OFFICE MEMORANDUM

MICHIGAN
DEPARTMENT OF STATE HIGHWAYS

February 19, 1974

To: K. A. Allemeier
Acting Engineer of Testing and Research

From: L. T. Oehler

Subject: Study of Glare Due to Parking Lot Lighting on US 127 near M 36, Mason. Research Project 74 TI-198. Research Report No. R-903.

As a result of M. N. Clyde's memo of January 11, 1974 to K. A. Allemeier, the Photometry Group of the Research Laboratory measured and evaluated the effect of glare on drivers' vision from parking lot lights on southbound US 127 near M 36 in Mason. The following is a report by G. M. Smith, Supervisor of the Photometry Section.

Results of this evaluation show that with the maximum glare measured on southbound US 127, it would be difficult for the average driver to see the roadway edge even with a new edgeline stripe. It is recommended, therefore, that the glare or intensity of the parking lot lights be reduced by approximately one-half.

The pavement brightness and the glare (Disability Veiling Brightness) from the parking lot lights were measured on a clear night and again on a night with a light rain falling. There was little difference in the Disability Veiling Brightness (DVB) measured under each condition; however, brightness of the edge stripe was reduced on the rainy night because of the incapability of the glass beads in the paint stripe to reflect light when covered with water.

In the southbound lanes the maximum DVB produced by the parking lot lighting was 0.06 ft-L (foot Lamberts) which was greater than the pavement brightness at 0.02 ft-L. The maximum DVB measured from headlights of oncoming vehicles was 0.02 ft-L (a string of seven automobiles). Both the DVB and the pavement brightness were measured with the Pritchard Brightness Photometer, located in the average driver's eye position and aimed at typical driver's sight points near the pavement edge and between 30 and 200 ft from the vehicle.

In addition to pavement brightness, the brightnesses of other typical driver's visual tasks, such as the white edgeline, the shoulder asphalt, and the grass near the shoulder were measured (Table 1). Illumination was provided by the low beam headlights of a 1971 Ambassador sedan (AMC). The headlamps were aimed according to the Society of Automotive Engineers Standard J 599 C, 1973.

TABLE 1
TASK BRIGHTNESS

Location, Distance from Vehicle	Brightness, ft-L (low beams)			
	Concrete Pavement	Edge Stripe	Shoulder Asphalt	Grass
30-50 ft	0.021	0.52	0.044	0.24
150-200 ft	0.018	0.25	0.030	----

The brightness contrast between the various visual tasks was computed with and without DVB from the parking lot lights and glare from oncoming vehicle headlamps.

Table 2 gives the brightness contrast levels for each visual driving task (see Appendix for a sample computation of visual task contrast level). The three contrast levels for each task are listed for three glare conditions: the maximum glare situation with both peak oncoming headlamp glare and maximum parking lot lighting glare; the peak oncoming headlamp glare; and the no-glare situation. These values are listed for the limits of the range of a driver's practical nighttime viewing distance; 30 to 50 ft and 150 to 200 ft.

Table 2 lists the minimum contrast levels necessary for the human eye to accomplish the visual tasks, i.e., to see the brightness difference between the objects listed. There are two values of contrast listed for each visual task. The lesser of the two values is appropriate for the case where the driver knows approximately where to look for an object involved in the task, such as the edge of the roadway. The higher contrast value denotes the situation where the driver must search for the edge of the roadway. In either case, the values shown were obtained from data representing nearly 500,000 observations by 35 visually normal observers between 20 and 30 years old. The values apply to 99 percent of all drivers in a dynamic (rather than static) situation.

The criterion that is used to apply the Table 2 data to a specific visual task is simply the determination whether the actual contrast level exceeds the minimum contrast level necessary for the accomplishment of the visual task.

Table 2 indicates that the brightness contrast, whether between pavement and shoulder or between shoulder and grass, is clearly inadequate for those tasks to be seen by most drivers even without the glare from the parking lot lighting. Only the existence of an edge stripe enables the majority of drivers to perceive the demarcation between the roadway and shoulder. With the maximum glare measured on southbound US 127 it would be extremely difficult for the average driver to see the roadway edge even with a new edgeline stripe.

