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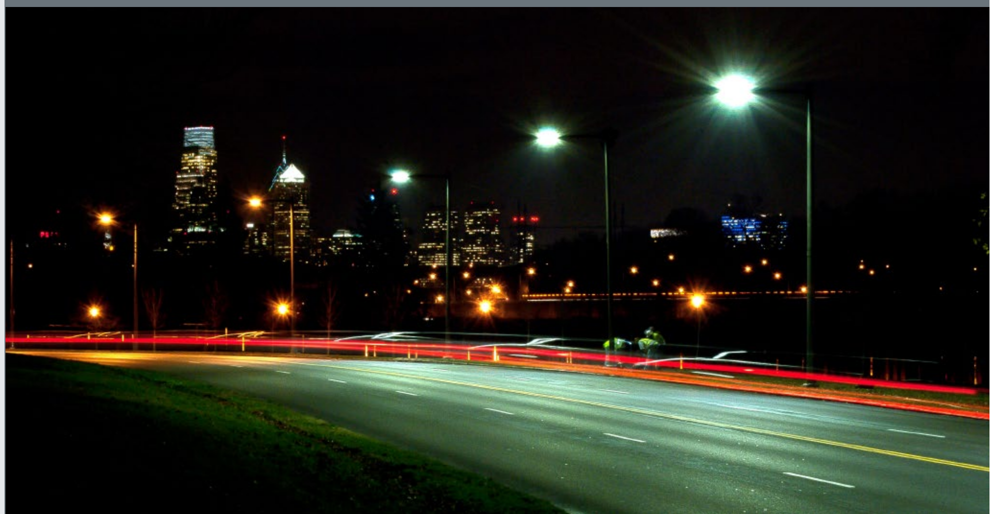
Municipal Solid-State STREET LIGHTING CONSORTIUM

GATEWAY Demonstrations



Demonstration Assessment of LED Roadway Lighting

Host Site: City of Philadelphia, Pennsylvania

September 2012

Prepared for:

Solid-State Lighting Program
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Prepared by:

Pacific Northwest National Laboratory

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Demonstration Assessment of LED Roadway Lighting

Host Site: Philadelphia, PA

Final Report prepared in support of the
U.S. Department of Energy Municipal Solid-State Street Lighting Consortium,
in cooperation with the
U.S. Department of Energy GATEWAY Solid-State Street Lighting Technology Demonstration Program

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Preface

This document includes observations and results obtained from a lighting demonstration project conducted under the U.S. Department of Energy (DOE) GATEWAY Solid-State Lighting Technology Demonstration Program. The program supports demonstrations of solid-state lighting (SSL) products in order to develop empirical data and experience with field applications of this advanced lighting technology. The GATEWAY program focuses on providing a source of independent, third-party data for consideration in decision making by lighting users and professionals; this data should be considered in combination with other information relevant to the application under examination. Each GATEWAY demonstration compares one or more SSL products with the incumbent technology used in that location. Depending on available information and circumstances, the SSL product(s) may also be compared to other alternative lighting technologies. Although products demonstrated by the GATEWAY program may have been prescreened and tested to verify their actual performance, DOE does not endorse any commercial product or guarantee that users will achieve the same results.

Acknowledgments

The City of Philadelphia—represented by the Mayor's Office of Transportation and Utilities and the Streets Department—was instrumental in facilitating this demonstration project. In particular, we would like to thank Carol Rosenfeld, Mike Faulkner, Stephen Buckley, and Rich Montanez.

Summary

For this demonstration assessment, 10 different groups of LED luminaires were installed at three sites in Philadelphia, PA. Each of the three sites represented a different set of conditions, most importantly with regard to the incumbent HPS luminaires, which were nominally 100 W, 150 W, and 250 W. The performance of each product was evaluated based on manufacturer data, illuminance calculations, field measurements of illuminance, and the subjective impressions of both regular and expert observers.

Most, but not all, of the LED luminaires had a higher rated luminous efficacy compared to the HPS product they were replacing. Some provided more lumens than their HPS counterpart, whereas others emitted fewer, and they drew between 10% and 40% less power. All of the LED luminaires had improved color rendering and a higher CCT.

Field illuminance measurements were taken at each site, but the large difference in pole spacing for each area limited the usefulness of that dataset for comparing performance. However, it did reveal that the difference in measured and calculated illuminance was up to approximately 40%, and that the HPS luminaires were more likely to provide lower illuminance than predicted by calculations.

In order to compare luminaire performance, supplemental calculations were performed using a single representative model of each of the three sites. These calculations showed that the delivered illuminance from the LED luminaires was generally similar to the baseline HPS luminaires. On average, the LED luminaires were predicted to provide 24% higher *initial* illuminance on the roadway surface, but 13 % less on the bicycle lanes and 11% less on the adjacent sidewalks. Based on the lumen depreciation factor applied to each luminaire type, the difference in predicted *maintained* illuminance would change. Two of the three HPS luminaires and seven of the ten LED luminaires were predicted not to meet at least one of the maintained illuminance design criteria. These results are dependent on both the lumen output and luminous intensity distribution characteristics of the luminaires. Importantly, the LED systems were designed with the intent of providing performance similar to the HPS luminaires, rather than to meet illuminance criteria.

Despite lower input power for the LED luminaires, energy cost savings are not currently possible for Philadelphia because they have yet to reach an agreement for a new tariff for LED street lighting with the local utility, a situation that is common throughout the country. Even with a new tariff, energy savings alone are unlikely to result in a reasonable payback period given current LED efficacy levels. However, additional cost savings from reduced maintenance could make widespread luminaire replacement cost effective. In particular, the LED luminaires installed at one of the three sites—where the luminaires were mounted on an elevated rail track—were less susceptible the premature failure from strong vibrations.

Two sets of subjective evaluations were collected: one included local residents and passersby, whereas the other was completed by lighting professionals. In general, there were only small deviations in the perception of the luminaires, and it would be difficult to select any products that were clearly superior to the others in the same category. Nonetheless, both groups generally viewed the demonstration LED lighting favorably, especially compared to the typical HPS luminaires used in Philadelphia.

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Acronyms and Abbreviations

AASHTO	American Association of State Highway and Transportation Officials
ANSI	American National Standards Institute
CCT	correlated color temperature
CRI	color rendering index
DOE	United States Department of Energy
HPS	high-pressure sodium
IALD	International Association of Lighting Designers
IES	Illuminating Engineering Society of North America
LED	light-emitting diode
PNNL	Pacific Northwest National Laboratory
SSL	solid-state lighting

Units of Measurement

A	amperes
fc	footcandles
g	g-force (equal to 9.8 m/s^2), a measure of acceleration
lm	lumens
mph	miles per hour
V	volts
W	watts

1 Introduction

This report describes a demonstration of solid-state lighting (SSL) technology used for roadway lighting in Philadelphia, PA. The demonstration was conducted by the Pacific Northwest National Laboratory (PNNL) in conjunction with the City of Philadelphia, and supported by the U.S. Department of Energy (DOE) GATEWAY Solid-State Lighting Demonstration Program and the DOE Municipal Solid-State Lighting Consortium (MSSLC). PNNL was responsible for assisting with the design and specification process, taking measurements, and analyzing the results. The City of Philadelphia—represented by the Mayor's Office of Transportation and Utilities and the Streets Department—was responsible for acquiring and installing the demonstration luminaires, as well as obtaining feedback from local residents.

PNNL manages the GATEWAY demonstration program for DOE and represents DOE's perspective in the conduct of the work. DOE supports demonstration projects to develop real-world experience and data with SSL products in general illumination applications. The GATEWAY approach is to carefully match applications with suitable products and form project teams to carry out the evaluation. Other project reports and related information are available on DOE's SSL website, http://www.ssl.energy.gov/.

Philadelphia Street Lighting

Some consider Philadelphia the birthplace of street lighting in the United States, with the service dating back to the candle-based luminaires of Benjamin Franklin. Today, the typical street lighting in Philadelphia uses high-pressure sodium (HPS) lamps and cobrahead-style luminaires, with nominal input power of the lamps ranging from 100 to 400 W. At 100 W and 150 W, the standard luminaire is the GE M-250A2 Powr/Door, whereas at 250 W and 400 W the standard luminaire is the GE M-400A Powr/Door with cutoff optics.

The Street Lighting Division of the Streets Department is responsible for approximately 100,000 streetlights and 18,000 alley lights. The City owns all of the streetlights and is responsible for repairing downed poles and defective luminaires. The City is also tasked with replacing obsolete equipment. A contractor responds to all service complaints, inspects non-operational streetlights, and replaces all defective lamps and photocontrols. The electric utility (PECO) provides power to all streetlights and repairs aerial and underground utility lines.

Philadelphia has been actively investigating alternatives to the existing HPS street lighting for several years, with a specific focus on SSL products. Although the City has conducted a number of prior demonstration projects to evaluate new products, widespread adoption has yet to occur.

Street Lighting Design Criteria

The City of Philadelphia generally follows the lighting design criteria set forth by the American Association of State Highway and Transportation Officials (AASHTO) [1], but aims to maintain a 2.0 fc average horizontal illuminance for vehicular travel lanes. This elevated average illuminance is considerably higher than the recommended illuminance for any roadway classification according to the AASHTO guidelines. Similarly, it is much higher than the levels recommended by the Illuminating Engineering Society of North America (IES) in RP-8-00 [2], especially for the road types considered in this demonstration project. The justification for this deviation is partially due to safety concerns and partially due to historical precedent; however, the City plans to reevaluate current practice as the transition to more energy-efficient street lighting is made. The City does not have separately defined targets for uniformity (e.g., average: minimum ratio), bicycle lane illuminance, or sidewalk illuminance.

Current Demonstration Program

A new street lighting demonstration project was initiated in early 2011 with the goal of evaluating products for future widespread adoption throughout the city. Specifically, along one major street the luminaires experience high vibration and premature failure because they are mounted on an overhead rail track; in this location, the City of Philadelphia was looking for a more robust product to reduce maintenance expenditures from relamping.

A number of candidate sites were proposed by the City, covering multiple situations. In May 2011, a visual survey was conducted by PNNL and the City. After the evaluation, three different streets—Kensington Avenue, 3rd Street, and Kelly Drive—comprising 10 separate demonstration areas were selected. Each street offered a unique set of conditions and the opportunity to examine several types of luminaires side-by-side. The final demonstration sites were chosen because they had limited shadowing from trees, experienced minimal spill light from neighboring properties, were isolated from other streetlights, and had a consistent arrangement of matching luminaires.

This report documents the initial performance of the installed lighting systems—including reported, calculated, and measured values—and documents user feedback collected from local residents and a group of Illuminating Engineering Society (IES) and International Association of Lighting Designers (IALD) members who toured the sites. This report does not contain any long-term performance evaluations or laboratory measurements of luminaire performance. The discussion of economics is limited because the demonstration luminaires were donated and the City of Philadelphia does not yet have an agreement with PECO regarding LED streetlights.

2 Project Description

Although Philadelphia has numerous LED street lighting demonstrations, this project was limited to three sites: (1) Kelly Drive near Fountain Green Drive; (2) N 3rd Street between Brown Street and Cambridge Street; and (3) Kensington Avenue between E York Street and E Cumberland Street, as well as between M Street and E Airdrie Street. The sites had two, four, and four demonstration areas, respectively, with configurations as listed in Table 1. Each demonstration area was comprised of four (Kelly Drive, N 3rd Street) or eight (Kensington Avenue) luminaires of the same type.

Kelly Drive

At the location of the demonstration areas, Kelly Drive is classified as a *Non-Freeway Principal Arterial / Intermediate* according to AASHTO standards. It is a major transit route leading into the downtown area, and has a posted speed limit of 35 mph. It is comprised of four vehicular travel lanes; the center lanes are approximately 10 feet wide, whereas the outside lanes are approximately 15 feet wide (see Figure 1). A six-foot wide bicycle and pedestrian path is set back approximately 30 feet from the roadway.

The existing lighting system includes nominally 250 W HPS luminaires mounted at approximately 100 feet on center along the southwestern side of the street. Notably, the pole spacing within the demonstration areas varied from 71 feet to 121 feet. The metal poles are approximately 25-feet tall, with a 6-foot setback and 8-foot arm.

Electrical service is delivered to the lighting system through dedicated lighting circuits. Single-phase 120 VAC is fed underground to the pole, with connection to the luminaire made through the pole hand well (Figure 1). Electrical connections are not fused in either the hand well or the luminaire. Electrical measurements were easily made by connecting voltage probes and current clamps to service wires accessed through the hand well.

The bicycle and pedestrian path is illuminated by decorative post-top luminaires, which were not part of the demonstration. Although the main roadway lighting provides some illumination to the path, in many areas it is obscured by large trees. Thus, measurements for this section are not reported.

Table 1. Description of the 10 demonstration areas.

Area Label	Street	Cross Street(s)	Vehicle Lane(s)	Bicycle Lane(s)	Sidewalk(s)	Existing Luminaire
A	Kelly Drive	Fountain Green	2 × 15' 2 x 10'	-	1 × 6' *	250 W HPS
B	Kelly Drive	Fountain Green	2 × 15' 2 x 10'	-	1 × 6' *	250 W HPS
C	3rd Street	Cambridge-George	1 × 12'	-	2 × 10'	100 W HPS
D	3rd Street	George-Wildey	1 × 12'	-	2 × 10'	100 W HPS
E	3rd Street	Wildey-Poplar	1 × 12'	-	2 × 10'	100 W HPS
F	3rd Street	Poplar-Brown	1 × 12'	-	2 × 10'	100 W HPS
G	Kensington Ave	York-Boston	2 × 10'	2 × 4.5'	2 × 12'	150 W HPS
H	Kensington Ave	Hager-Letterly	2 × 10'	2 × 4.5'	2 × 12'	150 W HPS
I	Kensington Ave	Letterly-Cumberland	2 × 10'	2 × 4.5'	2 × 12'	150 W HPS
J	Kensington Ave	M-Airdrie	2 × 10'	2 × 4.5'	2 × 12'	150 W HPS

* Pedestrian/bicycle path separated from roadway and not included in demonstration assessment.

Figure 1. **Kelly Drive.**

Table 2. **Products installed along Kelly Drive.** The 250 W HPS luminaire is the incumbent technology. Complete specification sheets are available in Appendix A.

Area/ID	Source	Manufacturer	Product Family	Model Number
250 HPS	HPS	GE	M-400A Powr/Door	MDCL-40-S-3-H-2-2-G-MC3
A	LED	Philips Lumec	RoadView	RVM-270W160LED4K-LE3-240-RC-BR
B	LED	BetaLED	LEDway	STR-LWY-2S-HT-12-D-UL-SV-700-43K-R

For R3 pavement, the average maintained illuminance recommended by AASHTO for Kelly Drive is 1.2 fc, with a 3:1 avg:min uniformity ratio. Also according to AASHTO, all separated pedestrian ways and bicycle ways are to be illuminated to an average maintained illuminance of 2.0 fc or greater, assuming R3 pavement.

Demonstration Lighting

Kelly Drive was host to two demonstration areas. As with all the installations that are part of the demonstration reported herein, the luminaires were mounted to the existing poles and utilized the existing electrical infrastructure. The two demonstration areas were directly adjacent to one another, with the existing HPS luminaires left in place in the surrounding area. The identification numbers used throughout this report, as well as manufacturer and product information for both the HPS and LED luminaires installed along Kelly Drive are shown in Table 2.

3rd Street

N 3rd Street between Brown Street and Cambridge Street is part of the semi-regular grid that comprises downtown Philadelphia. It is mostly bordered by mid-rise and adjoined single family residential properties, but restaurants and other small stores are present, along with a small park. The street is classified as a *Collector / Intermediate* according to AASHTO, and has a posted speed limit of 25 mph. The single, one-way vehicular travel lane is approximately 12 feet wide, with a 7-foot wide parking lane on either side (see Figure 2). The sidewalks on either side are nominally 10 feet wide, with numerous small trees, planters, and stairways interspersed throughout.

The existing lighting system includes nominally 100 W HPS luminaires mounted at approximately 100 feet on center on the western side of the street. Notably, the spacing of the wood poles within the demonstration areas varied from 60 feet to 123.5 feet; if unaccounted for, this difference can have a substantial effect on measured performance. For example, the average measured illuminance provided by two luminaires emitting the same number of lumens, but spaced at 60 feet versus 120 feet would be different by a factor of two.

The luminaires are mounted approximately 25-feet above the road surface—the poles are taller and support an above ground electrical distribution system, along with other communication wires and equipment. The arm length and orientation is somewhat variable. In several places along 3rd Street in the designated demonstration site there are luminaires mounted on the adjacent buildings. In some cases, these provided substantial illumination to the sidewalk or street. Because these luminaires could not be turned off or easily shielded by the City, they contributed to the measured illuminance for both the HPS and LED luminaires.

Figure 2. **N 3rd Street.**

Table 3. **Products installed along N 3rd Street.** The 100 W HPS luminaire is the incumbent technology. Complete specification sheets are available in Appendix A.

Area/ID	Source	Manufacturer	Product Family	Model Number
100 HPS	HPS	GE	M-250A2 Powr/Door	M2AR-10-S-1-H-2-A-MS2
C	LED	Acuity American Electric	Autobahn	ATB1-60LED-E53-MVOLT-R2-DE
D	LED	LED Roadway Lighting	Satellite	S72M-0-R-AL-2-NN-G3-GBQ-B1H-LF
E	LED	Lighting Science Group	Prolific Roadway	LSR3-CW-R2-MVOLT-2B-PCR-SH-GR
F	LED	Philips Hadco	LEDGINE	RX140-I-2-N-A-M-R-N-S-N

Electrical service is delivered to the luminaires through individual connections between each pole and the above ground electrical distribution system. Split-phase 120 VAC, consisting of two hot or live legs and a neutral, is fed to each pole, with connection to the luminaire made at or near the mast arm. Ideally, consecutive luminaires along a street are connected to alternating hot legs. Electrical connections are not fused in the luminaire. Electrical measurements were made by connecting voltage probes and current clamps to service wires accessed at or near the mast arm. For various reasons, the ideal practice of connecting luminaires to alternating hot legs is not always followed in the field, and the load imbalance created by this practice results in non-zero neutral currents. Proper connection and configuration of electrical measurement equipment for such conditions can be more challenging and time consuming.

For R3 pavement, the average maintained illuminance recommended by AASHTO for N 3rd Street is 0.8 fc, with a 4:1 uniformity ratio. For pedestrian ways and bicycle ways adjacent to roadways, the roadway design values should be used. As noted, the average maintained illuminance design target loosely used by the City of Philadelphia is higher at 2.0 fc—this will be discussed further in the performance analysis section.

Demonstration Lighting

N 3rd Street was host to four demonstration areas. As with the other installations that are part of the demonstration reported herein, the luminaires were mounted to the existing poles and utilized the existing electrical infrastructure. The demonstration areas included the four poles in the middle of the block, excluding the poles at the intersection that were left as HPS. This method was chosen in order to limit spill light from the cross streets. It also provided a buffer between the demonstration areas. The identification numbers used throughout this report, as well as manufacturer and product information for both the HPS and LED luminaires installed on N 3rd Street are shown in Table 3.

Kensington Avenue

Kensington Avenue, classified as a *Minor Arterial / Intermediate* street, traverses the Kensington neighborhood of northeastern Philadelphia, a few miles from Center City. Kensington Avenue is unique because it is underneath an elevated rail track for its entire length (see Figure 3). The street is home to a variety of properties, including small storefronts, residential buildings, empty lots, car dealerships, and warehouses, among others. The street has one 10-foot wide vehicular travel lane in each direction, the posted speed limit is 25 mph, and the street is bounded on both sides by a 5.5-foot wide bicycle lane and 7-foot wide parking lane. The steel frame of the overhead rail is anchored by columns at the edge of the sidewalk that are spaced approximately 52.5 feet on center.

The existing lighting system includes nominally 150 W HPS luminaires mounted at approximately 52.5 feet on center. The horizontal tenons for the luminaires are attached directly to the underside of the rail

Figure 3. **Kensington Avenue.**

structure, and are approximately 17.5 feet above the road surface. The mounting locations are nominally at the center of each column span; however, the spacing was measured to vary several feet in either direction. This led to measured luminaire spacing ranging from 46 to 58 feet. There are two parallel rows of luminaires, which are situated approximately overtop of the bicycle lane. Importantly, the luminaires are oriented in the opposite direction from traditional streetlights. That is, the street side of the luminaire is actually facing the sidewalk. Consequently, luminaires designed to direct more light toward the travel lanes actually direct more light toward the sidewalk in this application. The sidewalk is approximately 12-feet wide.

Electrical service is delivered to the luminaires through small lighting circuits connected to the above ground electrical distribution system at or near one of the horizontal tenons. Electrical distribution is again achieved by split-phase 120 VAC, and electrical connections are not fused in the luminaire. Electrical measurements were made by connecting voltage probes and current clamps to service wires accessed at or near the horizontal tenon.

For R3 pavement, the average maintained illuminance recommended by AASHTO for Kensington Avenue is 1.0 fc, with a 4:1 uniformity ratio. For pedestrian ways and bicycle ways adjacent to roadways, the roadway design values should be used. As noted, the average maintained illuminance design target loosely used by the City of Philadelphia is higher at 2.0 fc—this will be discussed further in the performance analysis section. For Kensington Avenue in particular, this elevated design target is in part instituted for safety and security—Kensington Avenue is generally considered a high-crime area.

In part due to the mixed-use nature of the surrounding area, there are some properties that contribute a substantial amount of illumination to the roadway. As with N 3rd Street, it was not possible to negate this contribution when measurements were taken. It was assumed that the amount of spill light was equal for the HPS and LED measurements.

Vibration

One of the main reasons Kensington Avenue was selected for this demonstration project was because the luminaires experience higher-than-normal vibration. This is a direct result of the mounting configuration on the elevated rail track. Representatives from the Streets Division estimated that new HPS lamps were failing approximately three months after installation, on average, or at less than 5% of the rated lifetime. This high failure rate increases maintenance costs for these luminaires, making any alternative technology capable of withstanding the vibration especially attractive. The vibration of the luminaires was visible from the ground when illuminance measurements were being taken.

Although a comprehensive scientific study was not conducted, measurements were taken to help understand the magnitude of the vibration problem. In late January, 2012, an Instantel Blastmate III vibration monitor was used to record the vibration experienced by a typical HPS luminaire installed near the demonstration site. The non-functioning luminaire was fit with a tri-axial geophone—a measurement device that converts movement into electrical signals—and the monitor was set to record when a minimum level of vibration was reached, thus ensuring that the period when a train was passing overhead was recorded. Notably, the geophone added additional weight to the luminaire, and the measurements do not represent a statistical sample. Nonetheless, the data collected provide valuable insight into the extreme vibration that the luminaires along Kensington Avenue experience.

From approximately 6:00 AM to 11:00 AM on January 30, 2012, 47 events (i.e., passing trains) were recorded by the Blastmate III device. The highest recorded peak velocity[1] was 274 mm/s, and the lowest was 158 mm/s. For all of the events, the most substantial contributor to the peak velocity was the vertical velocity vector, a logical result of the measurement situation. Notably, the peak vertical velocity was out of range during four of the recorded events. Typical frequencies were between 10 and 100 Hz. The peak displacement of 8.43 mm occurred in the transverse direction. **Peak acceleration, which always occurred in the vertical plane, ranged from approximately 8.0 g to 25.4 g.**

ANSI standard C136.31-2010 [3] addresses vibration for roadway and area lighting, but its reach appears limited. The literature for many luminaires, including all of those installed as part of the demonstration in Philadelphia, does not include any indication that the product was tested according to the standard. Notably, the standard only includes testing up to 3.0 g for bridge and overpass applications, with a lower level of 1.5 g for normal applications. Testing to these levels would not be rigorous enough to help identify products capable of withstanding the high peak accelerations experienced by the Kensington Avenue luminaires.

At least theoretically, LED luminaires should have a higher resistance to vibration because they do not have filaments or other breakable parts; however, exploiting this advantage requires careful consideration of all product components and the full assembly.

Demonstration Lighting

Kensington Avenue was host to four demonstration areas. The luminaires were mounted to the existing tenons and utilized the existing electrical infrastructure. Three of the demonstration areas were adjacent to one another, with the fourth area approximately two miles away. The identification numbers used throughout this report, as well as manufacturer and product information for both the HPS and LED luminaires installed on Kensington are shown in Table 4.

[1] Peak velocity is the sum of the velocity vectors for the three axes of measurement: transverse, vertical, and longitudinal.

Table 4. **Products installed along Kensington Avenue.** The 150 W HPS luminaire is the incumbent technology. Complete specification sheets are available in Appendix A.

Area/ID	Source	Manufacturer	Product Family	Model Number
150 HPS	HPS	GE	M-250A2 Powr/Door	M2AR-15-S-1-H-2-A-MS2
G	LED	BetaLED	LEDway	STR-LWY-2M-HT-06-D-UL-SV-700-43K-R
H	LED	Leotek	Green Cobra	GC1-80E-MV-NW-3-GY
I	LED	Cooper Streetworks	OVF LED	OVF-C06-LED-EU-5XQ
J	LED	EcoFit	LED Light Engine	D-5-240-525-63-4600

Demonstration Process

Procurement

The City of Philadelphia arranged for donation of demonstration products from numerous manufacturers, which were all received in November 2011. More luminaire types were donated than could be monitored and discussed in this report; these luminaires were installed in other locations, as appropriate. The 10 products that were documented for this report were those that were predicted to be the best fit for the application. After receiving the products, each was tested by an engineer with the Philadelphia Streets Department to ensure it was in working condition.

Installation

All baseline HPS luminaire measurements were taken on December 12, 2011. The HPS luminaires in the demonstration areas were cleaned and relamped shortly before measurements were taken. The LED luminaires were installed on December 13–14, 2011 by electricians from the Streets Department. Illuminance measurements were taken in the evening after the luminaires were installed. Examples of the HPS and LED luminaires, as installed at the demonstration sites, are shown in Figure 4.

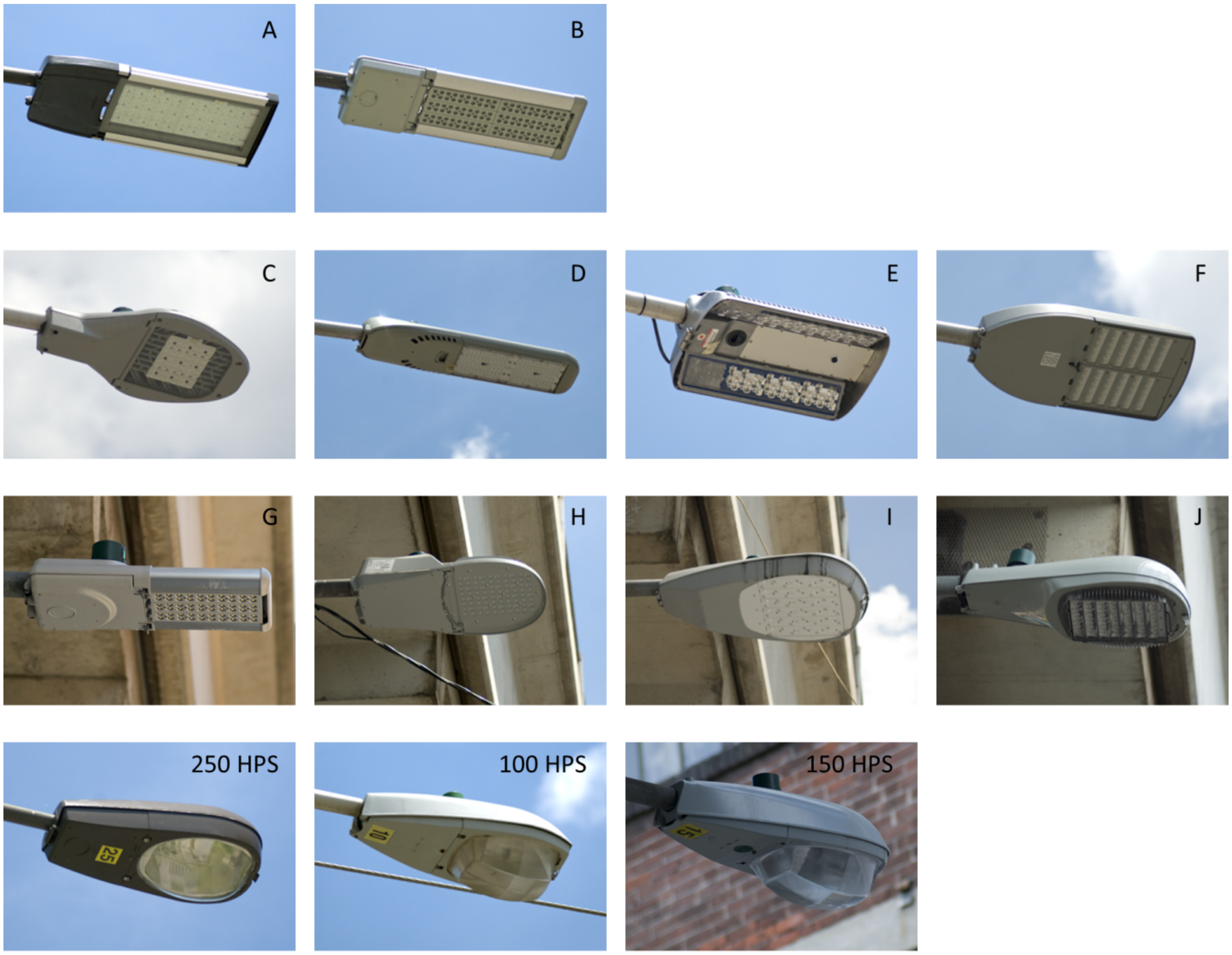

Figure 4. Photographs of the 10 demonstration products and three benchmarks installed in Philadelphia.

3 Performance Data

There are many ways to evaluate prospective and/or installed luminaires, all providing useful information. For this report, the demonstration luminaires were evaluated based on their listed performance according to the manufacturer, calculations of predicted performance, and field measurements. Because the three sites had different baseline luminaires, among other physical differences, the analysis is also separated where appropriate.

Importantly, there is substantial difference between the spacing of the measured pole intervals within each demonstration site. This can make between-product comparisons of measured illuminance deceptive, because the area being illuminated is very different. To address this issue, relative measures of performance, such as application efficacy[2] and delivery efficiency,[3] are emphasized. Additionally, two different calculation methods were used:

- With the pole spacing as measured (i.e., unique to each product type)
- With the pole spacing set to a typical value for each of the three demonstration sites

These calculations can be used to evaluate different aspects of the performance of the system. The first method provides the best comparison to the measured data, whereas the second method provides the most direct comparison between different luminaires and corresponds to the basis for product selection. Detailed results from both calculation methods are available in Appendix D. In both cases, initial and maintained illuminance are reported; the initial values correspond to the measured values—the measurements were taken on the day of installation—whereas the maintained values are relevant to the design criteria. Notably, calculated values are predictions that do not account for other ambient illumination that is usually present in urban environments. Further, physical differences (e.g., the presence of trees) can affect the ability of calculations to represent field performance.

Currently, there is no recommended method for calculating the lamp lumen depreciation (LLD) light loss factor that accounts for differences in lumen maintenance for LED luminaires—the IES recommends that all LED luminaires used in street lighting applications use an LLD of not greater than 0.70. Because specific lumen maintenance calculations and long-term measurements were outside the scope of this report, it was not possible to accurately evaluate and compare the performance of the demonstration LED luminaires over time. Thus, initial illuminance values are reported by default. Nonetheless, it would be reasonable to note concerns about future performance (i.e., maintained illuminance) for LED luminaires measured or calculated to have an average initial illuminance value close to or below the target criterion. Predicted maintained illuminance—using total light loss factors of 0.77 (HPS) and 0.63 (LED)[4]—is reported in Appendix C (measured values) and Appendix D (calculated values); however, these values do not account for individual differences between the products and thus should be compared with caution.

Luminaire Selection Process

The luminaires included in this demonstration were selected based on their maintained performance being similar to the baseline HPS luminaires installed at each site. They were not specified based on their ability to meet AASHTO or City of Philadelphia design criteria. This important distinction is critical

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[2] *Application efficacy* is calculated as the quotient of total lumens delivered to the target area (e.g., vehicular travel lanes) and the input power of the luminaire. **This metric should not be used to compare luminaires used in different applications.**

[3] *Delivery efficiency* is calculated as the quotient of lumens delivered to the target area (e.g., vehicular travel lanes) and the manufacturer's rated lumen output. **This metric should not be used to compare luminaires used in different applications.**

[4] For the HPS systems, the light loss factor was comprised of an LLD of 0.85 and a luminaire dirt depreciation (LDD) factor of 0.90. For the LED systems, the LLD was 0.70 and the LDD was 0.90.

to the performance evaluation. In many cases, the performance could have been better aligned with design criteria by choosing a different product. For example, in some cases the predicted average maintained illuminance on the roadway was over twice as high as recommended by AASHTO—although in some cases the same area has a predicted average maintained illuminance on the sidewalk that does not meet AASHTO criteria. Additional energy savings may be possible if illuminance levels were reduced where appropriate.

Measured Illuminance Procedure

Field illuminance measurements were taken December 12–14, 2011 between 6: 10 p.m. and 11:30 p.m. each night. The air temperature was between approximately 27 °F and 50 °F, depending on the site and day. Weather varied between clear and overcast, but there was no precipitation and the ground surfaces were dry. Nautical twilight occurred at 5:40 PM each day. A full moon occurred on December 10, and the moonrise during the measurement days was 6:44 p.m., 7:48 p.m., and 8:53 p.m., respectively. Illuminance contributions from the moon or other sources of environmental illumination were not accounted for in the results provided in this report because they were within the reasonable margin of error for the regular streetlight measurements.

The existing HPS luminaires—which were cleaned and relamped in the weeks preceding evaluation—were measured on December 12, and the new LED luminaires were installed on December 13–14. LED measurements were taken during the evening of the day the luminaire was installed. All luminaires were operating for at least one hour prior to measurement.

Prior to completing the illuminance survey, all measurement points were marked using temporary paint. The measurement points were determined according to RP-8-00 procedures: vehicular travel lanes were each marked with two parallel rows of grid points at the quarter point of the lane, with each row containing 10 points. The measurements were taken between the pair of poles at the center of the string of a specific luminaire type. The bicycle lanes and sidewalks each had a single row of measurement points at the center of the path.[5]

Illuminance was measured with a Minolta T-10 meter, which was within its initial calibration period. A custom-built apparatus was used to slide the meter between measurement points and level the meter at each point. Using this apparatus, the illuminance meter was elevated approximately 6.5 inches above the road surface. Complete results of the illuminance survey are available in Appendix C.

