1145-19

City of Racine, Wisconsin

US to Metric Conversion	
0 miles	0 km
0 feet	0 m
0 mph	0 km/hour
0 feet	0 km

Road Name ______________________
From ______________ To ______________
Warrant Undertaken by ______________
Date ______________

Warrants for Lighting Arterial, Collector, and Local Roads

Item No.	Classification Factor	Rating Factor "R" 1	2	3	4	5	Weight "W"	Enter "R" Here	Score "R" x "W"	
Geometric Factors (See Note 6)										
1	Number of Lanes	<= 4	5	6	7	>=8	0.15		0	
2	Lane Width (m)	>=3.6	3.4 to 3.6	3.2 to 3.4	3.0 to 3.2	<3.0	0.35		0	
3	Median Openings/km	<2.5 or 1-Way	2.5 to 5.0	5.0 to 7.2	7.2 to 9.0	>9.0 or No Median	1.4		0	
4	Driveways and Entrances/km	<20	20 to 40	40 to 60	60 to 80	>80	1.4		0	
5	Horizontal Curve Radius (m)	>600	450 to 600	225 to 450	175 to 225	<175	5.9		0	
6	Vertical Grades (%)	<3	3 to 4	4 to 5	5 to 7	>7	0.35		0	
7	Sight Distance (m)	>210	150 to 210	90 to 150	60 to 90	<60	0.15		0	
8	Parking	Prohibited	Loading	Off Peak	One Side	Both Sides	0.1		0	
				Subtotal Geometric Factors					0	G
Operational Factors										
9	Signalized Intersection (%)	80 to 100	70 to 80	60 to 70	50 to 60	0 to 50	0.15		0	
10	Left Turn Lane	All Major Intersections or 1-Way	Substantial No. of Major Intersections	Most Major Intersections	Half of Major Intersections	Infrequent No. or TWTL (See Notes 1 & 3)	0.7		0	
11	Median Width (m)	>10	6 to 10	3 to 6	1.2 to 3	0 to 1.2	0.35		0	
12	Operational or Posted Speed (km/h) (See Note 5)	<=40	50	60	70	>=80	0.6		0	
13	Pedestrian Activity Level (See Note 2)			Low	Medium	High	3.15		0	
				Subtotal Operational Factors					0	O
Environmental Factors										
14	Percentage of Development Adjacent to Road (%) (See Note 4)	nil	nil to 30	30 to 60	60 to 90	>90	0.15		0	
15	Area Classification	Rural	Industrial	Residential	Commercial	Downtown	0.15		0	
16	Distance from Development to Roadway (m) (See Note 4)	>60	45 to 60	30 to 45	15 to 30	<15	0.15		0	
17	Ambient (off Roadway) Lighting	nil	Continuous	At All Intersections (100%)	At Most Intersections (51% to 99%)	At Few Intersections (<= 50%) (See Note 7)	1.38		0	
18	Raised Curb Median			Low	Medium	High	0.35		0	
				Subtotal Environmental Factors					0	E
Collision Factors										
19	Night-to-Day Collision Ratio	< 1.0	1.0 to 2.0	1.2 to 1.5	1.5 to 2.0	> 2.0 (See Note 1)	5.55		0	
				Subtotal Collision Factors					0	A
						G + O + E + A = Total Warranting Points				
							Warranting Condition		60.00	
							Difference		0	D

Notes:

1. Light Warranted
2. Pedestrian Activity Level (Refer to 9.1.0 - Pedestrian Related Definitions)
3. Two-Way Left Turn Lane
4. Development Defined as Commerciasl, Industrial or Residential Buildings
5. 85th Percentile Nigh Speed Should Be Used if Available, Otherwise Posted Speed Shall be Used
6. Worst Case Geometric Factors for a Segment of Roadway Shall Apply
7. Also Includes Isolated Medians (Non-Continuous) Between Intersections

1145-19

City of Racine Residential Street and Alley Lighting

Policy and Guidance

Purpose of Lighting

Purpose of Policy

This policy has been prepared to provide guidance to lighting designers and city officials concerning the design and application of roadway lighting. It is not intended to be a detailed design guide. It is primarily a resource for policy makers and the design and construction community to evaluate potential need, benefits, and applicable references when considering a roadway or street lighting system. Documents available from organizations such as the American Association of State Highway and Transportation Officials (AASHTO), the Illuminating Engineering Society (IES), and the Commission Internationale de l'Eclairage (CIE) offer recommendations on lighting levels, lighting configurations, and other considerations. This policy directs users to that information where applicable, and provide supplemental information on topics not addressed in those documents.

Purpose of Roadway and Street Lighting

Studies have shown a reduction in nighttime fatal crashes of up to 60% with the use of roadway lighting. Driving or walking on, or across, a roadway is less safe in darkness than in a lighted area, due to the reduced visibility of hazards and pedestrians. Though the number of fatal crashes occurring in daylight is about the same as those that occur in darkness, only 25 percent of vehicle-miles traveled occur at night. Because of that the nighttime fatality rate is three times the daytime rate, as illustrated in Figure 1 below. Figure 2 shows the difference in the number of fatal crashes on lit and unlit roadways.