TABLE 2
ACTUAL CONTRAST LEVELS

Driver's Visual Task	At 30-50 ft from Driver			At 150-200 ft from Driver			Theoretical Minimum Contrast Needed to Perceive Task		Minimum Contrast Needed; near static condition.
	Max. Glare (DVB)	Headlight Glare Only	No Glare	Max Glare (DVB)	Headlight Glare Only	No Glare	If task location approx. known	If task location not known	
1. Perception of Brightness Difference Between Pavement and Shoulder	0.2	0.6	1.1	0.1	0.3	0.6	7.4	11.0	2.5
2. Perception of Brightness Difference Between Shoulder and Grass	1.6	3.1	4.5	---	---	---	6.3	9.5	2.1
3. Perception of Brightness Difference Between Pavement and Edge Stripe	4.9	12.0	24.0	2.4	6.1	13.0	7.4	11.0	2.5
4. Perception of Brightness Difference Between Edge Stripe and Shoulder	3.8	7.4	11.0	2.0	4.5	7.5	6.3	9.5	2.1

By computation, it was determined that the maximum parking lot lighting glare must be reduced to approximately 40 percent of its value in order that the typical driver may see the roadway edge.

However, if the assumption can be made that, since the most important visual task is keeping track of the pavement edge, and that the angular position of the pavement edge in relation to the driver's line of sight makes comparatively slow movements, the visual task then becomes more nearly a static state than a dynamic state. Furthermore, the driver ordinarily is not compelled to search for the edgeline since he is guided by the reflector button delineators.

The static state hypothesis was confirmed in a phone conversation with Richard N. Schwab of the FHWA research staff (January 31, 1974). Mr. Schwab is conducting a study using drivers and vehicles in an actual driving situation where the driver must see an edge stripe against various glare levels. He has found so far that the minimum contrast levels in the Blackwell and Taylor laboratory study[1] were approximately four times too high. The minimum contrast levels listed in Table 2 are within the range that Schwab is finding in the field. The last column in Table 2 lists the minimum contrast levels for the static situation. The table shows that, in this static situation, and with a maximum glare, a driver may not be able to distinguish the roadway edge at 150 to 200 ft with or without an edge stripe. The driver can see the edge stripe at 30 to 50 ft even with maximum glare; however, a sight distance of 30 to 50 ft does not allow adequate time for maneuvering at 50 mph.

By computation, in the static state, the DVB from the parking lot lights must be reduced by at least 20 percent to enable the driver to clearly see the edge striping.

The visual tasks can become further complicated if a driver looks directly at the parking lot lights. In this case, the DVB is 0.40 ft-L instead of 0.08 ft-L, or five times greater glare. While looking at these lights a driver cannot distinguish even the white edge stripe against the pavement. Therefore, it is recommended that the DVB or intensity of the parking lot lights in the direction of the approaching southbound vehicles be reduced to approximately one-half of the current level.

The recommended reduction might be attained by re-aiming the parking lot luminaires away from traffic, by reducing lamp wattage, or by shielding the luminaires from southbound US 127 motorists.

TESTING AND RESEARCH DIVISION

L. T. Oehler

Engineer of Research

LTO:GMS:bf

[1] Blackwell, H. R., and Taylor, J. H., "A Consolidated Set of Foveal Contrast Thresholds for Normal Human Binocular Vision," Ohio State University and University of California at San Diego, 1970.

APPENDIX

Sample brightness contrast level computation:

Without Disability Veiling Brightness (glare), the brightness contrast between the pavement and shoulder is:

$$C = \frac{B_s - B_p}{B_B}$$ where

B_s = brightness of shoulder

B_p = brightness of pavement

B_B = brightness of background to which the driver's eyes are adapted, in this case the pavement brightness, so that

$$B_B = B_p$$

At 30 to 50 ft from the driver:

$$C = \frac{0.044 - 0.021}{0.021}$$

$$C = 1.1$$

Disability Veiling Brightness (glare) in the field of vision increases the apparent brightness of every object such that the brightness contrast becomes:

$$C' = \frac{(B_s + DVB) - (B_p + DVB)}{(B_p + DVB)}$$

$$= \frac{B_s - B_p}{B_p + DVB}$$

At 30 to 50 ft, if DVB = 0.08 ft-L:

$$C' = \frac{0.044 - 0.021}{0.021 + 0.08}$$

$$C' = 0.23$$