Measured versus Calculated Illuminance

Field measurements are important for examining the relationship between predicted and actual performance. They account for local environmental conditions, as well as differences between listed and actual performance of luminaires. However, other nearby light sources can also contribute to field measurements, making precise examinations of measured versus calculated illuminance difficult to achieve, especially in urban environments.

Measured and calculated illuminance values are compared in Table 5. The calculated values correspond to the same physical layout as the measured values; that is, the pole spacing and grid layout were intended to match. As is common, the field measurements did not match the predicted performance, deviating by up to 37% over and 28% under. For some areas, the illuminance associated with the HPS luminaire was measured to be substantially less than predicted and the illuminance associated with the LED substantially more than predicted, effectively negating the possibility that other light sources were

[5] Bicycle lanes and sidewalks along Kensington Avenue were only measured on one side of the roadway. It was assumed that performance would be similar for the other side.

Table 5. Measured versus calculated illuminance of vehicular travel lanes for the ten demonstration areas. Although the difference in average illuminance was as high as 37%, the average difference was within acceptable tolerances.

	Pole Spacing (ft)		Average Initial Horizontal Illuminance			Avg:Min Ratio		
			Measured	Calculated	Difference	Measured	Calculated	Difference
A	71	HPS	3.25	3.36	-3.46%	2.73	4.73	-73.34%
		LED	3.88	3.87	0.31%	3.26	4.78	-46.41%
B	82	HPS	2.50	3.04	-21.62%	3.02	1.11	63.29%
		LED	3.59	3.13	12.81%	4.54	8.24	-81.43%
C	92	HPS	-	1.66	-	-	2.24	-
		LED	2.58	2.36	8.53%	1.54	1.41	8.24%
D	60	HPS	2.62	2.30	12.21%	1.49	1.29	13.28%
		LED	3.91	3.13	19.95%	1.48	1.45	2.09%
E	72	HPS	3.17	2.00	36.91%	1.73	1.64	5.24%
		LED	2.86	2.45	14.34%	1.28	1.34	-4.59%
F	124	HPS	-	1.21	-	-	2.33	-
		LED	1.74	1.33	23.56%	2.64	2.56	3.12%
G	55	HPS	-	3.15	-	-	1.63	-
		LED	3.31	4.00	-20.85%	2.05	1.17	43.11%
H	58	HPS	2.41	3.09	-28.22%	1.63	1.71	-4.74%
		LED	4.16	4.32	-3.85%	3.18	1.28	59.81%
I	46	HPS	3.04	3.64	-19.74%	1.63	1.52	6.56%
		LED	5.95	5.29	11.09%	1.12	1.13	-0.71%
J	52	HPS	-	3.26	-	-	1.59	-
		LED	4.49	4.01	10.69%	1.26	1.13	10.60%

the sole cause of the difference. Further, there was little to no ambient illumination provided by other sources at Kelly Drive.

Overall, the mean difference in average illuminance was -4.0% for the HPS luminaires and 7.7% for the LED luminaires—positive values indicate measured illuminance was greater than predicted. These values are generally within acceptable tolerances, although the higher deviations for individual areas are more striking. Examining only the magnitude of the disparity (i.e., without regard to positive or negative), the mean difference in average initial illuminance was 20.4% for the HPS luminaires and 12.6% for the LED luminaires. For the LED luminaires, only 2 of 10 areas had measured illuminance less than predicted illuminance; in contrast, 4 of the 6 areas that were evaluated with HPS luminaires installed had measured illuminance less than predicted. Although the HPS luminaires were cleaned and relamped, it is notable that they were existing fixtures that had been installed for a considerable length of time.

The mean difference for the average to minimum illuminance ratio was 1.72% for the HPS luminaires and -0.62% for the LED luminaires. However, the mean magnitude of the difference was 27.7% for the HPS luminaires and 26.0% for the LED luminaires. Many of the areas had uniformity that was dramatically different from what was predicted.

Given the complications with pole spacing and ambient illumination, among other factors, it is difficult to establish that measured performance is more relevant than calculated performance when comparing the demonstration luminaires. Even for the personal on-site evaluations, the measured illuminance for the center pole interval of each sequence of four luminaires does not represent the broader performance throughout the area. Thus, calculations using consistent pole spacing for the luminaires in each site are considered the most effective tool for comparing luminaire performance in this report. Nonetheless, field measurements are an important tool that can provide validation of actual performance, among other uses.

Kelly Drive

Manufacturer Listed Performance

The manufacturer data—characterizing expected performance—of the luminaires installed along Kelly Drive is shown in Table 6 and Figure 5. The LED luminaires selected for this demonstration were rated as drawing slightly less power and emitting slightly fewer lumens, but having slightly higher efficacy. One important difference compared to the baseline HPS luminaire is that the LED luminaires have rated CCTs of 4100 and 4300 K with a CRI near 70. The other key difference is in the luminous intensity distributions: the maximum candela for the HPS luminaire was substantially greater than for either LED luminaire. However, maximum candela—and other characteristics shown in polar plots—only present a limited characterization of product performance.

Table 6. Manufacturer reported performance for the products installed along Kelly Drive. In order to match the calculated values reported herein, data from IES-format files took precedence over other manufacturer literature.

Site/ID	Input Power (W)	Lamp Output (lm)	Luminaire Efficiency (%)	Luminaire Output (lm)	Luminaire Efficacy (lm/W)	CCT (K)	CRI
250 HPS	305	28,000	76	21,292	69.8	2100	22
A	271	-	-	19,546	72.2	4100	70
B	271	-	-	19,643	72.5	4300	70

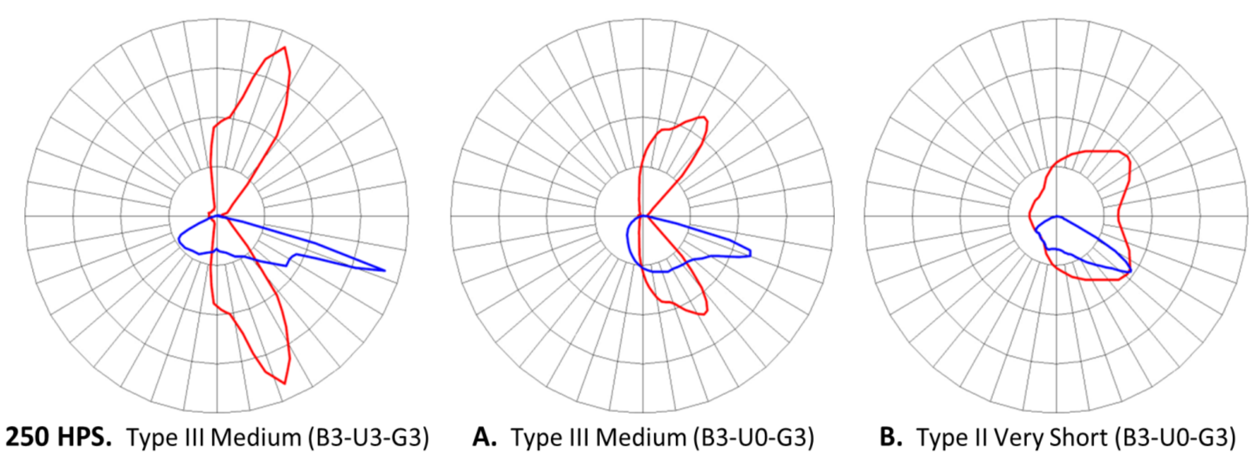


Figure 5. Polar plots of luminous intensity distribution for the Kelly Drive luminaires. The maximum for each plot is 20,000 cd. Distribution types and BUG ratings are as determined by Photometric Toolbox. The blue line represents luminous intensity in the vertical plane that includes the maximum value, whereas the red line represents a luminous intensity in a horizontal cone through the vertical angle containing the maximum value.

Table 7. Rated and calculated performance for the luminaires installed along Kelly Drive. The calculations were based on the nominal average measured pole spacing of 100 feet.

	Luminaire Type		
	250 HPS	**LED A**	**LED B**
Manufacturer Rated Values			
Input Power (W)	325	271	271
Output (lm)	21,292	19,546	21,292
Luminous Efficacy (lm/W)	66	72	79
Calculated Average Initial Illuminance (fc)			
Auto Lanes	2.57	2.89	2.65
Bicycle Lanes	-	-	-
Sidewalks	-	-	-
Drive Lane Performance (Full Area)			
Delivered Lumens	12,850	14,450	13,250
Delivery Efficiency	60%	74%	62%
Application Efficacy (lm/W)	39.5	53.3	48.9

Evaluation of Delivered Illuminance

Despite emitting fewer lumens, both LED luminaires installed along Kelly Drive were calculated to provide a slightly higher average initial illuminance, as shown in Table 7. This is a direct result of the luminous intensity distribution of each product. Notably, the calculated average maintained illuminance might not exhibit the same relationship, depending on the light loss factor applied for each luminaire type. Further, actual performance over time is dependent on the specific lumen depreciation characteristics of each luminaire type.

Regardless of the calculation method used, none of the luminaires (LED or HPS) evaluated for Kelly Drive met the AASHTO average to minimum uniformity requirement. This was also confirmed by the field measurements. As previously described, Kelly drive is a four-lane road that is illuminated from one side only.

The lower input power and improved distribution characteristics resulted in higher initial application efficacies for the LED luminaires. Initially, LED A was calculated to deliver 53.3 lm/W and LED B was calculated to deliver 48.9 lm/W, whereas the 250 HPS luminaire was calculated to deliver just 39.5 lm/W.

N 3rd Street

Manufacturer Listed Performance

Manufacturer data for the demonstration luminaires installed on N 3rd Street is shown in Table 8. In contrast with Kelly Drive, three of the four LED luminaires were listed as emitting more lumens than the baseline 100 W HPS luminaire. Notably, the reported luminaire efficacy reached up to 92.3 lm/W, the highest of any product examined for this demonstration. Similar to the Kelly Drive luminaires, the LED luminaires on N 3rd Street had CCTs between 4000 K and 5000 K, with CRIs in the 60s and 70s (or not reported). They also had lower rated input power. Despite having a range for input power of just 11%, the lumen output of the LED luminaires varied by 37%, illustrating the importance of comparing lumens rather than watts.

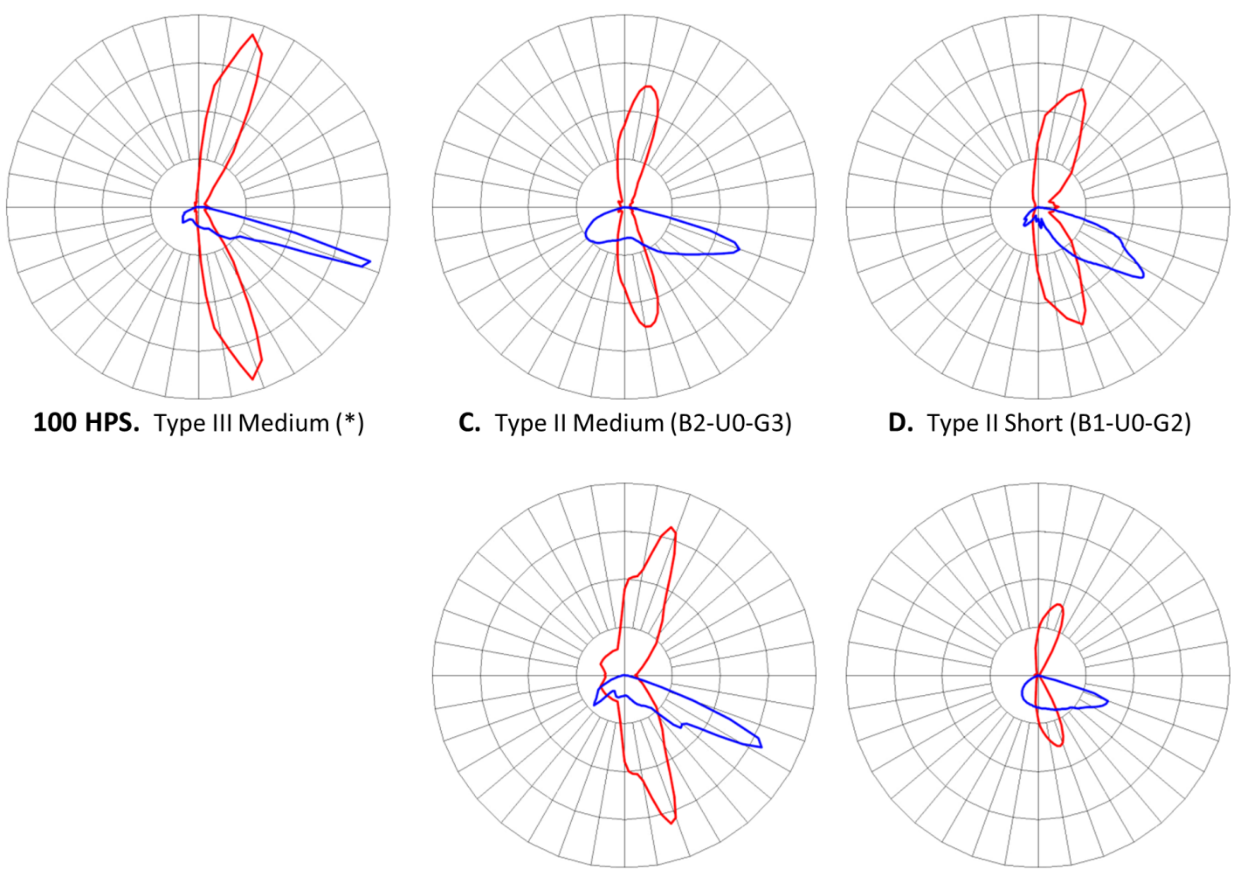
As shown in Figure 6, the luminous intensity distributions of all five luminaires appear more similar than for the three Kelly Drive luminaires. However, there was a substantial difference in maximum candela that cannot be entirely attributed to the difference in lumen output.

Evaluation of Delivered Illuminance

As with Kelly Drive, all four LED luminaires were calculated to deliver higher average initial illuminance

Table 8. Manufacturer reported performance for the products installed along N 3rd Street. CRI was not provided for LED type F. In order to match the calculated values reported herein, data from IES-format files took precedence over other manufacturer literature.

Site/ID	Input Power (W)	Lamp Output (lm)	Luminaire Efficiency (%)	Luminaire Output (lm)	Luminaire Efficacy (lm/W)	CCT (K)	CRI
100 HPS	123	9,500	73	6,971	56.7	2100	22
C	106	-	-	9,028	85.4	4000	64
D	108	-	-	7,223	66.9	5000	70
E	101	-	-	9,364	92.3	5000	65
F	96	-	-	5,927	61.5	4000	



100 HPS. Type III Medium (*)
C. Type II Medium (B2-U0-G3)
D. Type II Short (B1-U0-G2)
E. Type II Short (B2-U1-G2)
F. Type II Medium (B2-U0-G1)

Figure 6. Polar plots of luminous intensity distribution for the N 3rd Street luminaires. The maximum for each plot is 11,000 cd. The blue line represents luminous intensity in the vertical plane that includes the maximum value, whereas the red line represents a luminous intensity in a horizontal cone through the vertical angle containing the maximum value. *BUG ratings could not be calculated for the HPS luminaire.

to the vehicular travel lanes than the HPS luminaire.[6] However, as shown in Appendix C, this relationship is likely to change over time based on the assumed light loss factors. Similarly, three of the four LED luminaires provided higher average initial illuminance on the sidewalks, although the 100 HPS, D-type, and F-type luminaires failed to meet the AASHTO requirement (0.8 fc). This deficiency becomes even more pronounced when evaluating predicted maintained illuminance.

All four luminaire types had higher listed efficacy than the HPS luminaire, but also had higher initial application efficacies for the vehicular travel lane alone and the full area (including the sidewalks). Notably, there is parking along both sides of N 3rd Street, resulting in lumens that are not captured by the calculation/measurement grids; this is just one example of why application efficacy should not be compared between sites with different configurations (e.g., N 3rd Street versus Kelly Drive).

It is apparent from Table 9 that the LED luminaires generally save energy and provide higher initial illuminance levels. Assuming lumen depreciation is higher for the LED luminaires than the HPS luminaires, the difference in illuminance would decrease—and possibly revers—over time. Although the initial illuminance levels were high and met AASHTO criteria, they did not meet the City's stated goal of 2.0 fc. However, it would have been possible to select products to meet that goal, or to select products that saved additional energy by not exceeding the AASHTO criteria by as wide a margin. As previously noted, the products were selected simply based on their ability to provide similar performance to the existing HPS luminaires.

Table 9. Rated and calculated performance for the luminaires installed along N 3rd Street. The calculations were based on 100-foot pole spacing. Red values fail to meet AASHTO criteria.

	Luminaire Type				
	100 HPS	**LED C**	**LED D**	**LED E**	**LED F**
Manufacturer Rated Values					
Input Power (W)	123	106	108	101	96
Output (lm)	6,971	9,028	7,223	9,364	5,927
Luminous Efficacy (lm/W)	57	85	67	93	62
Calculated Average Initial Illuminance (fc)					
Auto Lanes	1.54	2.19	1.99	1.79	1.69
Bicycle Lanes	-	-	-	-	-
Sidewalks	0.77	0.92	0.79	1.15	0.65
Drive Lane Performance					
Delivered Lumens	1,822	2,591	2,355	2,118	2,000
Delivery Efficiency	26%	29%	33%	23%	34%
Efficacy (lm/W)	14.8	24.4	21.8	21.0	20.8
Full Area Performance					
Delivered Lumens	2,592	3,511	3,145	3,268	2,650
Delivery Efficiency	37%	39%	44%	35%	45%
Application Efficacy (lm/W)	21.1	33.1	29.1	32.4	27.6

[6] Calculations were based on a pole spacing of 100 feet.

Kensington Avenue

Manufacturer Listed Performance

All four LED luminaire types[7] evaluated for Kensington Avenue were listed as drawing less power than the baseline 150 W HPS luminaire, but they were also listed as emitting fewer lumens—one emitted less than 50% of the lumens compared to the baseline. As shown in Table 9, only two of the LED products had a higher efficacy than the HPS luminaire, although all products had a higher CRI (if listed). All of the LED products had a listed CCT between 4000 K and 4600 K.

More than for the other sites, the LED luminaires installed along Kensington Avenue had substantially different luminous intensity distributions compared to the HPS baseline (see Figure 7). In particular, the I- and J-type luminaires emitted equal amounts of light to the house side and street side. However, it is worth reiterating that in this case the house side faces the sidewalk because the luminaires are mounted to the elevated rail track. Thus, a quadrilaterally symmetric luminous intensity distribution may be more suitable to the site.

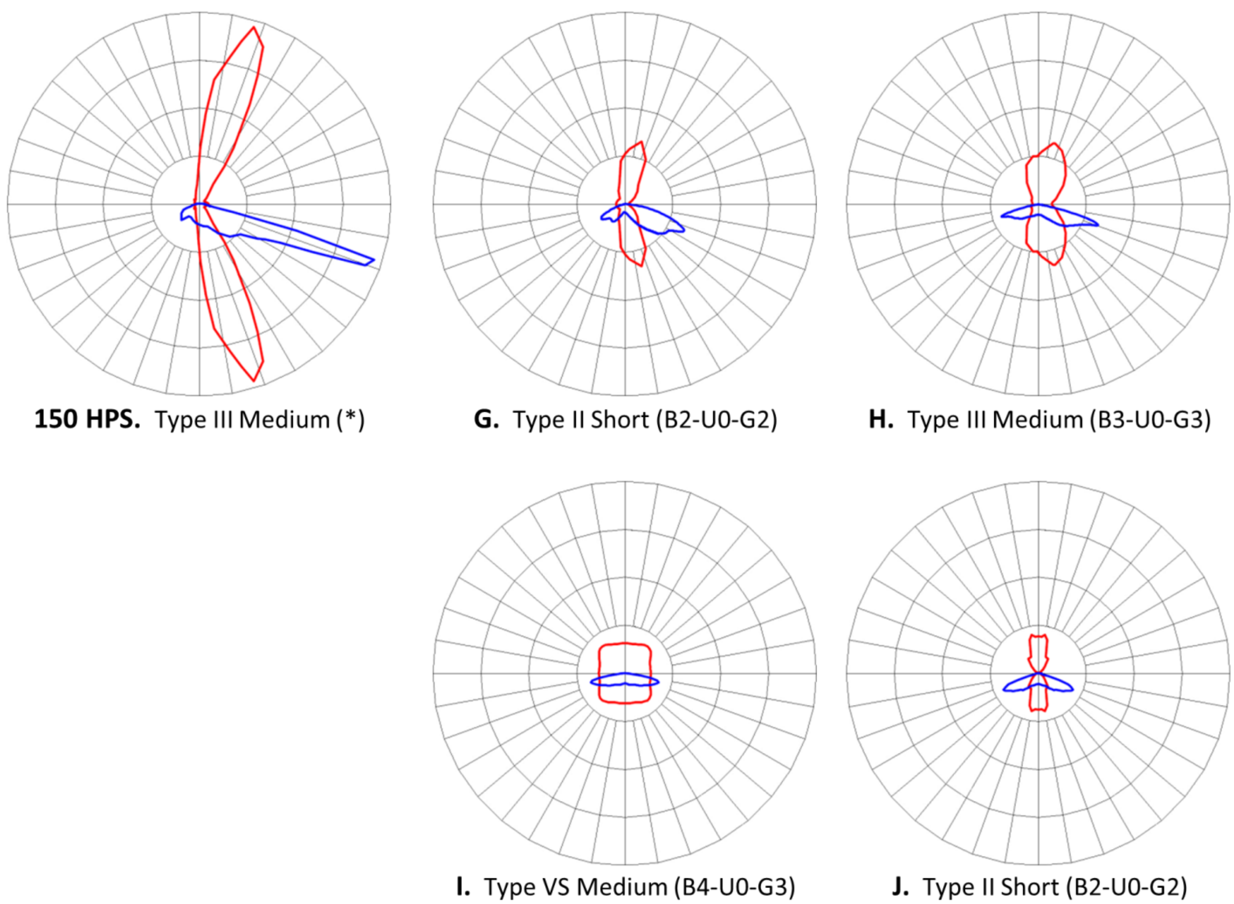


Figure 7. Polar plots of luminous intensity distribution for the Kensington Avenue luminaires. The maximum for each plot is 18,000 cd. The blue line represents luminous intensity in the vertical plane that includes the maximum value, whereas the red line represents a luminous intensity in a horizontal cone through the vertical angle containing the maximum value. *BUG ratings could not be calculated for the HPS luminaire.

[7] Product type J was a retrofit kit.

Table 10. **Manufacturer reported performance for the products installed along Kensington Avenue.** In order to match the calculated values reported herein, data from IES-format files took precedence over other manufacturer literature.

Site/ID	Input Power (W)	Lamp Output (lm)	Luminaire Efficiency (%)	Luminaire Output (lm)	Luminaire Efficacy (lm/W)	CCT (K)	CRI
150 HPS	173	16,000	73	11,741	67.9	2100	22
G	132	-	-	9,628	73.2	4300	70
H	132	-	-	10,772	81.9	4300	
I	154	-	-	10,396	67.5	4000	70
J	105	-	-	5,781	55.2	4600	82

Evaluation of Delivered Illuminance

Despite all emitting fewer lumens, all four LED products were calculated to provide a higher average initial illuminance for the vehicular travels lanes (see Table 10), although the maintained values may be more similar. For some of the areas, these values were more than four times as high as the AASHTO-recommended level and two times greater than the City of Philadelphia target of 2.0 fc; this margin is unlikely to be completely eliminated over time. In contrast, three of the four LED products provided a lower average initial illuminance for the bicycle lanes, and none matched the performance of the HPS luminaire for the sidewalk. Still, all of the LED products had higher application efficacy and greater delivery efficiency. As previously noted for the other sites, it is possible that different, lower-wattage LED luminaires could be selected to better align illuminance with the recommended values and save energy.

As calculated for initial performance, all three zones met the AASHTO requirement of 1.0 fc and the average to minimum uniformity requirement of 4.0 initially; in fact, no product had a uniformity ratio greater than 1.65. However, it is unlikely that the J-type LED luminaire would meet the AASHTO recommended average illuminance level for the sidewalk over time, which is the intent of the criteria.

Luminaire Reliability

One of the important reasons for choosing Kensington Avenue as a demonstration site was to investigate the possibility that LED luminaires could better withstand the intense vibration. A log of any maintenance issues was kept for several months following installation of the demonstration luminaires. Between December 28, 2011 and April 10, 2012, photocontrol replacements were required 30 times. These replacements occurred for all four luminaire types, but were most common in Area J (20 times). Notably, this area is separated from the other three by a substantial distance; thus, it may experience different vibration.

Despite the issue with the photocontrols, none of the luminaires experienced any damage, an important advantage compared to the HPS luminaires that are typical of Kensington Avenue. However, the period of monitoring was relatively short, especially compared to the rated lifetime of the LED luminaires. Nonetheless, based on anecdotal evidence, some HPS luminaires would have failed within the same timeframe—failure data for the HPS luminaires surrounding the demonstration sites was not recorded. Thus, there is some evidence to support predictions of substantial cost savings due to reduced maintenance on LED luminaires. An extensive study of vibration issues for street lighting—including cost savings and reduced maintenance—is warranted, but is outside the scope of this report.

Table 11. Rated and calculated performance for the luminaires installed along Kensington Avenue. The calculations were based on 55-foot pole spacing.

	Luminaire Type				
	150 HPS	**LED G**	**LED H**	**LED I**	**LED J**
Manufacturer Rated Values					
Input Power (W)	173	132	132	154	105
Output (lm)[1]	11,741	9,628	10,772	10,396	5,781
Luminous Efficacy (lm/W)	68	73	82	68	55
Calculated Average Initial Illuminance (fc)					
Auto Lanes	3.16	3.98	4.39	4.60	3.81
Bicycle Lanes	5.12	5.23	4.17	4.32	4.06
Sidewalks	4.85	4.34	4.15	2.83	1.16
Drive Lane Performance					
Delivered Lumens	3,592	4,524	4,990	5,229	4,331
Delivery Efficiency	15%	23%	23%	25%	37%
Application Efficacy (lm/W)	10.4	17.1	18.9	17.0	20.6
Full Area Performance					
Delivered Lumens	8,342	8,970	8,990	8,403	6,324
Delivery Efficiency	36%	47%	42%	40%	55%
Application Efficacy (lm/W)	24.1	34.0	34.1	27.3	30.1

1. Listed output is for one luminaire. Due to the luminaire configuration on Kensington Avenue, each calculated area receives contributions from the equivalent of two luminaires (i.e., half of each of the four luminaires bounding an area).

4 Subjective Evaluation

A valuable aspect of lighting demonstrations is the subjective evaluation that can be made by human observers. Although numerical metrics and design calculations are invaluable to understanding the performance of a given luminaire, evaluations of real installations often provide critical information, such as general public acceptability, that cannot be obtained in other ways. Demonstrations also serve as important tools for educating the public about alternative street lighting solutions. For this demonstration project, two separate questionnaires were used to collect feedback on the performance of the installed luminaires. One was intended to capture the opinion of local residents or other people who happened to be on the street at the time, referred to as *General Population.* The second was administered during an event where members of the IES or IALD—two prominent organizations in the lighting industry—toured the demonstration sites; these participants are referred to as *Lighting Professionals.*

Questionnaire and On-site Evaluation: General Population

Methodology

During the evening of March 27, 2012, representatives from the Mayor's Office of Transportation and Utilities or the Streets Department canvassed the demonstration sites seeking the opinion of anyone who happened to be in the area. This data was never intended to be scientific in nature and must be analyzed cautiously, but is nonetheless valuable to the City. Data was collected for N 3rd Street and the three southeasterly segments of Kensington Avenue only, due to the lack of foot traffic in the other areas.

Participants were given a single sheet of paper with the questions listed in Appendix E. These notably simple questions did not capture nuanced opinions, but were useful for obtaining feedback from a group unfamiliar with the technical aspects of street lighting. Most importantly, the different LED luminaires were not distinguished to the participants, and the reported responses represent a general comparison of the LED luminaires (collectively) compared to the conventional HPS luminaires used throughout the city. The effects of this simplification are not easily discernible.

Results: N 3rd Street

The questionnaire form was completed by 64 people, with an additional person completing only the first two questions. The age of the respondents was skewed toward the 18-29 age group, and 39 of the respondents identified themselves as male. The sample included 27 people who indicated they either lived or worked on N 3rd Street. Complete histograms of the survey responses are available in Appendix F.

The majority (49 of 65) of respondents felt that the amount of light in the demonstration site was just right, with 58 of 65 respondents indicating agreement or strong agreement with the statement that the lighting made them feel safer in comparison to other nearby streets. Additionally, 56 of 64 respondents indicated that they preferred the color of light emitted by the LED luminaires compared to the typical street lighting in Philadelphia. All except one respondent indicated that the lighting was slightly better or much better than typical Philadelphia street lighting, with a majority of respondents indicating that the amount of light was most influential in the evaluation (as opposed to the color of the light or the comfort of the lighting).

Although these results fail to recognize the differences between the LED luminaires, they do account for the substantial difference in CCT between all of the LED luminaires and the baseline HPS luminaires.

Notably, the mean light level provided by the four demonstration LED luminaires was very similar to the mean light level for the two sections of HPS luminaires that were measured.

Results: Kensington Avenue

The questionnaire form was completed by 38 people, including at least two police officers. The age of the respondents was more balanced than for N 3rd Street, and the gender breakdown more heavily male (23 of 38). The sample included 16 people who indicated they either lived or worked on Kensington Avenue. Complete histograms of the survey responses are available in Appendix F.

Similar to N 3rd Street, 32 of the 38 respondents felt that the amount of light in the demonstration site was just right, and 35 of 38 respondents indicated agreement or strong agreement with the statement that the lighting made them feel safer in comparison to other nearby streets. An overwhelming majority (36 of 38) preferred the color of light emitted by the LED luminaires. All 38 respondents felt the lighting was better than what is typical in Philadelphia, with 36 of the 38 indicating it was much better. There was nearly an even split between those who indicated the comfort of the lighting was the most influential factor (17) versus the amount of light (16), with the color of the lighting (4) receiving less support. One of the police officers indicated that his evaluation was most heavily influenced by the improved ability to see crime in progress.

As with the responses for N 3rd Street, there are notable limitations based on the system that was used to collect feedback. Nonetheless, for both areas the respondents showed indisputable preference for the LED luminaires. Given the strong sentiment that the light level was "just right" on both N 3rd Street and Kensington Avenue—despite substantial differences in measured illuminance—it is possible that the general population (i.e., non-lighting professionals) are less perceptive of differences in illuminance and/or differences between luminaires. However, it is also plausible that the participants had a difficult time answering the question and chose the middle ground. It is also interesting that many respondents indicated that the quantity of light was very influential in their overall performance evaluation.

In general, the general population data can only serve as a broad, uncontrolled comparison between LED luminaires with more neutral CCTs and conventional HPS luminaires. The second, more complex questionnaire intended for lighting professionals is more suitable for comparing the performance of the individual LED luminaires.

Questionnaire and On-site Evaluation: Lighting Professionals

Methodology

In conjunction with the local chapters of the IES and IALD, an event was held on May 30, 2012 that included touring the demonstration sites and evaluating the performance of the LED luminaires. The 26 lighting professionals who participated were divided into three groups, visiting all three of the streets in round robin fashion (i.e., approximately 1/3 of the group was at each of the sites simultaneously, rotating to visit all three). The sky was clear, the temperature was approximately 72 °F, and the pavement was dry. The evaluations began at approximately 8:30 p.m.[8]

After a brief introduction, the participants were each given an instruction sheet and set of 10 questionnaire forms (see Appendix G). The participants walked each site at their own pace, and were asked to provide a "holistic impression of the performance of each luminaire type." Maps were provided to indicate the luminaire type designation, but detailed information about the installed products was

[8] This time is somewhat earlier than nautical twilight, but because the groups evaluated the sites in different sequences, any confounding effect should be counterbalanced. A later start time was logistically not possible.

not provided until all questionnaires were completed. Signs were also used to aid participants in correctly identifying the alphabetical designation for each luminaire on the questionnaire forms.

The questions listed for the lighting professionals were much more nuanced and complex than the questions asked in the prior investigation. With the additional rigor in writing the questions and orchestrating the event, these results are more specific and generally more valuable. Notably, the results are largely consistent with the opinions of the general population observers. Further, in many cases the responses were similar across all ten sites—the baseline HPS luminaires were not evaluated. Histograms of the responses, as well as tables of the mean and mode (most frequent) responses are available in Appendix H.

Of the nine questions presented to the lighting professionals, three had response scales that included two divergent disagree viewpoints (e.g., the light is too warm versus the light is too cool) on a single 0–10 scale. Notably, in all cases a majority of the respondents chose the middle value (agree). In contrast, when questions were asked on a 0–5 scale with a single disagree viewpoint, fewer people chose the endpoint of the scale (agree).

Results: Kelly Drive

Light Level – For both areas, the respondents indicated strong agreement that there was an appropriate amount of light on the street, with more than half of the respondents giving a rating of five (agree). For both areas, twice as many respondents indicated they felt there was too much light (response between six and ten) than not enough light (response between zero and four). With regard to light trespass, the responses trended toward agreement that there was little or no spill light, but the ratings ranged from one to five with no clear predominant response.

Distribution of Light – For both areas, there was a trend toward agreement that the surface was uniform. Additionally, there was a trend toward disagreement with the statement that glare was a problem. There was little distinguishable difference in the ratings for the two areas.

Color Quality – As with most of the areas included in this demonstration, there was a fairly strong trend indicating agreement that the lighting allowed for objects to be easily distinguished (i.e., the CRI was appropriate). For both areas of the Kelly Drive site, over half the participants gave a rating of four or five. With regard to color temperature, again over half of the respondents indicated agreement that the color of the light helped to create a pleasing atmosphere, although more people rated the areas as too cool than as too warm.

Overall Impression – Compared to the typical street lighting in Philadelphia, a majority of respondents indicated that the demonstration luminaires were an improvement. These ratings, which were very similar between the two areas, were the highest of any of the demonstration sites. The quality of the light and the distribution of light were cited most frequently as the most influential factor. Similar results were seen when respondents were asked to provide an overall impression of the lighting without comparing it to the baseline HPS lighting used throughout Philadelphia. The similarity of responses for the two demonstration luminaires installed on Kelly Drive could be expected because the measured and calculated performance was also very similar.

Results: N 3rd Street

Light Level – For all four areas, the respondents indicated agreement that there was an appropriate amount of light on the street, although there was less agreement than at Kelly Drive. For Area C and Area E, more respondents indicated they felt there was too much light (response between six and ten), but for Area D and Area F, more respondents indicated they felt there was not enough light (response between zero and four). The question regarding the quantity of light on the sidewalk revealed similar impressions—for all four areas, the most frequent responses was a five—although only Area E had more responses of too much light than not enough light. There was little consensus with regard to light trespass, although Area E tended to have the most favorable rating.

Distribution of Light – Of the four demonstration areas along N 3rd Street, Area C was rated as displaying substantially better uniformity. The other three areas received notably poor ratings for this criterion. This finding is somewhat peculiar given that Area C did not have better measured or calculated uniformity; in fact, all four areas had reasonably good uniformity. Area C was also rated as the most uncomfortable due to glare within the site, with Area F being rated the most comfortable of any of the 10 demonstration luminaires.

Color Quality – Although the mean responses were similar, Area C and Area D had noticeably more responses indicating that it was difficult to distinguish between objects. Interestingly, the rated CRI for these products was not substantially different than any of the other demonstration luminaires. Like the other demonstration areas, the respondents most frequently indicated agreement (a response of five) with the statement that the light helps to create a pleasing atmosphere, but more respondents indicated that the light was too cool than too warm.

Overall Impression – Compared to the other two sites, the luminaires installed on N 3rd Street generally had lower ratings for overall performance. Although all four areas had slightly higher ratings when compared to the baseline lighting in Philadelphia, luminaire type D had particularly low ratings. As with the other areas, participants provided responses across the range.

Results: Kensington Avenue

Light Level – As with the other demonstration sites, for all four areas the respondents indicated agreement that there was an appropriate amount of light on the street. For Areas G, H, and I, far more respondents indicated they felt there was too much light (response between six and ten), but for Area J more respondents indicated they felt there was not enough light (response between zero and four). This evaluation is consistent with measured illuminance levels, although all areas were measured to exceed the AASHTO criterion. Again, there was high correlation between the question regarding street illumination and sidewalk illumination. There was no clear consensus regarding light trespass for any of the areas.

Distribution of Light – For all four luminaire types, the respondents tended to think the light was evenly distributed across the road surface, with somewhat higher ratings for Area H and Area I. In general, the Kensington Avenue luminaires had the worst ratings for glare; luminaire type G was rated particularly poorly, with half of the participants indicating they needed to squint or shield the light.

Color Quality – All four luminaire types had similar distributions for the responses to the two questions specifically addressing color quality. The responses were similar to those for the other sites, with participants generally indicating that the luminaires made it easy to distinguish between objects and that the color of the light helped to create a pleasing atmosphere (although in all cases more felt the light was too cool than too warm).

Overall Impression – As with the other sites, the luminaires installed along Kensington Avenue fared marginally better when compared to HPS luminaires than just on their own, but in both cases the ratings were just slightly above average. There was not much distinction between the four luminaire types. The respondents most frequently indicated the quantity of light was the most influential factor in their rating, except for Area J, where the distribution of light was the most influential. It was not determined whether these factors were more prevalent for positive or negative ratings.

5 Conclusions

For this demonstration assessment, 10 different LED luminaires were installed at three different sites in Philadelphia, PA. Each of the three sites represented a different set of conditions, most importantly with regard to the incumbent HPS luminaires, which used nominally 100 W, 150 W, and 250 W lamps. Most, but not all, of the LED luminaires had a higher rated luminous efficacy compared to the HPS product they were replacing. All of the LED luminaires had improved color rendering and a higher CCT.

Besides generally matching the delivered illuminance levels of the baseline HPS luminaires, all of the LED luminaires had higher application efficacies than their HPS counterparts; that is, they delivered more lumens to the target areas—roadway and sidewalk—per watt of input power. They also drew between 10% and 40% less power, and generally provided more uniform illumination. Nonetheless, energy cost savings are not currently possible for Philadelphia because they have yet to reach an agreement with the local utility for a new tariff for LED street lighting, a situation that is common throughout the country. A full economic analysis was not conducted for this demonstration because the luminaires were donated.

Energy savings alone are unlikely to result in a reasonable payback period using currently-available products, but additional cost savings from reduced maintenance could make widespread luminaire replacement cost effective. With efficacy improving and prices declining, the payback situation may change in the future. Along Kensington Avenue, some HPS lamps were reportedly failing just months after installation due to extremely high vibration, which was measured at up to 274 mm/s and 25.4 g. None of the LED luminaires failed within the first four months, although numerous photocontrols had to be replaced.

Field illuminance measurements were taken at each site, but the large difference in pole spacing for each area limited the usefulness of that dataset for comparing performance. However, it did reveal differences between measured and calculated illuminance of up to approximately 40%. Similarly, the HPS luminaires were found to be more likely to provide lower illuminance than predicted by calculations, presumably due in part to non-recoverable component degradation. The exact cause of these discrepancies requires further investigation.

Additional calculations were performed using a single representative model of each of the three sites. These calculations indicated that the delivered illuminance was generally similar to the baseline HPS luminaires. In some cases, AASHTO criteria were not met. For example, at Kelly Drive, both demonstration luminaires as well as the HPS luminaire were calculated to exceed the AASHTO limit for the average to minimum illuminance ratio (i.e., they were less uniform than the criterion). Additionally, for the sidewalks along N 3rd Street the average maintained illuminance provided by all four LED products and the HPS baseline was calculated to be less than the AASHTO minimum. One of the LED luminaires installed along Kensington Avenue also failed to meet the same criterion.

Notably, the City of Philadelphia has its own 2.0 fc criterion for average maintained illuminance, on roadways only. As calculated, that level was reached by the luminaires installed along Kensington Avenue, but not by any of the other luminaires, LED or HPS. The 2.0 fc requirement may also have some effect on the higher-than-normal initial illuminance levels both calculated and measured during the assessment. For example, the LED luminaires installed along Kensington Avenue were calculated as delivering between 3.81 and 4.60 fc—the HPS luminaire was calculated to deliver 3.16 fc initially. Although the higher light levels have precedence in Philadelphia, better aligning with AASHTO or IES recommendations during the changeover to LED streetlights could provide additional energy and cost savings.

Two sets of subjective evaluations were collected: one included local residents and passersby, whereas the other was completed by lighting professionals. In general, there were only small deviations between the luminaires, and it would be difficult to select any products that were clearly superior to the others in the same category. Nonetheless, both groups generally viewed the lighting favorably, especially compared to the typical HPS luminaires used in Philadelphia.

6 References

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2. IES. 2000 (reaffirmed 2005). IESNA Roadway Lighting Committee, Standard Practice Subcommittee. ANSI / IESNA RP-8-00, American National Standard Practice for Roadway Lighting. Illuminating Engineering Society of North America. New York, NY.

3. ANSI. 2010. ANSI C136.31-2010, American National Standard for Roadway and Area Lighting Equipment—Luminaire Vibration. National Electrical Manufacturers Association. Rosslyn, VA.

4. State of California—Business, Transportation and Housing Agency. 1998. California Test 611. Method of test for testing durability of mast arm-mounted luminaires. Accessed June 14, 2012. Available at: http://www.dot.ca.gov/hq/esc/ctms/pdf/CT_611.pdf

Appendix A: Product Specification Sheets

Specification sheets for the luminaires listed in Table A1 are included subsequently. The specification sheets are not marked with the specific model numbers.

Table A1. Luminaire types.

Area/ID	Source	Manufacturer	Product Family	Model Number
250 HPS	HPS	GE	M-400A Powr/Door	MDCL-40-S-3-H-2-2-G-MC3
A	LED	Philips Lumec	RoadView	RVM-270W160LED4K-LE3-240-RC-BR
B	LED	BetaLED	LEDway	STR-LWY-2S-HT-12-D-UL-SV-700-43K-R
100 HPS	HPS	GE	M-250A2 Powr/Door	M2AR-10-S-1-H-2-A-MS2
C	LED	Acuity American Electric	Autobahn	ATB1-60LED-E53-MVOLT-R2-DE
D	LED	LED Roadway Lighting	Satellite	S72M-0-R-AL-2-NN-G3-GBQ-B1H-LF
E	LED	Lighting Science Group	Prolific Roadway	LSR3-CW-R2-MVOLT-2B-PCR-SH-GR
F	LED	Philips Hadco	LEDGINE	RX140-I-2-N-A-M-R-N-S-N
150 HPS	HPS	GE	M-250A2 Powr/Door	M2AR-15-S-1-H-2-A-MS2
G	LED	BetaLED	LEDway	STR-LWY-2M-HT-06-D-UL-SV-700-43K-R
H	LED	Leotek	Green Cobra	GC1-80E-MV-NW-3-GY
I	LED	Cooper Streetworks	OVF LED	OVF-C06-LED-EU-5XQ
J	LED	EcoFit	LED Light Engine	D-5-240-525-63-4600

M-400A POWR/DOOR® LUMINAIRE WITH CUTOFF OPTICS

250 HPS

APPLICATIONS

- For street, highway and parking lot lighting

SPECIFICATION FEATURES

- Powr/Module ballast assembly
- Filtered optics
- Universal two or four-bolt slipfitter
- Standardized reflector
- "Dead back" tunnel type, FRP terminal board
- 2 in. pipe mounting only with MDCA
- Die-cast aluminum housing with polyester powder gray paint finish
- Adjustable mogul base socket (house side) – E39 standard
- ALGLAS® finish on reflector
- No-tool PE receptacle
- Plug-in ignitor available
- External paddle type stainless steel bail latch
- UL/cUL listed unit available—See Options
- True 90° cutoff—no light above 90° (meets RP8-2000 for full cutoff) with flat glass

ORDERING NUMBER LOGIC

MDCL	40	S	1	A	2	1	F	MC3	1	F
PRODUCT IDENT	WATTAGE	LIGHT SOURCE	VOLTAGE	BALLAST TYPE	PE FUNCTION	IGNITOR MOUNTING	LENS TYPE	IES DISTRIBUTION TYPE	FILTER	OPTIONS
XXXX	XX	X	X	X	X	X	X	XXX	X	XXX
MDCA = M-400A with Cutoff ★ Optics 4-Bolt Slipfitter MDCL = M-400A with Cutoff ★ Optics 2-Bolt Slipfitter ★ = Previously IESNA Full Cutoff Optics	10 = 100 15 = 150 (55V) 17 = 175 20 = 200 24 = 250/400 25 = 250 31 = 310 32 = 320 35 = 350 40 = 400 NOTE: Dual wattage connected for lower wattage only	E = Energy Act Compliant Pulse MH (EPMH) S = HPS P = PMH Standard: Lamp not included.	60Hz 0 = 120/208/240/277 Multivolt 1 = 120 2 = 208 3 = 240 4 = 277 5 = 480 7 = 120X240 8 = 240V Ballast 120V PE Receptacle not reconnectable D = 347 F = 120X347 T = 220 W = 230 50Hz 6 = 220 R = 230 Y = 240 NOTE: Dual voltage connected for lower voltage	See Ballast Selection Table A = Autoreg H = HPF Reactor or Lag M = Mag-reg N = NPF Reactor or Lag P = CWI with Grounded Socket Shell	1 = None 2 = PE Receptacle NOTE: Receptacle connected same voltage as unit except as noted. Order PE Control separately.	1 = Non Plug-in/None 2 = Plug-in base and Ignitor	A = Acrylic Clear Globe (250 watt Maximum) F = Flat Glass ★ G = Shallow Glass Globe L = Polycarbonate Clear Globe (250 watt) HPS only ★ = Previously IESNA Full Cutoff Optics	See Photometric Selection Table S = Short M = Medium C = Cutoff ★ 1 = Type I 2 = Type II 3 = Type III ★ = Previously IESNA Full Cutoff Optics	1 = Fiber gasket 2 = Charcoal with elastomer gasket	F = Fusing (Not available with multivolt or dual voltage) J = Line Surge Protector, Expulsion Type N = Meets ANSI C136.31 requirments for Bridge and Underpass Vibration U = UL Listed Glass Lens and (60Hz only)

R

ROADWAY LIGHTING

PHOTOMETRIC SELECTION TABLE

CLEAR REFRACTORS All light sources are clear.

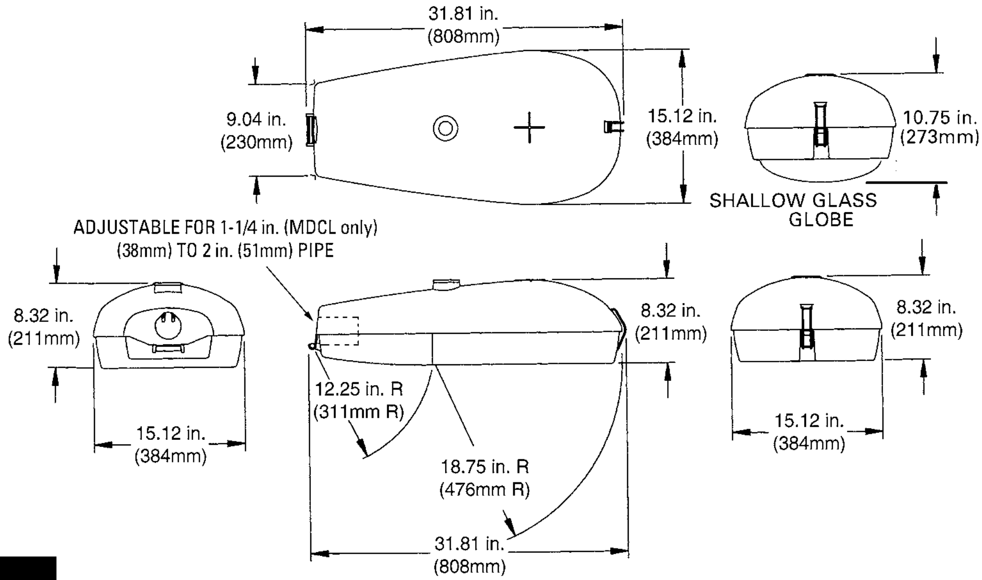
Wattage	Light Source	IES Distribution Type Photometric Curve Number 35–45xxxx							
		Flat Glass "F"		SAG Glass Globe "G"					Polycarbonate
		MC2	MC3	MC1	SC2	SC3	MC2	MC3	
150 (55V)	HPS	0386	0387	N/A	N/A	N/A	0547	0546	C/F
200-400	HPS	1001	1002	N/A	0101	0102	1003	1004	1045** (MC3)
175, 250, 320,	EPMH	0343	0342	N/A	N/A	N/A	0544	0545	C/F
350, 400	EPMH	*452880	*452882	0281	N/A	N/A	0280	N/A	N/A

NOTE: N/A = Not Available C/F = Contact Factory
PMH—Contact Factory
*Requires the use of ED-28 Lamp
**250 watts maximum

M-400A POWR/DOOR® LUMINAIRE WITH CUTOFF OPTICS & 4 BOLT SLIPFITTER

250 HPS

FIXTURE DIMENSIONS



DATA

Approximate Net Weight	33-39 lbs	15-19 kgs
Effective Projected Area	1.1 sq. ft. max	.01 sq. M max
Suggested Mounting Height	30-50 ft.	9-15 M

REFERENCES

See Page R-48 for start of Accessories.
See Page R-52 for Explanation of Options and Other Terms Used.
See Pole and Bracket Section Page P-2 for pole selection.

BALLAST SELECTION TABLE

Wattage	Light Source	Multi-volt	Ballast Type/Voltage 60Hz 120	208	240	277	480	120X 240	347, 120X347	240/120 PE R	220	230	50Hz 220	230	240
150 (55V)	HPS	H,N,A	G,H,M,N	G,M	G,M	G,M	G,M	G,H,M,N	G*,H,M*,N	G,M	N/A	N/A	N/A	N/A	N/A
200	HPS	A,M,P	A,G,H,M,N,P	A,G,H,M,N,P	A,G,H,M,N,P	A,G,M,P	A,G,M	A,G,M,P	N/A	A,G,H,M,N	N/A	H	N/A	N/A	N/A
250	HPS	A,M,P	A,G,H,M,N,P	A,G,H,M,N,P	A,G,H,M,N,P	A,G,M,P	A,G,M,P	A,G,M,P	A,M,P	A,G,H,M,N	A,H	H	A,H,M,N	H	M
250/400	HPS	A	A	A	A	A	A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
310	HPS	A,M	A,G,M	A,G,H,M,N	A,G,H,M,N	A,G,M	A,G,M	A,G,M	N/A	A,G,H,M,N	N/A	H	N/A	N/A	N/A
400	HPS	A,M	A,G,M	A,G,H,M,N	A,G,H,M,N	A,G,M	A,G,M	A,G,M	A,G,M	A,G,H,M,N	H,A,N	H	A,H,M,N	N/A	A,H,M
175	EPMH	A	A	A	A	A	A	A	N/A	A	N/A	N/A	N/A	N/A	N/A
250	EPMH	A	A	A	A	A	A	A	N/A	A	N/A	N/A	N/A	N/A	N/A
320	EPMH	A	A	A	A	A	N/A	A	N/A	A	N/A	N/A	N/A	N/A	N/A
350	EPMH	A	A	A	A	A	N/A	A	N/A	A	N/A	N/A	N/A	N/A	N/A
400	EPMH	A	A	A	A	A	A	A	N/A	A	N/A	N/A	N/A	N/A	N/A

NOTE: N/A = Not Available
*Not available in 120X347 volt
C/F = Contact factory

MDCA SUGGESTED CATALOG ORDERING NUMBERS

Catalog Number	Wattage	Light Source	Voltage (60 Hz)	Ballast Type	Refractor Type	Photometric Distribution
MDCA25S0A22FMC21	250	HPS	Multivolt	Auto-Regulator	Glass	MC2
MDCA40S0A22FMC31	400	HPS	Multivolt	Auto-Regulator	Glass	MC3

All GE suggested catalog ordering numbers come with PE receptacle. PE control must be ordered separately. Order and install SCCL-PECTL if no PE is desired.

Multivolt ballasts can be for either 120, 208, 240, or 277 volt incoming power supply.

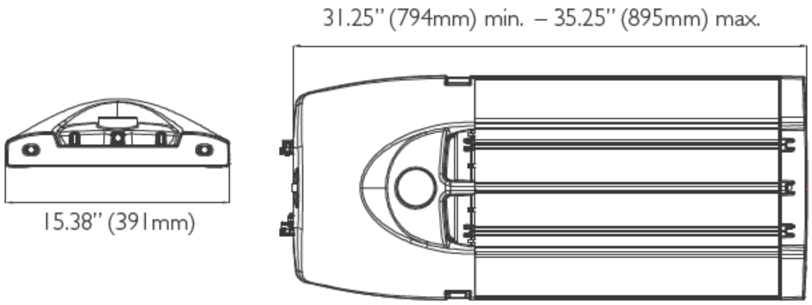
Print Form

Project name		Type	A
Date		Prepared by	

RVM					
Luminaire	Lamp	Optical system	Voltage	Options	Finish

RoadView series

RVM



RVM
Weight: 34 to 37 lbs
(15.4 to 16.8 kg)

Lamps

LUMINAIRE PERFORMANCE DATA (Nominal 4100K CCT)							Weight		Length		EPA	
	Lamp	LEDs	Drive Current	Luminaire Lumens*	System Watts	Max. system current (amps)	lb.	kg.	in.	mm.	sq. ft.	sq. m.
☐	110W96LED4K	96	350	8796	118	1.08	34	15.4	31.25	794	0.71	0.066
☐	130W96LED4K	96	400	9822	138	1.26	34	15.4	31.25	794	0.71	0.066
☐	160W96LED4K	96	530	12042	180	1.63	34	15.4	31.25	794	0.71	0.066
☐	215W96LED4K	96	700	14330	235	2.16	34	15.4	31.25	794	0.71	0.066
☐	125W112LED4K	112	350	10262	138	1.26	34	15.4	31.25	794	0.71	0.066
☐	150W112LED4K	112	400	11459	162	1.47	34	15.4	31.25	794	0.71	0.066
☐	190W112LED4K	112	530	14049	208	1.90	34	15.4	31.25	794	0.71	0.066
☐	145W128LED4K	128	350	11728	158	1.44	34	15.4	31.25	794	0.71	0.066
☐	170W128LED4K	128	400	13096	188	1.73	34	15.4	31.25	794	0.71	0.066
☐	215W128LED4K	128	530	16056	240	2.18	34	15.4	31.25	794	0.71	0.066
☐	160W144LED4K	144	350	13194	178	1.62	37	16.8	35.25	895	0.78	0.072
☐	190W144LED4K	144	400	14733	208	1.89	37	16.8	35.25	895	0.78	0.072
☐	245W144LED4K	144	530	18063	270	2.45	37	16.8	35.25	895	0.78	0.072
☐	180W160LED4K	160	350	14660	198	1.80	37	16.8	35.25	895	0.78	0.072
☐	210W160LED4K	160	400	16370	230	2.10	37	16.8	35.25	895	0.78	0.072
☐	270W160LED4K	160	530	20775	300	2.72	37	16.8	35.25	895	0.78	0.072

**For Type II distribution. To be verified with final photometric tests.*

PHILIPS

Optical systems / LED

- ☐ **LE2** TYPE II / Asymmetrical distribution
- ☐ **LE3** TYPE III / Asymmetrical distribution
- ☐ **LE4** TYPE IV / Asymmetrical distribution

Voltage

☐120 ☐208 ☐240 ☐277 ☐347 ☐480

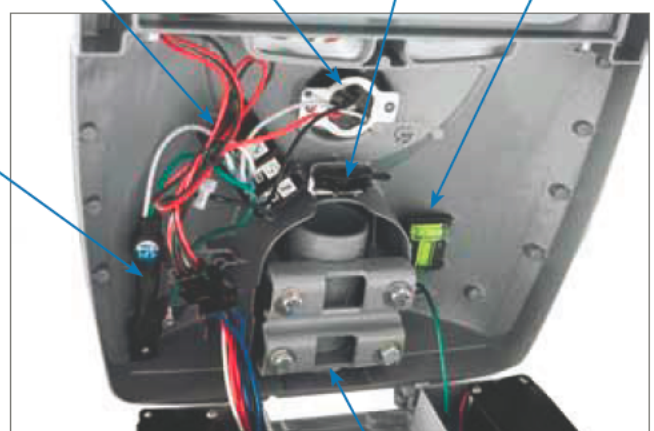
A

Driver options**

- ☐ **AST** Driver pre-programmed with progressive lamp starting*
- ☐ **CDMG** Dynadimmer standard dimming program*
- ☐ **CDMGP** Dynadimmer custom dimming program*
- ☐ **CLO** Constant Light Output, driver pre-programmed to achieve the same light intensity for the duration of the lifespan of the lamp*
- ☐ **DALI** Driver compatible with DALI control systems*
- ☐ **DMG** Dimmable driver 0-10 volt
- ☐ **OTL** Over The Life, driver pre-programmed to signal the end of lamp life*
- ☐ **OVR** Dynadimmer override function for use with motion detector or other switching device

*Only available with 120 - 277 volts.

** For all programmable options please consult the factory for details



Luminaire options

- ☐ **BDG** Bird guard insert for 1.66" and 1.9" O.D. tenon
- ☐ **BL** Bubble level
- ☐ **OSL3W** