in completing and returning the survey form.

Sincerely yours,

R. L. Carstens, P.E.
Professor of Civil Engineering
Principal Investigator

RLC/ca

Enclosure a/s

Accident data are available to us (using the ALAS record) only for the period beginning in 1977. We can draw valid conclusions from these data only if no significant change has occurred at a lighted location during that period. Answer "Yes" in the column regarding significant changes and indicate the year of the change if any of the following has occurred since December 31, 1976, relating to an intersection having light(s):

1. The approach, or an intersecting approach, was paved for the first time.
2. The type of control was changed (2-way stop to 4-way stop, uncontrolled to 2-way stop, or a similar change).
3. The nature of the traffic control devices was materially changed, such as would occur if beacons had been added.
4. The applicable speed limit was changed.
5. There was a change in alinement.
6. The sight distance in at least one quadrant has either increased or decreased significantly.
7. Rumble strips have been installed.
8. Traffic volumes have changed substantially, such as would occur if a nearby road were permanently closed.
9. Some other change was made that would tend to invalidate before-and-after comparisons of accident experience at this location.

Please answer "No" if none of the above changes occurred since December 31, 1976. (A change in functional classification would not be significant for our purposes.) If your answer is "Yes", it would be helpful if you would indicate which type of change occurred, from the list above, by using the appropriate number (1 through 9) in the "Yes" column.

County ____________________

SECONDARY ROAD LIGHTING INSTALLATION SURVEY

Number, use on county map	Number of luminaires	Type of lamps					Source of electrical energy	Initial cost of installation	Annual costs		Type of location			Year installed		Significant change since 1976 (see reverse)		
		A	B	C	D	E			Maintenance (wear & vandalism)	Energy	Stop sign	RR x-ing	Other (explain)	Before 1977	Other (specify)	No	Yes	Year
1																		
2																		
3																		
4																		
5																		
6																		
7																		
8																		
9																		
10																		
11																		
12																		
13																		
14																		
15																		

A = Mercury vapor
B = Metal halide
C = High pressure sodium
D = Low pressure sodium
E = Other (please specify)

In general: Are secondary road intersection lighting installations well-received in your county? By county supervisors? Motorists? Property owners?

Please explain. ____

____

____

____

Return to: R. L. Carstens, Department of Civil Engineering,
Iowa State University, Ames, Iowa 50011

APPENDIX B

FIELD SURVEY FORM

SECONDARY ROAD LIGHTING SURVEY

LOCATION: ______________________ DATE OF SURVEY: ______________

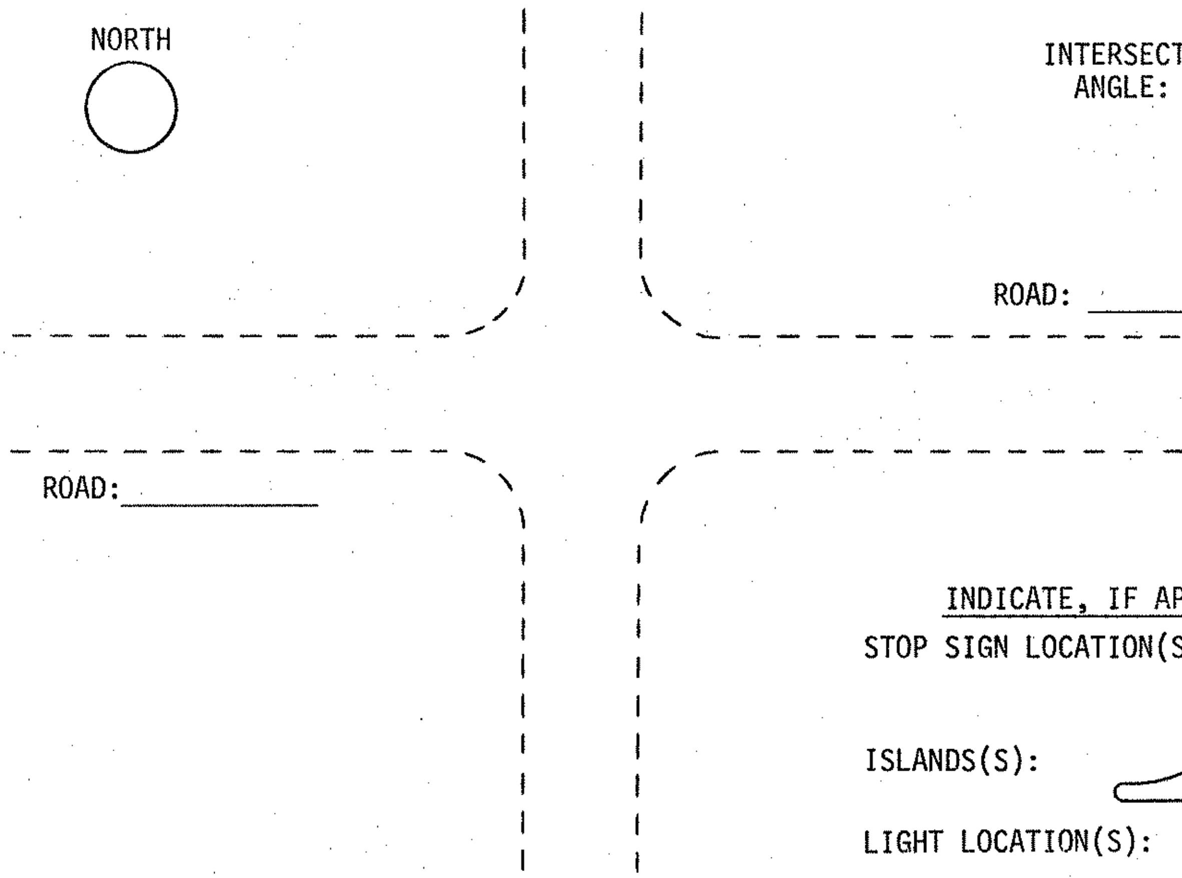
COUNTY: ______________________ TIME STARTED: ______________

INTERSECTION OF __________ WITH __________ SURVEY BY: ______________

ROAD: __________

NORTH

INTERSECTING ANGLE: ________ °



ROAD: __________

ROAD: __________

INDICATE, IF APPLICABLE:

STOP SIGN LOCATION(S):

ISLANDS(S):

LIGHT LOCATION(S): ° #1 ° #2

RAILROAD CROSSING:

ROAD: __________

NUMBER OF LUMINAIRES: __________

TYPE OF LUMINAIRE: #1) ______________ #2) ______________

TYPE OF MOUNTING: #1) ______________ #2) ______________

MOUNTING HEIGHT: #1) ______________ FT. #2) ______________ FT.

COLOR OF LUMINAIRE: #1) ______________ #2) ______________

LEVEL OF ILLUMINATION AT CENTER OF INTERSECTION: __________ FOOT-CANDLES

ARE THERE FARM SECURITY LIGHTS WITHIN 500' OF THE INTERSECTION? ☐ YES ☐ NO

WHAT QUADRANT? ☐ NE ☐ SE ☐ SW ☐ NW

	APPROACH			
	EAST	SOUTH	WEST	NORTH
SURFACE TYPE:				
PAVEMENT WIDTH, FT.:				
DIFFERENCE IN ELEVATION, FT. (200' FROM INTERSECTION)				
NUMBER OF ACCESS POINTS WITHIN A DISTANCE OF $\frac{1}{4}$-MILE				
DRIVEWAYS				
FIELD ENTRANCES				
ROADS				

CHECK THE APPROACHES ON WHICH THE FOLLOWING SIGNS ARE VISIBLE.

	EAST	SOUTH	WEST	NORTH
	☐	☐	☐	☐
 or 	☐	☐	☐	☐
 or 	☐	☐	☐	☐
	☐	☐	☐	☐
OTHER WARNING SIGN (SPECIFY TYPE):	☐	☐	☐	☐

	EAST	SOUTH	WEST	NORTH
APPROACH SPEED LIMIT, MPH				
DISTANCE STOP SIGN IS VISIBLE AT NIGHT, MILES (IF LESS THAN 0.2)				
DISTANCE WHEN INTERSECTION LIGHT BECOMES VISIBLE AND ACQUIRES SIGNIFICANT TARGET VALUE (IF LESS THAN 1 MILE)				

APPENDIX C

LOCATIONS IN SAMPLE FOR

DETAILED ANALYSIS

BEFORE-AND-AFTER SAMPLE

(Lighting Installed 1978-1980)

County	Location
Black Hawk	D 35 and V 27
	D 38 and Ia 21
	C 66 and V 25
	C 57 and V 25
Bremer	US 218 3 mi. north of Janesville
	C 50 and V 56
	US 218 and T 77
	T 77 1.5 mi. south of C 33
	C 33 and T 77
	C 33 and V 43
	C 33 and V 56
	Ia 188 and V 21
	US 63 and V 5C
Butler	C 51 and Ia 14
	Ia 3 and Ia 326
	T 43 1 mi. north of Ia 3
	Local road off Ia 3, 0.5 mi. north of Shell Rock
Carroll	E 37 and N 33
	US 30 and N 38
	E 17 and N 38
Des Moines	US 61 and X 62
Dubuque	US 151 and Y 21
	US 20 and Y 21
	US 20 1.5 mi. east of Y 21
	US 20 3.2 mi. east of Y 21
	US 20 and D 29
Floyd	B 60 and Ia 14
	B 47 and S 70 North
	US 18 and T 24
	US 18 and S 70
	B 20 and S 70 North
Hamilton	R 27 0.5 mi. south of Ia 520
Hancock	B 20 and US 69

(Lighting Installed 1978-1980, continued)

County	Location
Humboldt	C 26 and P 19 West C 29 and US 169 C 29 and P 56 P 60 and 5th Street (south city limits of Luverne)
Jackson	Ia 64 and Y 46
Jones	US 151 and local road into Langworthy E 23 and Ia 38
Kossuth	P 30 1 mi. south of US 18
Linn	Ia 13 and 3rd Street (SE city limits of Coggon)
Louisa	G 62 and W 66 South W 66 South, 1 mi. north of G 62
O'Brien	Ia 10 and M 12 North Ia 60 0.5 mi. south of B 14 US 18 and L 50 US 18 and L 58 US 18 and M 18
Polk	SE 64th Street and SE 19th Street NW 48th Place and NW 6th Avenue NW 66th Avenue and Timberline Drive Ia 415 and NW 16th Street
Scott	Z 30 0.5 mi. south of I-80
Shelby	F 58 and M 16 East F 58 and US 59
Story	E 57 and US 69 South US 69 3.1 mi. north of Lincoln Way (Ames) US 69 3.5 mi. north of Lincoln Way (Ames) E 18 1.5 mi. south of Story City
Tama	Ia 146 and E 69 E 69 and T 47 E 69 and US 63 E 64 and US 63 E 64 and V 18 E 66 and V 18 E 49 and T 47 US 30 and Old Ia 135

County	Location
Tama (cont.)	US 63 and 1 mi. north of E 64
	E 43 and US 63
	E 43 and D 4
	US 30 and E 66
	US 30 and V 18
	V 18 and E 44 and south edge of Vining
	E 43 and V 18
	E 27 and T 47 West
	Ia 229 and E 29 and US 63
	Ia 318 and V 18
	Ia 318 and Ia 21
	E 29 and V 18
	Ia 96 and T 55
	Ia 8 and V 18
	Ia 8 1 mi. east of V 27
	D 65 and T 47 North
	D 65 and T 55
	D 65 and local street at Dinsdale
	D 65 and US 63 South
	D 65 and US 63 North
	D 65 and V 37 North
	D 65 and Ia 21
Washington	Ia 1 and Ia 92

LOCATIONS CONTINUOUSLY LIGHTED 1977-1982

County	Location
Adair	G 61 and P 33
Benton	E 44 and V 42
	E 30 and W 14
	D 65 and US 218
Black Hawk	D 48 and V 51
	Ia 281 and V 49
	US 20 and V 51 East
	C 57 and V 49
Bremer	C 55 4 mi. west of Janesville
	US 218 1 mi. north of Janesville
	Ia 3 and V 43
	C 33 and US 218
	C 33 and US 63
Butler	C 67 and T 55
	C 33 and T 43
	Ia 3 and T 55
	C 23 and Ia 14
	C 13 and T 24 South
	C 23 and T 47
Clay	B 24 and M 27
	B 24 and M 38
	US 18 and N 18
Emmet	A 33 and Ia 4
	Ia 9 2 mi. west of Ia 4
	A 21 and Ia 15
Floyd	B 60 and T 18
	B 60 and T 47
	B 67 and T 64
	B 47 and T 18
	Ia 147 and T 26 West
	Ia 147 and T 26 East
Franklin	C 55 and S 13 East
	C 55 and S 25
	C 55 and US 65
	C 47 and S 25
	Ia 3 and S 41
	C 25 and S 56

LOCATIONS CONTINUOUSLY LIGHTED 1977-1982 (continued)

County	Location
Greene	E 57 and P 30
Hamilton	D 56 and R 38 West
	Old US 20 and R 38 West
Hancock	B 55 and Ia 111 South
	B 14 and R 20
	B 16 and Ia 111
	B 14 1 mi. north of Crystal Lake
Henry	H 28 2 mi. east of X 13
Humboldt	C 46 and P 29
	C 46 and US 169
	C 48 and P 59
	Ia 3 and P 29
	C 26 and P 20
	C 12 and Ia 17 North
Jackson	Ia 62 and Y 61
Jones	E 45 and Ia 38 North
Kossuth	B 63 and P 60
	B 30 3 mi. east of Ia 15
	B 30 and P 30
	B 19 and P 20
	B 14 and P 20
	A 21 and P 40
Linn	East Post Road 0.25 mi. north of E 44
	W 58 1.2 mi. south of E 34
Louisa	G 62 and X 17
Lyon	L 14 2 mi. south of George
	1 mi. south of A 34 and 2 mi. west of L 14
	A 26 and Ia 182
	A 34 5 mi. east of Ia 339
Marshall	E 27, local road 0.05 mi. east of Ia 14
Mills	US 34 and M 16 East
	H 20 and Ia 242
Monona	Ia 175 and L 12

LOCATIONS CONTINUOUSLY LIGHTED 1977-1982 (continued)

County	Location
Osceola	A 22 and L 58 West
Pocahontas	C 49 and N 41
	C 29 and N 28 South
	C 29 and N 28 North
	C 15 and N 28 West
	Ia 15 and C 26 North
Polk	SE 6th Avenue and SE 68th Street
	NW 82nd Avenue and NW 128th Street
	NW 106th Avenue and NW 121st Street
	NE 70th Avenue and NE 112th Street
	NW 118th Avenue and NW 16th Street
	NW 142nd Avenue and NW 58th Street
Poweshiek	US 6 and V 18
	V 18 4.2 mi. north of US 6
Scott	Z 30 0.5 mi. north of I-80
Shelby	Ia 44 and M 47
	US 59 and local road at Defiance
Sioux	B 40 and K 64
	Ia 60 and L 14
	B 30 and K 18
	B 40 and K 30 East
Webster	US 169 4 mi. north of Ia 175
	D 43 and P 51
	Ia 7 0.5 mi. north of Barnum
	D 14 and P 59
	D 14 and P 71
Wright	C 70 and R 38 West
	C 54 and R 33
	C 54 and US 69
	Ia 72 and R 59
	Ia 3 and R 33
	C 25 and R 45

UNLIGHTED CONTROL LOCATIONS

County	Location
Benton	E 22 and V 42
Black Hawk	D 48 and V 62 Ia 218 and D 20 and V 51 C 55 and T 75 D 52 and US 63
Boone	E 26 1 mi. south of Fraser E 26 and P 70
Bremer	C 55 1 mi. west of Janesville
Buchanan	D 16 and V 62
Buena Vista	C 25 and M 44
Butler	US 20 and T 13
Calhoun	Ia 4 and Ia 175 and P 13
Carroll	E 26 and Ia 286
Cerro Gordo	B 20 and S 14 South B 43 and S 56 B 20 and S 14 North Ia 106 1.5 mi. west of Mason City B 47 and S 66 S 56 0.5 mi. south of US 18 B 47 and S 56 B 30 and S 14 US 65 2 mi. north of Sheffield
Chickasaw	B 54 and V 48 Ia 346 and V 21
Clay	B 53 and N 18 B 53 and N 14
Des Moines	H 38 and X 31 West H 38 and X 31 East
Emmet	A 33 and N 32 North A 33 and N 40 East Ia 15 0.5 mi. east of Armstrong

UNLIGHTED CONTROL LOCATIONS (continued)

County	Location
Floyd	Ia 14 and Ia 147
	T 26 1.5 mi. north of Marble Rock
Franklin	US 20 and S 55
	Ia 3 and Ia 107
	S 13 1 mi. south of C 55
	C 73 and S 25
	C 75 and S 41 West
Greene	E 53 and P 30
Grundy	D 35 and Ia 214
	Ia 175 and T 55
	D 17 and T 55 North
	D 55 4 mi. north of Conrad
	D 55 and Ia 14
Guthrie	F 25 and P 18
Hamilton	Old US 20 and R 61
	D 25 and R 77
	D 56 and R 27
	Ia 175 and US 69
	Ia 175 and R 77 West
	D 41 and US 69 North
	D 41 and R 61 West
	D 41 and R 61 East
	D 65 and R 61
	Ia 175 and R 77 East
Hancock	R 26 and B 55
	B 55 and Ia 111 North
Hardin	D 41 and S 55
Humboldt	C 26 4.5 mi. east of Bradgate
Jackson	Ia 62 0.5 mi. south of Andrew
Jasper	F 24 and S 52
	F 36 and S 52
	F 62 and T 14
Jones	E 23 and X 44 West
	E 17 and Ia 136
	D 65 and US 151

UNLIGHTED CONTROL LOCATIONS (continued)

County	Location
Kossuth	P 20 and US 18 A 42 and P 30 East A 38 and US 169 South A 21 and US 169 A 40 and US 169 A 42 and US 169 South B 14 and US 169 US 169 1.8 mi. north of Algona B 55 2 mi. east of US 169
Linn	E 16 and W 58
Lyon	A 34 and L 20 Ia 339 2 mi. north of George Ia 9 and K 60 A 50 and US 18
Marshall	Ia 14 2.5 mi. north of Marshalltown
Mills	US 34 and L 66 H 26 and M 16
Monona	Ia 175 and E 34
O'Brien	B 24 and M 12 B 53 and M 12
Pocahontas	Ia 7 1 mi. east of N 28 C 37 and N 57
Polk	SE Vandalia Road and SE 60th Street NE Rising Sun Drive and NE 70th Street NE 12th Avenue and NE 70th Street NE 110th Avenue and NE 72nd Street
Scott	F 55 and Z 16
Shelby	F 24 and Ia 37
Sioux	B 30 and K 30 B 46 and US 75 B 30 and K 52 B 30 and US 75 South
Story	E 57 and R 38 North

UNLIGHTED CONTROL LOCATIONS (continued)

County	Location
Webster	D 46 and P 33 Ia 175 1.5 mi. west of Ia 144
Wright	Ia 72 and R 65