Roadway Lighting

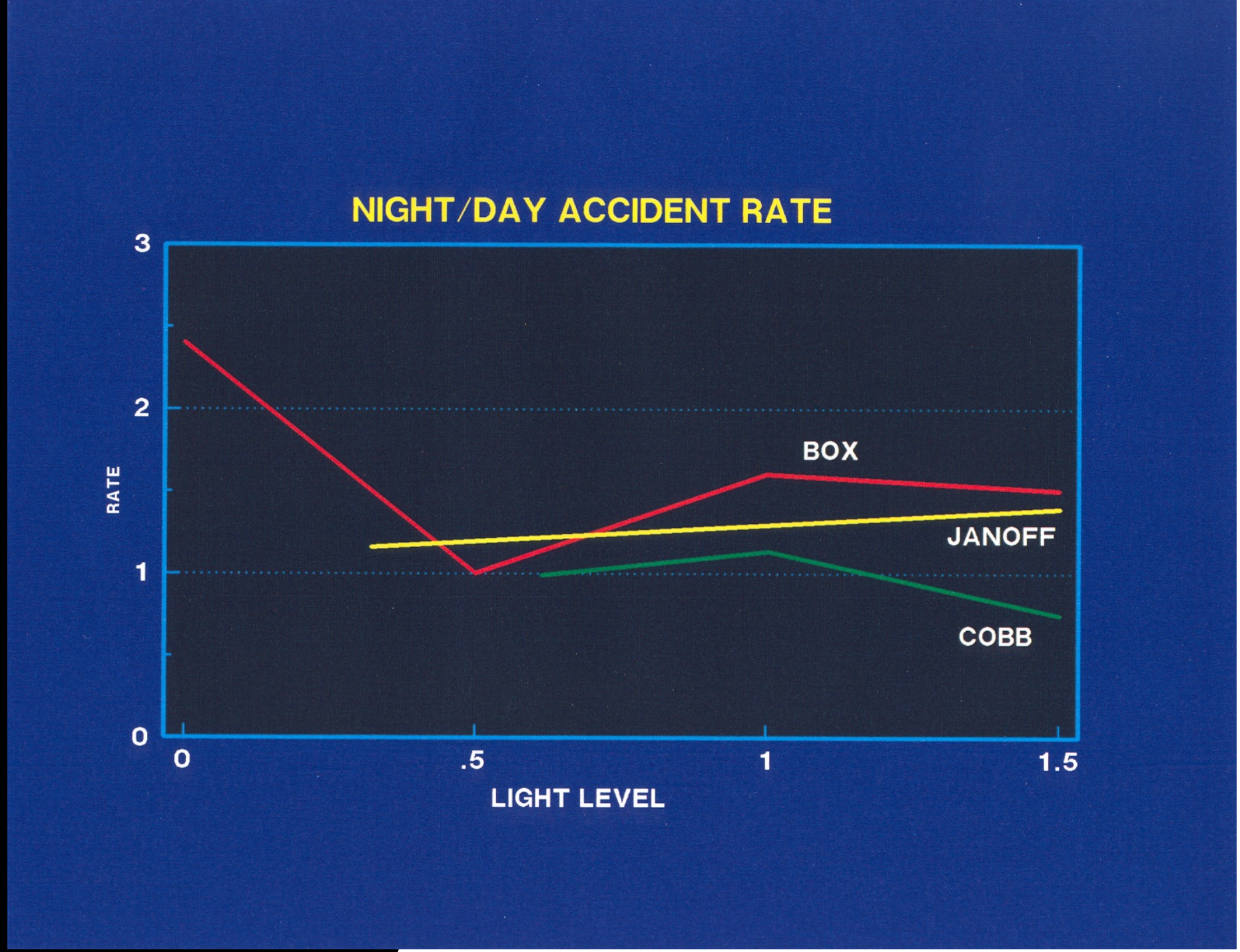
How Low
Can You Go?

Who Determines Lighting Design Criteria?

- American National Standards Institute / Illuminating Engineering Society (ANSI / IES)
  - RP-8, “Recommended Practice for Design and Maintenance of Roadway and Parking Facility Lighting”, 2018
- American Association of State Highway and Transportation Officials (AASHTO)
  - GL-7, “Roadway Lighting Design Guide”, Seventh Edition, October 2018
- Federal Highway Administration (FHWA)
  - “Lighting Handbook”, August 2012

How Humans See

- **Visibility Considerations for Roadways**


NIGHT/DAY ACCIDENT RATE
RATE
3
2
1
0
BOX
JANOFF
COBB
0
.5
1
1.5
LIGHT LEVEL

Aging Drivers

- “The 65 and older age group… will exceed 50 million by 2020, accounting for roughly 20% of the driving age population of this country.” --FHWA

The Washington Times

Aging drivers have few alternatives for a car

Transportation report offers ideas to make it easier for seniors to get around

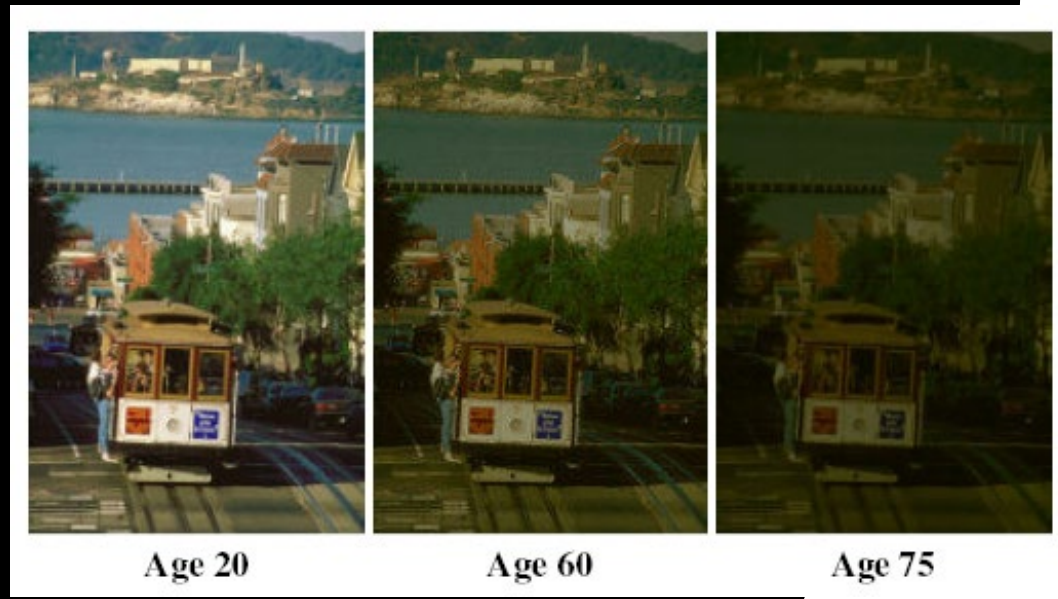
Aging baby boomers face another problem besides failing eyesight, aching joints and how to work the remote control.

A new survey finds that the largest cohort of drivers in the nation’s history is entering the age where they are in danger of losing their licenses but are living in communities where a car is essential.

The report released Tuesday by a transportation trade association says Congress should consider addressing seniors’ growing needs when it works on transportation issues later this year, including more mass-transit spending and retrofitting roads to accommodate older drivers.

Aging Eyes

- Decreased retinal illumination (scattering/absorption)
- Presbyopia-loss of accommodation (ability to focus)
- Lens yellowing
- Pupil size limits



6 Mo.

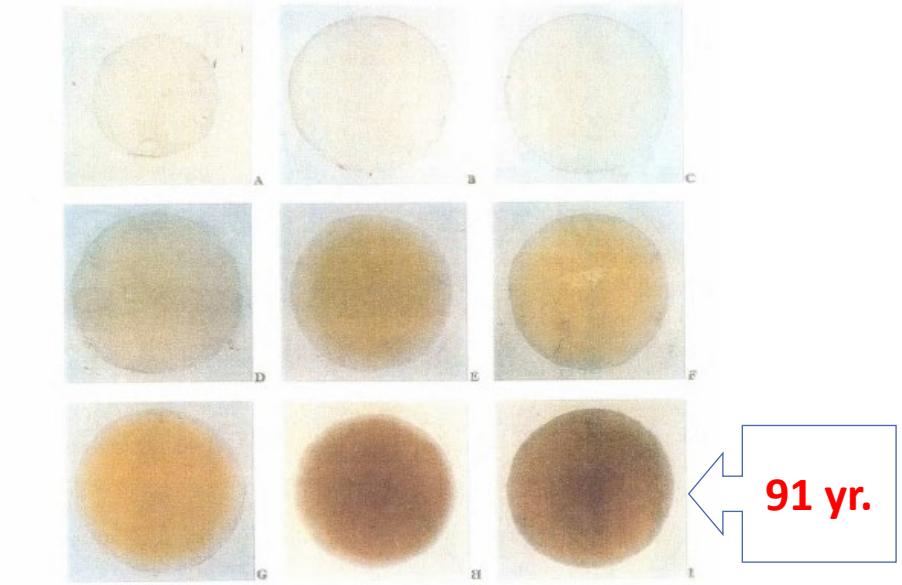


Figure 1 *Yellowing and transparency of the Human Lens from 6 month (A) to 8 years (B) ,12 years (C) , 25 years (D), 47 years (E), 60 years (F), 70 years (G), 82 years (H) and 91 years (I) of age.*

Adopted from Lerman,S "Radiant Energy and the Eye" Macmillan Publishing Co.Inc. New York 1980 Plate 3.1

Headlight Glare Mitigation

NIGHTTIME GLARE AND DRIVING PERFORMANCE

REPORT TO CONGRESS February, 2007

Glare reduces seeing distance because it causes light scatter in the eyes, which in turn reduces the contrast of roadway objects. This effect is known as "disability glare." The greater the intensity of the glare light and the closer the glare light is to where one is looking, the greater the disability glare will be. Disability glare can lead to the following effects:

- Decreasing visibility distance. The distance at which an object can be seen is known as the "visibility distance." This distance is reduced when disability glare is present.
- Increasing reaction times. As the intensity of oncoming headlamps increases, drivers' reaction times to objects in and along the roadway become longer.
- Increasing recovery time. After drivers pass an oncoming vehicle, the glare has a lasting effect that increases the time it takes for the drivers' eyes to recover their ability to detect objects. During that time, the visibility distance is reduced and reaction times are increased.

Age and Glare Recovery Time

Under these conditions, older drivers would lose visual contact with targets having contrasts in the 0 – 10% range for a period of over 2 seconds following exposure to a challenging glare source.

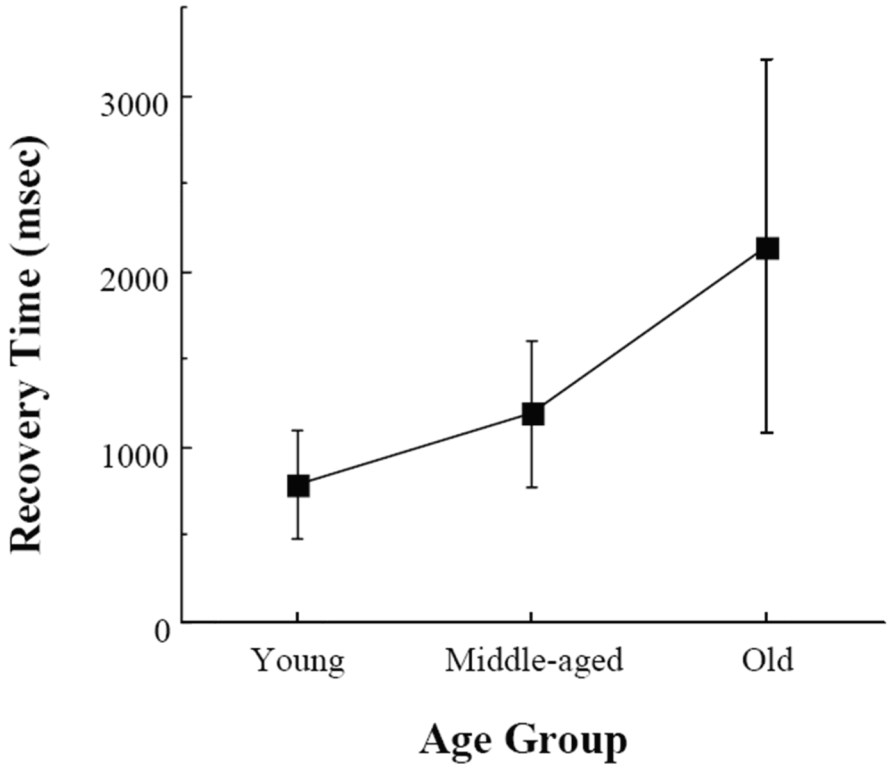


Figure 2. Glare recovery time as a function of age.

Age and Glare Recovery Time for Low-Contrast Stimuli

Frank Schieber
Department of Psychology
University of South Dakota
Vermillion, SD 57069

Detection and Safe Stopping Distances

Speed		Braking Distance		Reaction Time	Stopping Distance	
MPH	FPS	Cars (ft)	Trucks (ft)	(1.5 sec in Feet)	Cars (ft)	Trucks (ft)
15	22.0	11	14	33	44	47
25	36.7	30	40	55	85	95
35	51.3	58	78	77	135	155
45	66.0	96	129	99	195	198
55	80.7	144	192	121	265	313
65	95.3	201	268	143	344	411
75	110.0	268	357	165	433	522

Publisher: JMU Office of Public Safety
Contact: Public Safety (publicsafety@jmu.edu) Last Revised: October 02, 2009

Countermeasures for Reducing the Effects of Headlight Glare

Photo by Scott Osberg

Summary

Fixed lighting appears to be an effective countermeasure to the negative effects of headlamp glare that also improves visibility and reduces accidents. Rural two-lane roads would apparently benefit most from fixed lighting, because in these areas pavement luminance is more likely to determine visual adaptation than any other source of light, glare from oncoming headlamps is at its worst, and the night-day accident ratio is highest.

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Washington, D.C. 20005
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December 2001

Benefit-Cost Ratios

Table 5. Highway safety improvements with the highest cost-benefit ratios (82).

HIGHWAY SAFETY IMPROVEMENTS WITH THE HIGHEST BENEFIT-COST RATIOS 1974-1995

Rank	Improvement Description	Benefit-Cost Ratio
1	Illumination	26.8
2	Upgrade Median Barrier	22.6
3	Traffic Signs	22.4
4	Relocated/Breakaway Utility Poles	17.7
5	Remove Obstacles	10.7
6	New Traffic Signals	8.5
7	Impact Attenuators	8
8	New Median Barrier	7.6
9	Upgrade Guardrail	7.5
10	Upgrade Traffic Signals	7.4
11	Upgrade Bridge Rail	6.9
12	Improve Sight Distance	6.1
13	Median for Traffic Separation	6.1
14	Groove Pavement for Skid	5.8
15	Improve Minor Stricture	5.3
16	Turning Lanes and Channelization	4.5
17	New RR Crossing Gates	3.4
18	New RR Crossing Flashing Lights	3.1
19	Pavement Markings and Delineation	3.1
20	New RR Crossing Lights & Gates	2.9

82. Federal Highway Administration (1996) The 1996 Annual Report on Highway Safety Improvement Programs. Publication No. FHWA-SA-96-040.

Table 6. Location of lighting improvement and reported reduction factors (90).

Lighting Location	Type of Crash	State Survey (37)		Literature Review (61)	
		# Reporting	Reduction Avg.	# Reporting	Reduction Avg.
General	All	6	25%	5	10%
New Roadway	All	10	28%	8	18%
	Night	12	45%	5	38%
Upgrade Roadway	Night	2	42%	-	-
New Intersection	All	8	31%	2	22%
	Night	12	49%	6	64%
Upgrade	All	2	38%	-	-
Intersection	Night	1	50%	2	50%
New Interchange	All	5	25%	3	42%
	Night	4	50%	3	56%
Railroad Crossing	All	9	34%	2	46%
	Night	5	60%	6	61%
Bridge	Night	7	48%	5	52%
Illuminate Sign	All	-	-	1	15%

90. Agent, K.R., Stamatiadis, N., and Jones, S. (1996) Development of Accident Reduction Factors. Report No. KTC-96-13. University of Kentucky, Lexington, KY.

Governors Highway Safety Association
The States' Voice on Highway Safety

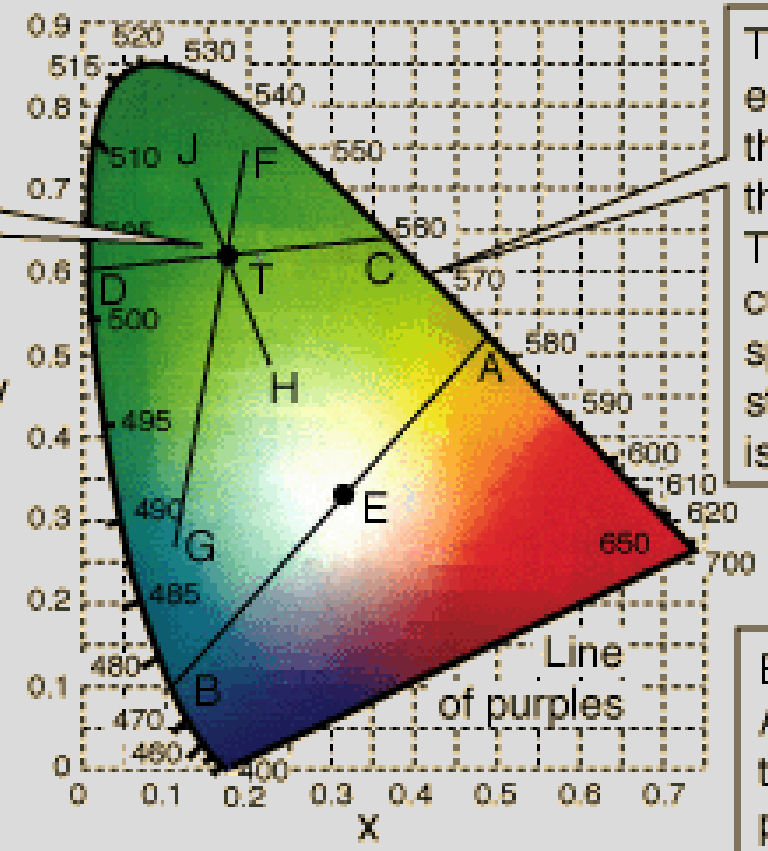
Most pedestrians are killed on local roads, in the dark and away from intersections, suggesting the need for safer road crossings and increased efforts to make pedestrians more visible through improved lighting and other countermeasures.

During the past 10 years, the number of drivers striking and killing a pedestrian after dark increased by 54%, compared to a 16% rise in pedestrian fatalities in daylight.


5700K
4000K
3500K
3000K

Color – CIE Chromaticity

The combination of light wavelengths to produce a given perceived color is not unique. The pairs CD, FG and JH can each produce the color T if combined in the right proportions.

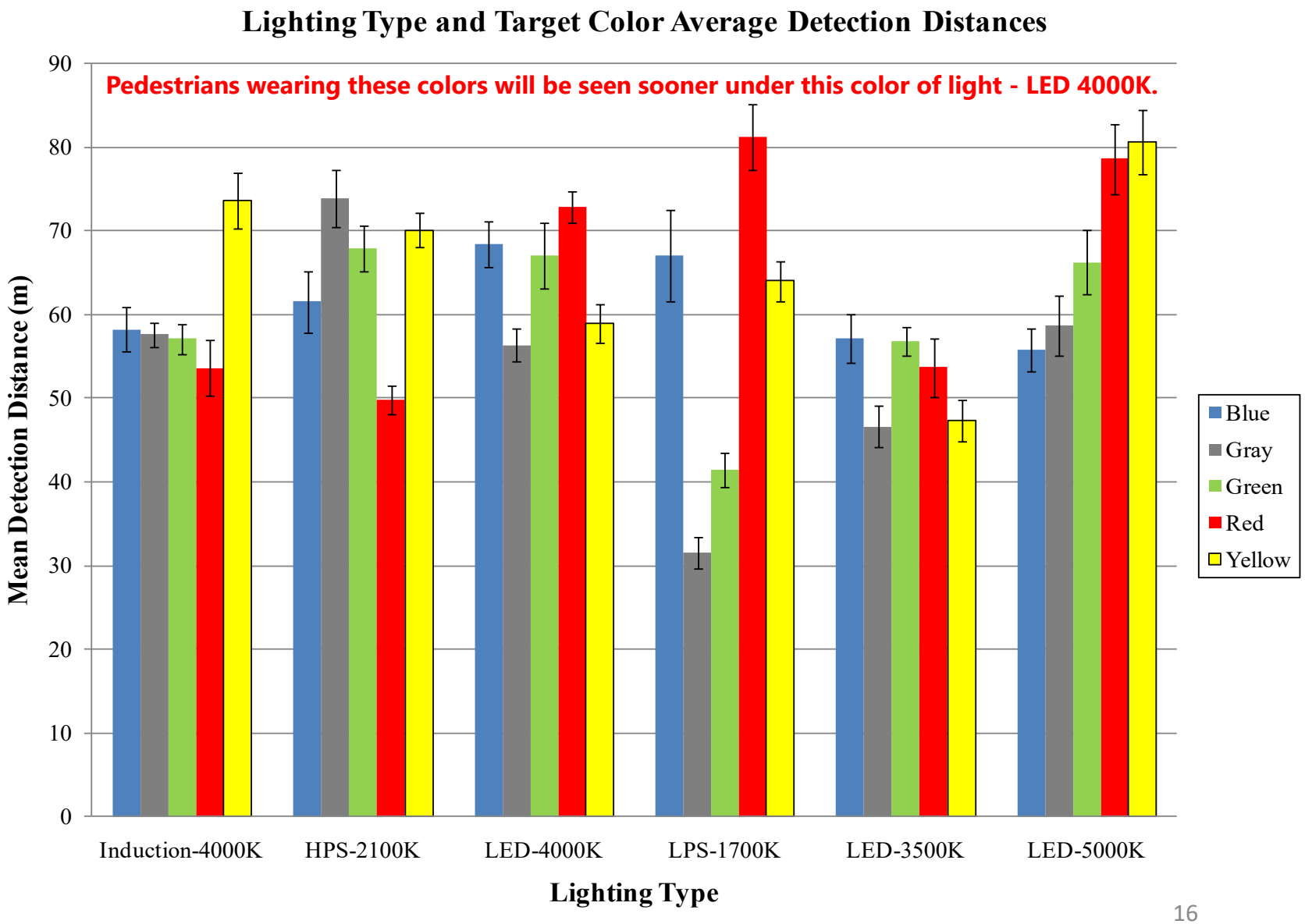


The solid line outline encompasses all the hues that are perceivable to the normal human eye. The horseshoe shaped curve contains the spectral colors. The straight line at the bottom is the line of purples.

Any point within the curve represents a unique perceivable hue. But there are many combinations that will produce that hue.

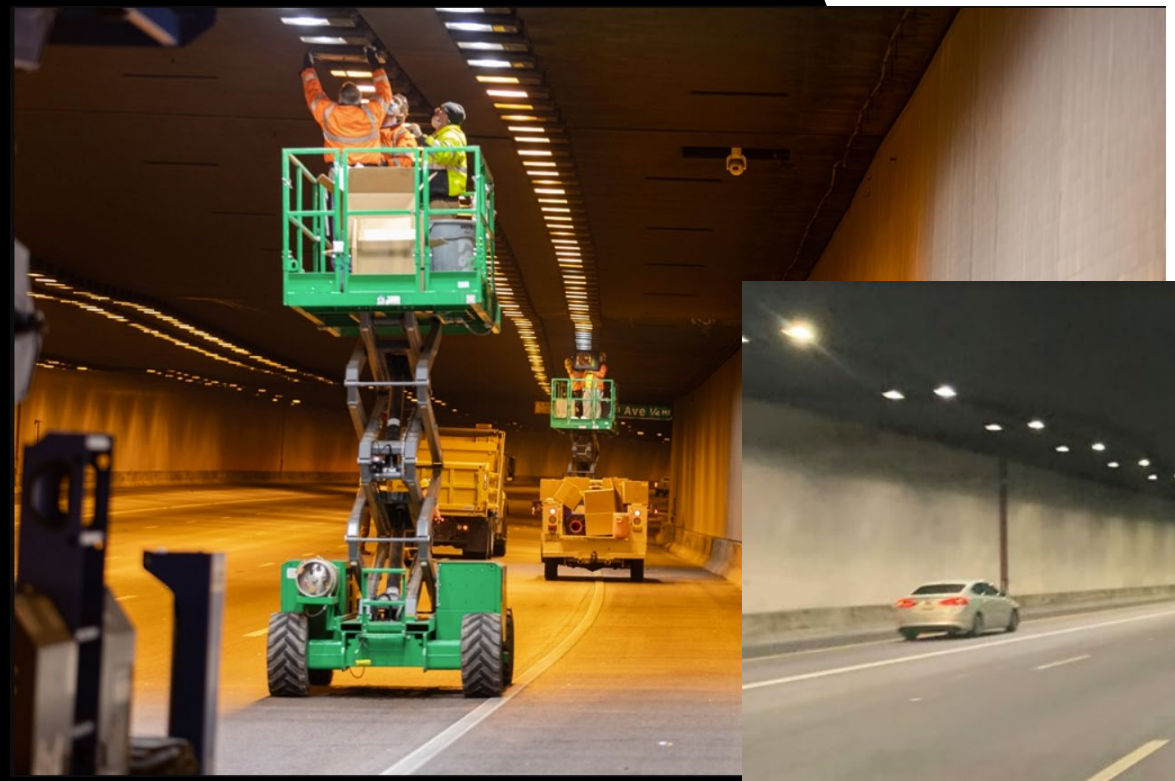
E is the achromatic point. AB or any pair for which the connecting line passes through E can form a complementary color pair.

Color Detection San Jose



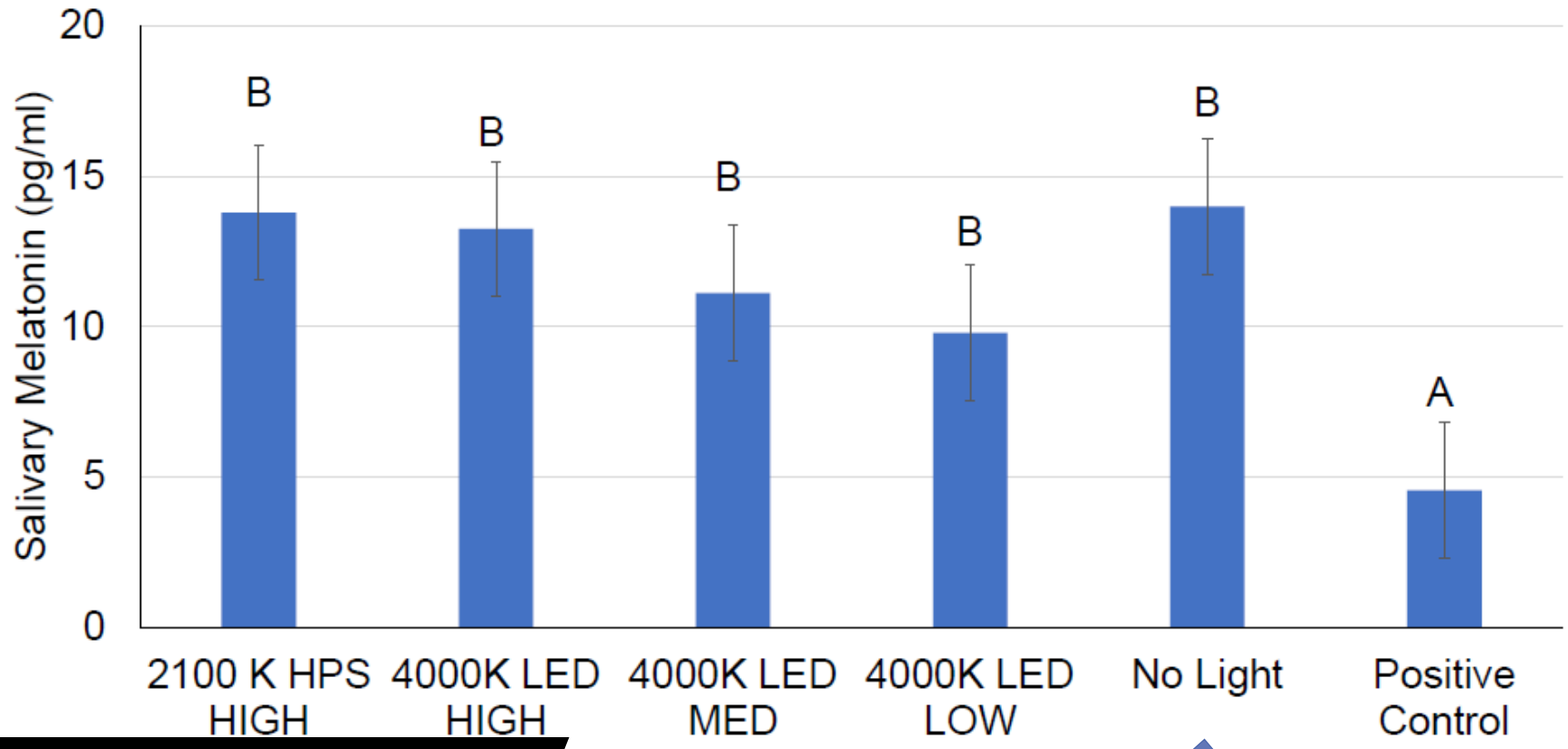
Organization	Correlated Color Temperature (CCT)
AASHTO	N/A
ADOT	N/A
ANSI/IES	N/A. Discussion, but no recommendation.
Apache Junction	N/A
Avondale	4,000K (arterial, industrial collector); 3,000K (local)
Buckeye	3000K
Chandler	4000 K
FHWA	See AASHTO or ANSI / IES RP-8
Fountain Hills	Shall not exceed 3000K

Organization	Correlated Color Temperature (CCT)
Gilbert	3000K
Glendale	N/A – HPS
Goodyear	4000K
IDA	N/A
MAG	N/A
Maricopa County	N/A
Mesa	3000K or lower.
Peoria	N/A – HPS
Phoenix	4000 K
Scottsdale	4100K +/- 300K or 2200K +/- 300K
Surprise	N/A
Tempe	N/A

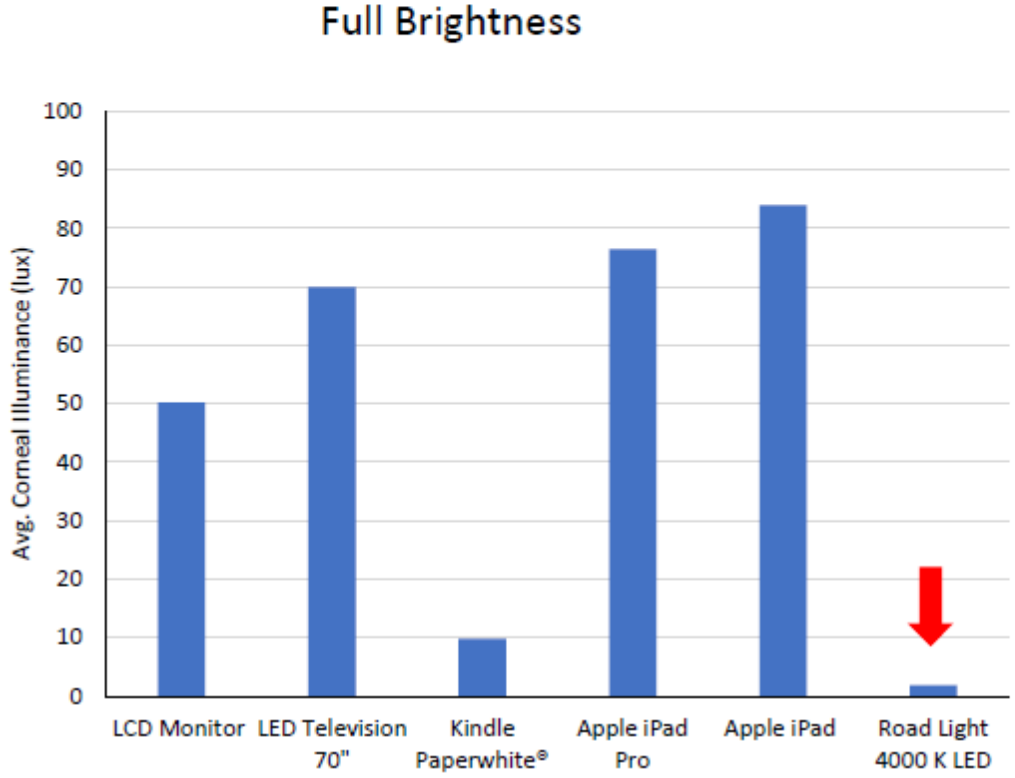


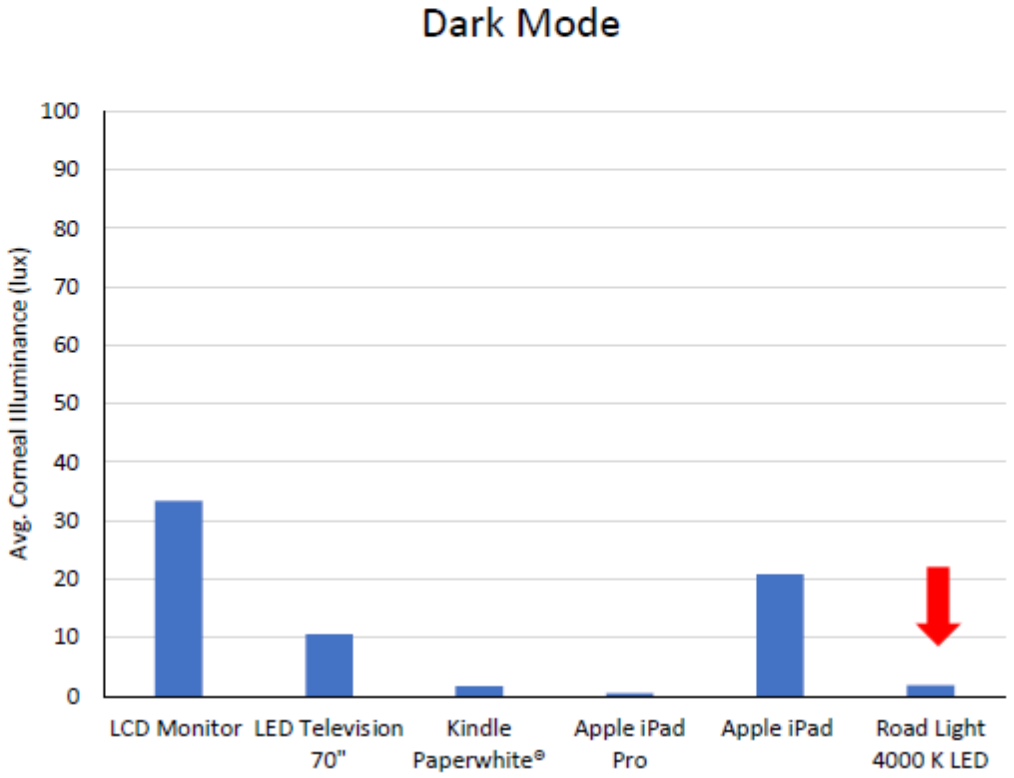
Results – Melatonin Suppression

No differences in any of the roadway conditions



Comparison of Consumer Electronic Devices to Roadway Lighting



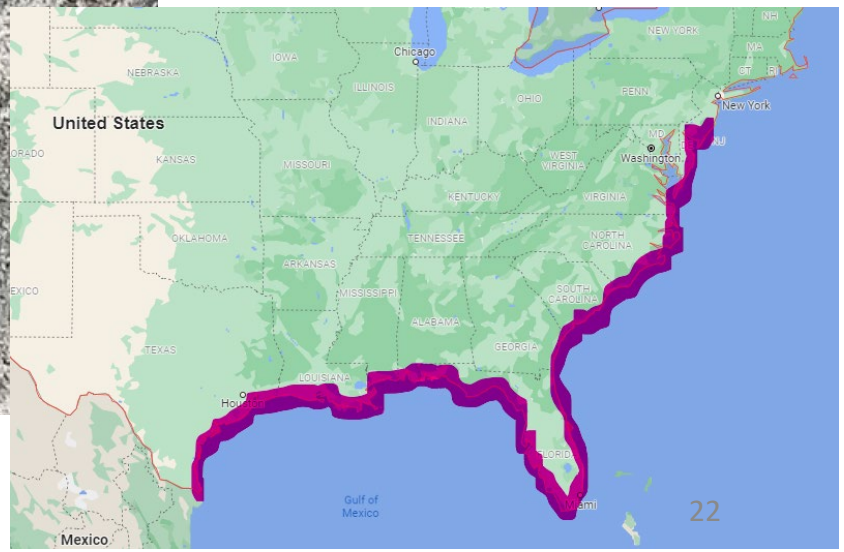


Light levels from streetlighting are not high enough to suppress melatonin production.

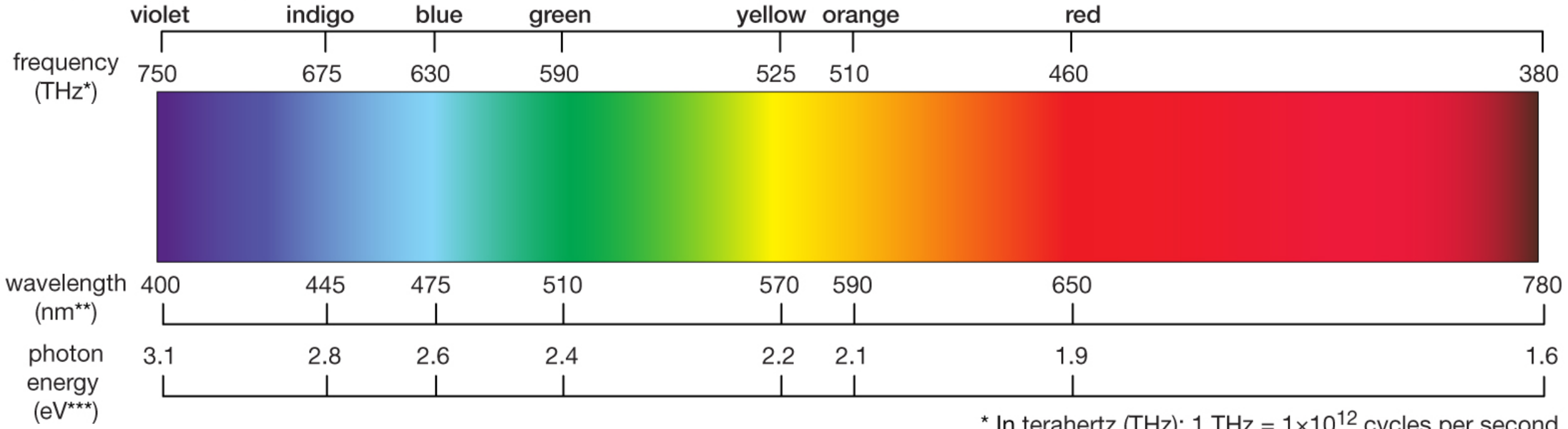
National Academies of Sciences, Engineering, and Medicine 2021. LED Roadway Lighting: Impact on Driver Sleep Health and Alertness. Washington, DC: The National Academies Press. https://doi.org/10.17226/26097

LED Effects

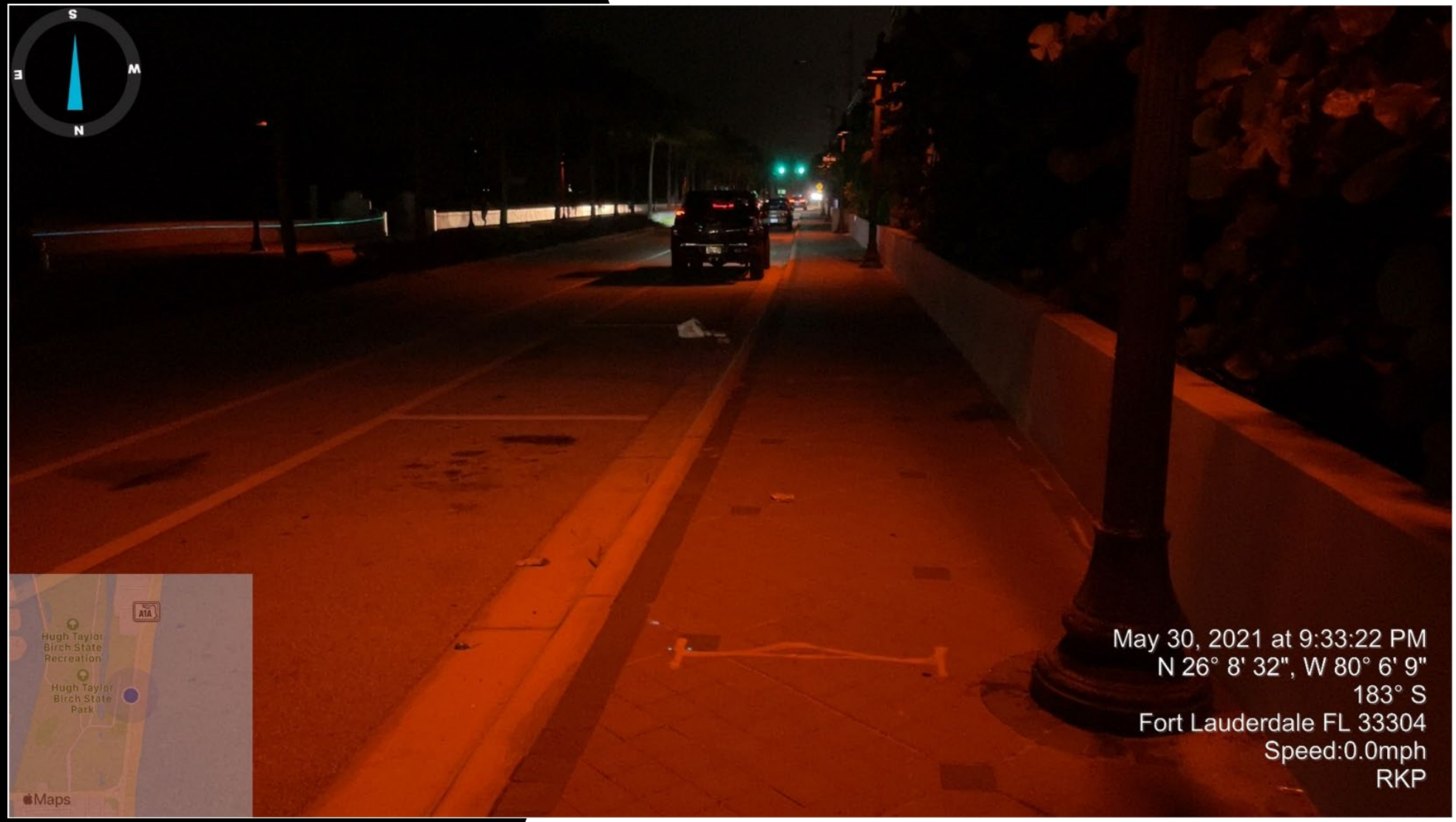
- Guidelines for LED roadway lighting for affecting human melatonin suppression and alertness – no modifications necessary.
- Potential for melatonin suppression from consumer electronic devices is considerably higher than LED roadway lighting.


United States
Chicago
New York
Washington
Houston
Miami
Gulf of Mexico
Mexico

Light, the visible spectrum



* In terahertz (THz); 1 THz = 1×10^{12} cycles per second.
** In nanometres (nm); 1nm = 1×10^{-9} metre.
*** In electron volts (eV).


S
E
M
N
A1A
Hugh Taylor Birch State Recreation
Hugh Taylor Birch State Park
Maps
May 30, 2021 at 9:33:22 PM
N 26° 8' 32", W 80° 6' 9"
183° S
Fort Lauderdale FL 33304
Speed:0.0mph
RKP

INTERNATIONAL DARK-SKY ASSOCIATION

The International Dark-Sky Association (IDA) is the recognized authority on light pollution and is the leading organization combating light pollution worldwide.

Municipal Solid-State STREET LIGHTING CONSORTIUM

DLC

Energy. Quality. Controllability.

The DLC® is a non-profit organization whose mission is to achieve energy optimization by enabling controllability with a focus on quality, people, and the environment.

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ADOT	N/A
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Mesa	3000K or lower.
Peoria	N/A – HPS
Phoenix	4000 K
Scottsdale	4100K +/- 300K or 2200K +/- 300K
Surprise	N/A
Tempe	N/A