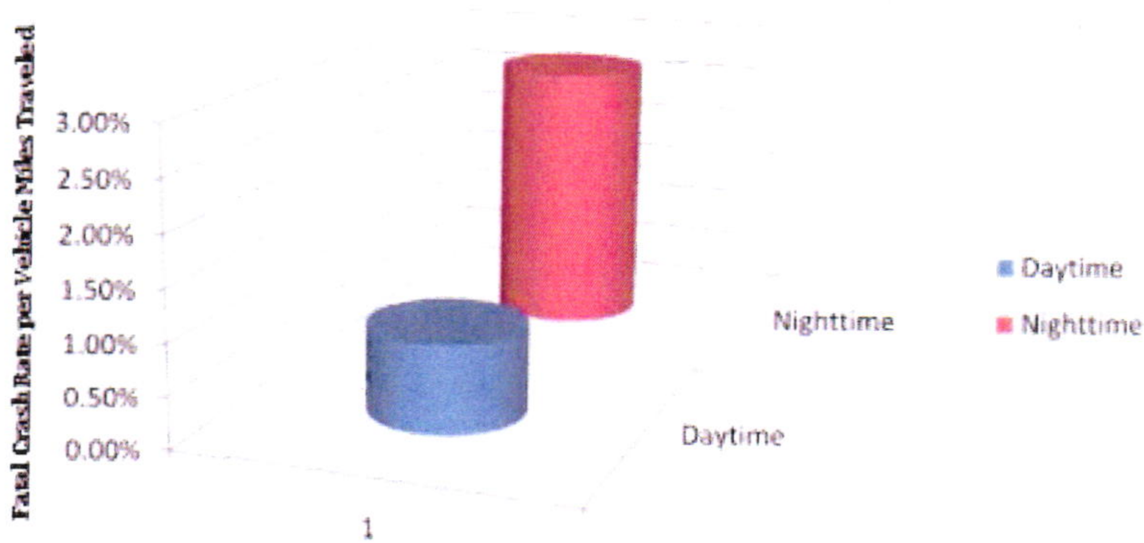


Figure 12 - Fatal Crash Rates per VMT for Day and Night (2009 FARS and NHTS data)

1145-19

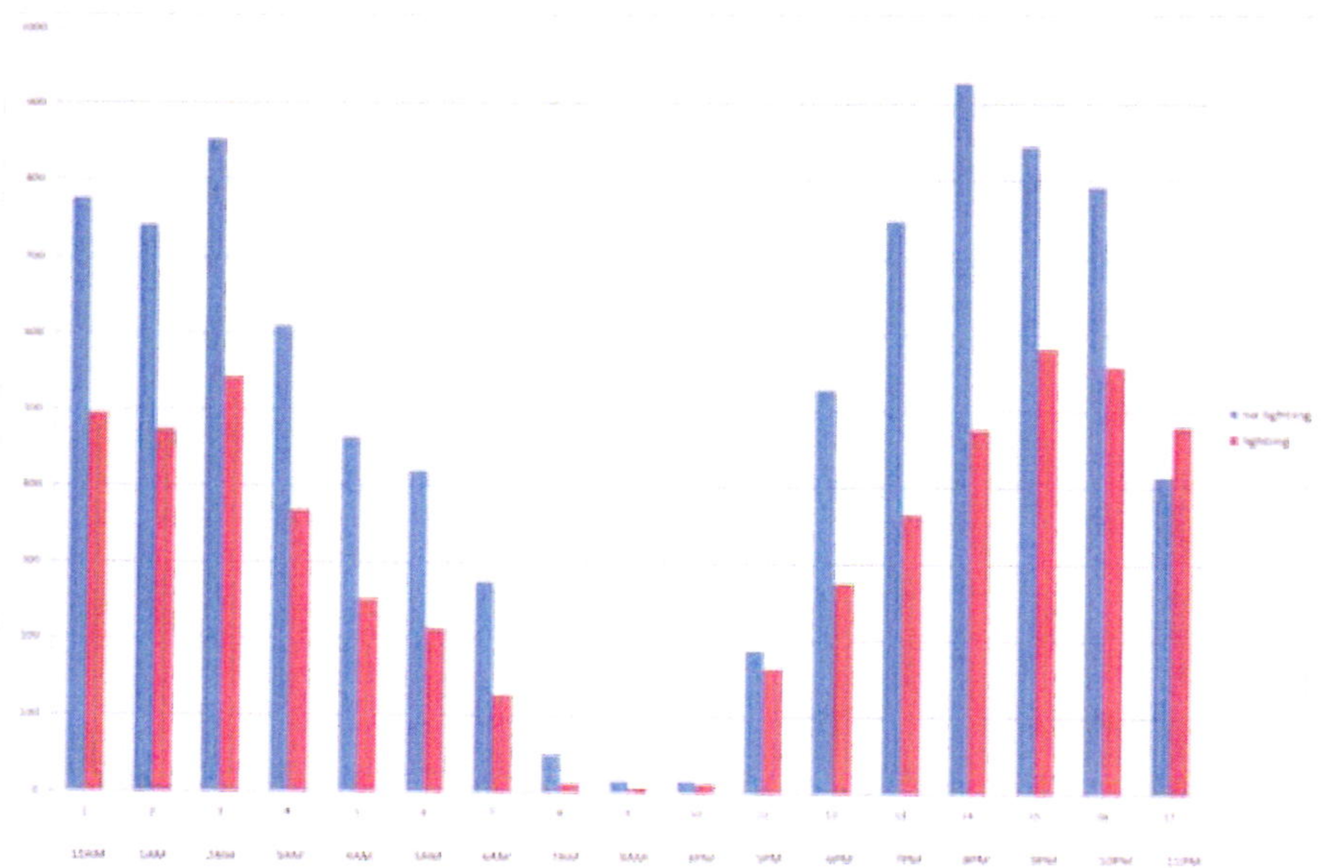


Figure 2 - Fatal Crashes during Darkness by Lighting Condition (2009 FARS data)

On a fundamental level, driving is largely a visual task. Being able to adequately see the road/street ahead and observe conflicting traffic and the behavior of other highway users is integral to the driving task. Lighting significantly improves the visibility of the roadway, increases sight distance, and makes roadside obstacles more noticeable to the driver, and therefore more avoidable.

Roadway lighting is a proven safety countermeasure. The positive safety effects of lighting have been documented in various reports and publications. For example, an FHWA/AASHTO documented that many countries showed a 20 to 30 percent reduction in the number of crashes when lighting was installed. More recently, the FHWA Signalized Intersection Informational Guide reported that adding lighting can reduce nighttime crashes by 50 percent and reduce fatal crashes by 43 percent. There have been many other studies that document similar safety benefits of lighting.

In addition to traffic safety, adequate lighting can provide benefits in terms of personal security. Roadway lighting often serves the purpose of safeguarding personal safety for pedestrians, bicyclists, and transit users as they travel along and across roadways. Deep shadows or darkness reduce personal security, and walking, bicycling or commercial activities may become uncomfortable or unsafe. Thus, ensuring that the lighting provides minimum acceptable levels of illumination is of great importance to all users of a roadway environment.

1145-19

Guidance and Recommendations Regarding Roadway Lighting/Fundamental Lighting Concepts

Light, Vision & Lighting Metrics

Many factors influence our ability to see an object while driving. These include the contrast of the object, both photometric and color (i.e., the difference between the object and its background); the driver's adaptation level (impacted by the brightness of the road and surrounds, how much glare is present from approaching vehicles and luminaires, etc.), and how long the driver has to view a hazard. Understanding these factors is vitally important to developing an effective design for roadway and street lighting.

Illuminance is the amount of light that falls onto a flat surface. Illuminance is measured as the amount of lumens per unit area either in foot-candles (lumens/ft2) or in lux (lumens/m2).

Vertical illuminance is the amount of illuminance that lands on a vertical surface. The units and properties are the same as horizontal illuminance. As it relates to roadway lighting, vertical illuminance is a reasonable criterion for determining the amount of light landing on pedestrians. It is also used as a criterion in determining adequate illumination for facial recognition. For roadway applications, vertical illuminance is most often used at a 5 foot (1.5 m) height above the roadway or sidewalk. The 5 foot height is a commonly used metric in outdoor criteria as the height of a pedestrian's face.

Luminance is the amount of light that reflects from a surface in the direction of the observer. It is often referred to as the "brightness" of the surface, although apparent brightness has a number of other factors to take into consideration. It is, however, a more complete metric than illuminance because it considers not only the amount of light that reaches a surface, but also how much of that light is reflected towards the driver.

Warranting Criteria

Warrants

Lighting warrants assist in evaluating locations where lighting will maximize benefit based on defined conditions or rating systems. Meeting these warrants does not obligate the state or other agencies to provide lighting. Conversely, using engineering judgment in addition to warrants, considering things such as roadway geometry, high crash rates, or frequent occurrences of poor weather conditions such as rain, fog, ice, or snow, may influence a decision on whether to install lighting.

Warrants indicate where lighting may be beneficial, but should not be interpreted as an absolute indication of whether or not lighting is required. The need for lighting should be determined by sound engineering judgment and rests with the agency having jurisdiction over the roadway.

Warrants do not represent a requirement to light, only an indication of situations where lighting should be investigated. Satisfaction of a lighting warrant shall not in itself require the installation of a lighting system.

Warranting Method Example for Collector/Major/Local Streets

The warrant system presented is based on the Transportation Association of Canada (TAC) Guide for the Design of Roadway Lighting which was based on the 1978 Roadway Lighting Handbook published by the U.S. Department of Transportation.

The warrant system is based on factors grouped into geometric, operational, environmental, and crash factors. For each factor a numeric rating (R) from 1 to 5 corresponding to the defined criterion is defined. Each criterion

1145-19

is assigned a weight (W) to indicate its relative importance. The rating value (R) is multiplied by the weight (W) to obtain a point-score (R x W) for each criterion characteristic, indicating its relative significance. The overall point-score for all items indicates the need for lighting, as well as the relative risk on that road compared with other roadways.

When undertaking a warrant analysis, the length of roadway segment being analyzed should be as long as possible, and should take into account future development. Where the roadway classification or roadway land use classification changes, a separate warrant analysis should be considered for each roadway section. Where classifications are relatively constant along the segment of roadway under consideration, a single warrant analysis may be undertaken.

Classification factors listed on the warrant sheets are defined as follows:

Geometric Factors

Includes key geometric factors listed for the length of roadway to which the warrant is being applied. These include:

- Number of lanes
- Lane width
- Number of median openings per kilometer
- Driveways and entrances per kilometer
- Horizontal curve radius
- Vertical grade
- Sight distance
- Parking

The worst-case rating factors (R) shall apply for the entire length of road being considered. The weighted value is very high for sharp horizontal curve radii.

Operational Factors

Includes operational factors for the entire length of roadway to which the warrant is being applied. These include:

- Signalized intersections
- Left turn lanes
- Median width
- Operating or posted speed
- Pedestrian activity (conflict) levels (ref to IESNA RP-8 for definition of high, medium or low activity)

The worst-case rating factors (R) shall apply for the entire length of road being considered. The weighted value is high for pedestrian activity level.

Environmental Factors

Includes environmental factors for the entire length of road to which the warrant is being applied. These include:

- Percentage of development adjacent to the roadway. Adjacent development must be a reasonable distance from the roadway and must tie into the roadway for which the warrant is being undertaken via a driveway or intersection which generates a reasonable amount of traffic. Determining the amount of

1145-19

ambient lighting present in an area depends on the judgment of the individual performing the warrant analysis. As a general guide, the following ambient lighting definitions may be applied:
  - Sparse - Would typically include rural freeways and highways with little or no development outside of city boundaries.
  - Moderate - Would typically include rural or urban roads with some building lighting and development outside of commercial areas. Areas with residential and industrial development will typically have moderate ambient lighting.
  - Distracting - Would typically be downtown commercial areas with well-lighted building exteriors adjacent to the roadway. Distracting lighting can also include that from fuel stations, automotive sales lots and other commercial development where lighting is used to attract attention to businesses.
  - Intense: Would typically be areas with large advertising signs, sports lighting, and other intense light sources adjacent to the roadway. Intense sources can be found in both rural and urban areas.
- Area classification
- Distance from development to roadway
- Ambient Lighting
- Raised median curb

The worst-case rating factors (R) shall apply for the entire length of road being considered. The weighted value is high for ambient lighting.

Crash Factors (Night and Day)

In the warranting forms crash factors are included using the night-to-day crash ratio for the given length of road to which the warrant is being applied. As the warrant point-score for this category is heavily based on night-to-day crash ratios, it is essential that detailed and well-defined crash data be applied. Where crash ratios are not known, engineering judgment should be applied using crash statistics from similar roads where data is available.

Where a low number of crashes have been recorded (i.e., two at night, and one during the day), lighting may meet the warrant crash ratio; however, due to the low numbers it may be of less benefit than for other areas with similar ratios and higher numbers.

See attached lighting warrant. Lighting is warranted where a total point-score of 60 or more is achieved. If the night-to-day crash ratio is 2:1 or greater, lighting is automatically warranted regardless of the overall point-score. Lighting may be prioritized solely on the basis of the point-scores

1145-19

City of Racine, Wisconsin

US to Metric Conversion	
0 miles	0 km
0 feet	0 m
0 mph	0 km/hour
0 feet	0 km

Road Name ______________
From ______________ To ______________
Warrant Undertaken by ______________
Date ______________

Warrants for Lighting Arterial, Collector, and Local Roads

Item No.	Classification Factor	Rating Factor "R" 1	2	3	4	5	Weight "W"	Enter "R" Here	Score "R" x "W"	
Geometric Factors (See Note 6)										
1	Number of Lanes	<= 4	5	6	7	>=8	0.15		0	
2	Lane Width (m)	>=3.6	3.4 to 3.6	3.2 to 3.4	3.0 to 3.2	<3.0	0.35		0	
3	Median Openings/km	<2.5 or 1-Way	2.5 to 5.0	5.0 to 7.2	7.2 to 9.0	>9.0 or No Median	1.4		0	
4	Driveways and Entrances/km	<20	20 to 40	40 to 60	60 to 80	>80	1.4		0	
5	Horizontal Curve Radius (m)	>600	450 to 600	225 to 450	175 to 225	<175	5.9		0	
6	Vertical Grades (%)	<3	3 to 4	4 to 5	5 to 7	>7	0.35		0	
7	Sight Distance (m)	>210	150 to 210	90 to 150	60 to 90	<60	0.15		0	
8	Parking	Prohibited	Loading	Off Peak	One Side	Both Sides	0.1		0	
				Subtotal Geometric Factors					0	G
Operational Factors										
9	Signalized Intersection (%)	80 to 100	70 to 80	60 to 70	50 to 60	0 to 50	0.15		0	
10	Left Turn Lane	All Major Intersections or 1-Way	Substantial No. of Major Intersections	Most Major Intersections	Half of Major Intersections	Infrequent No. or TWTL (See Notes 1 & 3)	0.7		0	
11	Median Width (m)	>10	6 to 10	3 to 6	1.2 to 3	0 to 1.2	0.35		0	
12	Operational or Posted Speed (km/h) (See Note 5)	<=40	50	60	70	>=80	0.6		0	
13	Pedestrian Activity Level (See Note 2)			Low	Medium	High	3.15		0	
				Subtotal Operational Factors					0	O
Environmental Factors										
14	Percentage of Development Adjacent to Road (%) (See Note 4)	nil	nil to 30	30 to 60	60 to 90	>90	0.15		0	
15	Area Classification	Rural	Industrial	Residential	Commercial	Downtown	0.15		0	
16	Distance from Development to Roadway (m) (See Note 4)	>60	45 to 60	30 to 45	15 to 30	<15	0.15		0	
17	Ambient (off Roadway) Lighting	nil	Continuous	At All Intersections (100%)	At Most Intersections (51% to 99%)	At Few Intersections (<= 50%) (See Note 7)	1.38		0	
18	Raised Curb Median			Low	Medium	High	0.35		0	
				Subtotal Environmental Factors					0	E
Collision Factors										
19	Night-to-Day Collision Ratio	< 1.0	1.0 to 2.0	1.2 to 1.5	1.5 to 2.0	> 2.0 (See Note 1)	5.55		0	
				Subtotal Collision Factors					0	A
					G + O + E + A = Total Warranting Points					
							Warranting Condition		60.00	
							Difference		0	D

Notes:

1 Light Warranted
2 Pedestrian Activity Level (Refer to 9.1.0 - Pedestrian Related Definitions)
3 Two-Way Left Turn Lane
4 Development Defined as Commerciasl, Industrial or Residential Buildings
5 85th Percentile Nigh Speed Should Be Used if Available, Otherwise Posted Speed Shall be Used
6 Worst Case Geometric Factors for a Segment of Roadway Shall Apply
7 Also Includes Isolated Medians (Non-Continuous) Between Intersections

1145-19

Residential Street & Alley Lighting General Guidelines

Purpose of Street Lights

Street lights are intended to:

- Illuminate roadway features such as edge of pavement, intersections, sharp curves, dead ends
- Light obstructions such as median strips and bridge piers
- Provide pedestrian safety at street crossings.

Streetlights, however, are not the only means by which the presence of features and obstructions can be made known. Streetlights are not intended to Illuminate private property nor provide home security.

Highway, Arterial and Collector streets

- Retain existing street light spacing

Local Streets (Residential)

- **Geometric Criteria:**
  - Street light at each intersection, cul-de-sac or dead end
  - Street light at a curve in the roadway
  - Street light at change in street geometry or road hazard
  - One mid-block street light for blocks from 400 feet to 599 feet long
  - Two mid-block street lights for blocks from 600 feet to 1,000 feet long

- **Spacing Criteria for 100W HPS (65 LED):**
  - 150' Ideal Spacing - Range - 120' minimum to 180' maximum

- **Spacing Criteria for 150W HPS (85 LED):**
  - 200' Ideal Spacing - Range - 160' minimum to 240' maximum

- **Spacing Criteria for 250W HPS (115 LED):**
  - 270' Ideal Spacing - Range - 240' minimum to 300' maximum

Alleys

- Typically 50W HPS (35 LED)
- Street or alley light at each alley entrance
- Lights at alley intersections or dead ends
- Spacing (if needed): One mid-block light for alleys from 300 feet to 549 feet long, two mid-block lights for alleys from 550 feet to 800 feet long

The following are some general guidelines to be followed for the design of street lighting in residential areas. This information pertains to "utility" or "cobra-head" style light fixtures only. Special consideration must be given to ornamental style lighting based upon the photometric data of the fixture being utilized. These general guidelines are based upon a 25' fixture mounting height. Please note that these are general guidelines and that actual field conditions will dictate appropriate and workable light locations.

All midblock lights and alley lights should have a Type II light distribution. Intersection lighting should be installed with the light angled towards the center of the intersection. Intersection lights should be at least a 150 watt high pressure sodium light with a Type III light distribution. Due to intersection lights being angled over the intersection as opposed to midblock lights being installed at 90 degrees to the roadway, the spacing for the first midblock light next to an intersection should be 50% of the ideal spacing for the block. For example, if 65 LED (100 W) midblock lights are installed at the 150' spacing, the first midblock light should be 50% of this 150' spacing, or 75', from the intersection. The remaining lights would be placed at 150' intervals.

1145-19

Again, these are to be used as general guidelines only. A field survey will indicate potential light locations and engineering judgment must be used in determining the most effective lighting layout.

Residential Street & Alley Lighting Impact on Operating Budget

The City of Racine must proceed with caution regarding any policy changes. A full understanding of the fiscal impacts that street lighting decisions of the past in imperative. This has had an effect on our budget which have resulted in a net savings of close to $1.7M in the last decade. Returning back to pre-LED retrofit and pre-We Energies Leased Lights (WE LL) removals could mean a reduction of up to three employees just to maintain a status quo budget.

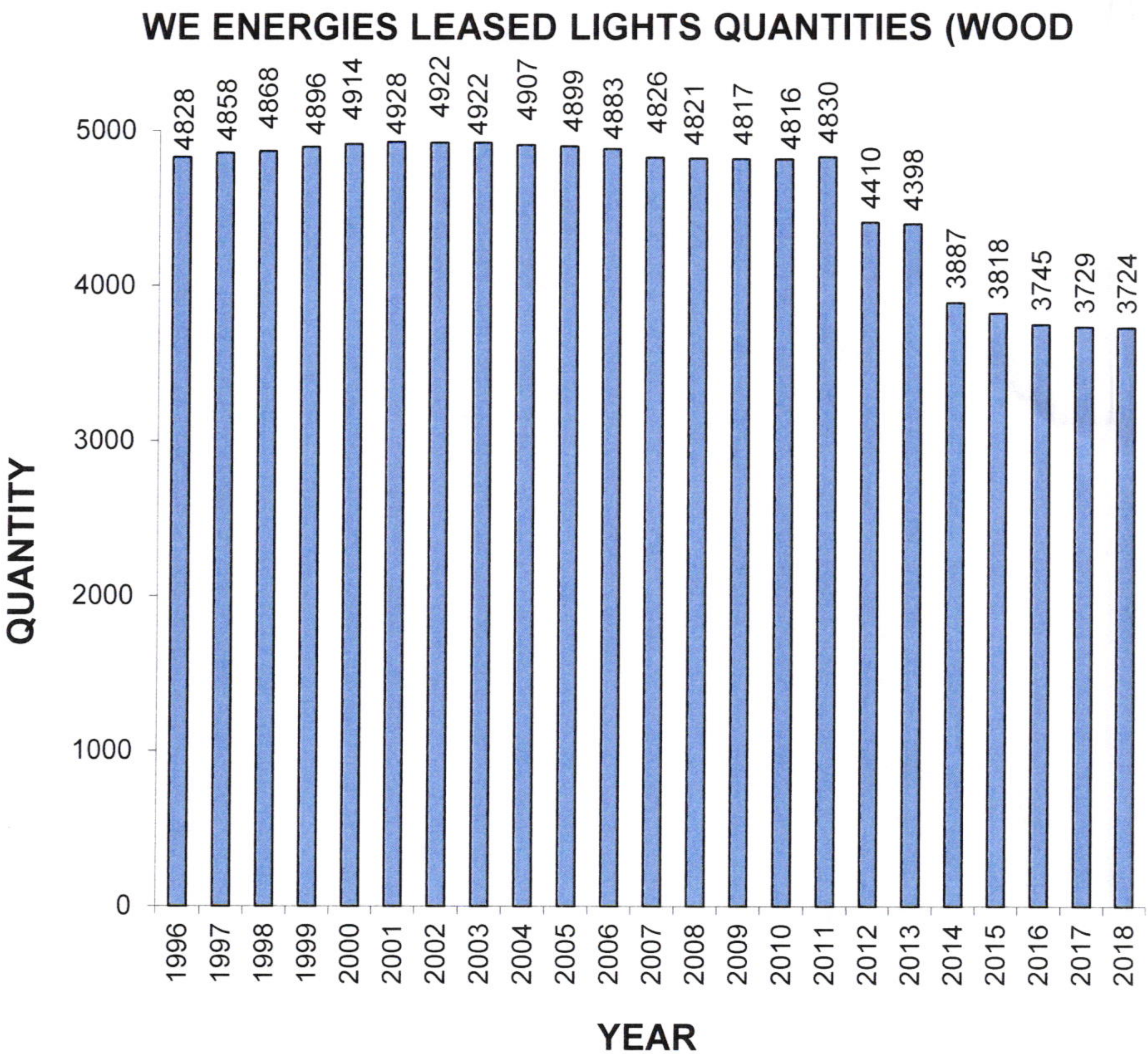
<u>We Energies Leased Lights (WE LL)</u>

As you can see in the graph below, the removal of WE LL began in 2012 and continued into 2013. The City of Racine leased 4,830 lights in 2011 and leased 3,724 lights in 2018. The current annual obligation to WE is estimated at $900,000 based on a few 3% increases in rates from 2011 to 2013 and flat rates the last 5 years. That said, the WE LL that were removed has taken approximately $1.1M off the operating budget from 2012 through 2018. This is a substantial whole to fill in the budget if the PW&SC or Common Council is desirous of returning to WE LL levels of the past. The savings of this program equates to two annual FTE's in DPW field operations.

<u>City Owned Street Lights</u>

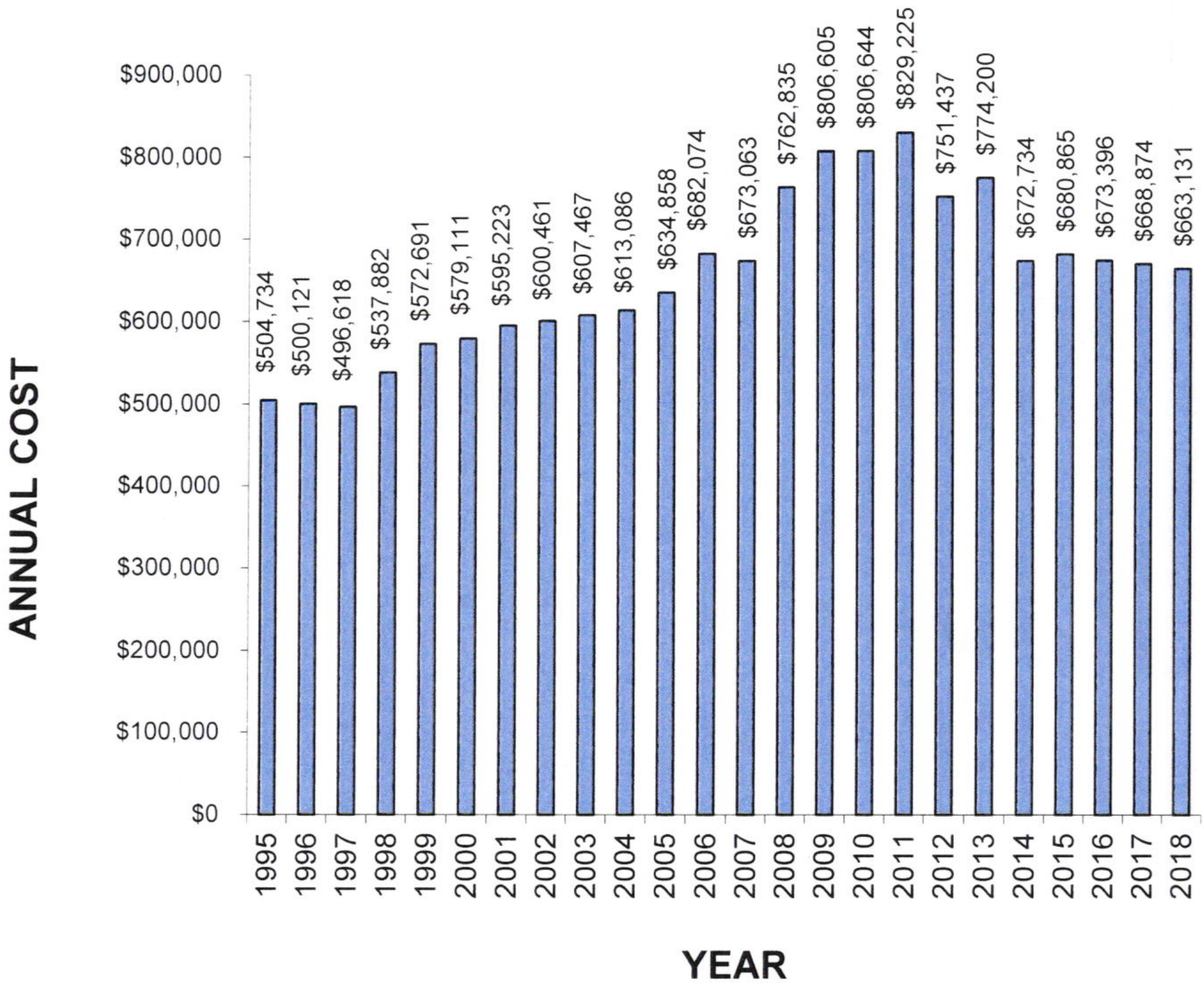
There has been some discussion concerning the perceived ineffectiveness of LED lighting to properly illuminate the right-of-way. It can be more of a concentrated and whiter color spectrum, but it's more about photo-metrics than product. I think it is very important to NOT consider going back to High Pressure Sodium (HPS) lights because they have a warmer and softer glow that may cover more area. The LED retrofits on City owned streetlights too have saved a substantial amount of money. With the advent of the ARRA funding after the financial crisis of 2007-8, the City of Racine applied for and received an Energy Efficient Community Block Grant of nearly $800K. With no local match required, the City Engineer's Office retrofitted over 1,800 (~54%) of the City owned 3,336 street lights in 2009 through 2011, resulting in large utility savings over time. We then used the energy savings metrics to apply for Focus on Energy (FOE) grants to retrofit over 500 more streetlights with LED lighting. The City of Racine then started retrofitting lights as part of WisDOT funded projects, resulting in LED conversion of nearly 70% of the City's street lights by 2015. In early 2017, we recently completed an 18 month performance contract with Johnson Controls Inc. to retrofit the remaining City of Racine owned lights. If the conversion of HPS to LED did not occur, the current annual utility cost to WE to pay for City owned metered streetlights is estimated at $300,000. This is based on a few 5% and 3% increases in rates over the last 5 to 10 years ago, along with flat rates the last 5 years. Altogether, the LED retrofits have taken approximately $790K off the operating budget from 2009 through 2018. This would be another substantial whole to fill in the budget if the PW&SC or Common Council is desirous of returning to HPS lighting used in the past. The savings of this program equates to one annual FTE in DPW field operations.

1145-19


WE ENERGIES LEASED LIGHTS QUANTITIES (WOOD
QUANTITY
YEAR
0
1000
2000
3000
4000
5000
1996
1997
1998
1999
2000
2001
2002
2003
2004
2005
2006
2007
2008
2009
2010
2011
2012
2013
2014
2015
2016
2017
2018
4828
4858
4868
4896
4914
4928
4922
4922
4907
4899
4883
4826
4821
4817
4816
4830
4410
4398
3887
3818
3745
3729
3724

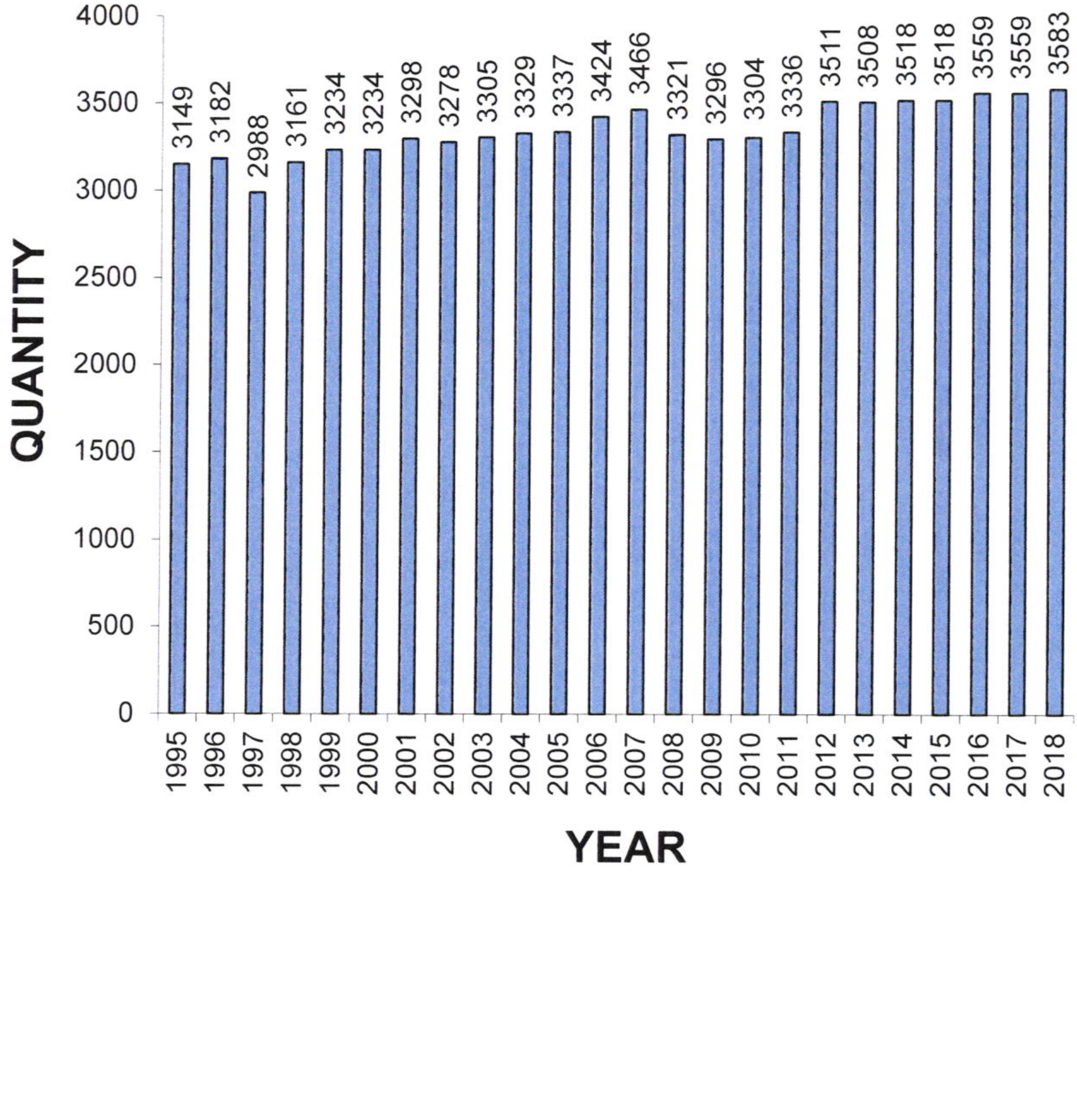
1145-19

WE ENERGIES LEASED LIGHT ANNUAL COSTS (WOOD

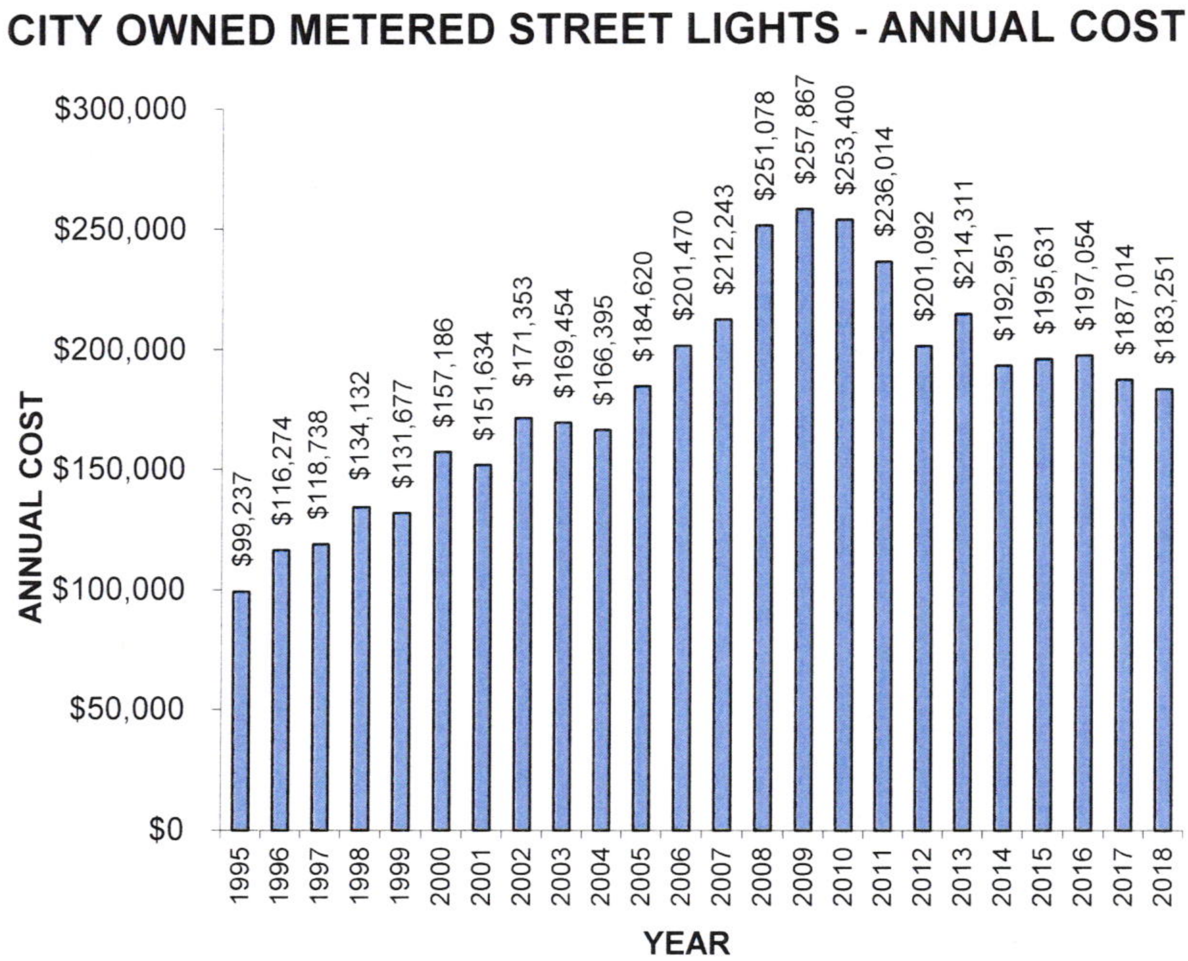


1145-19

CITY OWNED METERED STREET LIGHT



1145-19


CITY OWNED METERED STREET LIGHTS - ANNUAL COST
ANNUAL COST
YEAR
$300,000
$250,000
$200,000
$150,000
$100,000
$50,000
$0
1995 $99,237
1996 $116,274
1997 $118,738
1998 $134,132
1999 $131,677
2000 $157,186
2001 $151,634
2002 $171,353
2003 $169,454
2004 $166,395
2005 $184,620
2006 $201,470
2007 $212,243
2008 $251,078
2009 $257,867
2010 $253,400
2011 $236,014
2012 $201,092
2013 $214,311
2014 $192,951
2015 $195,631
2016 $197,054
2017 $187,014
2018 $183,251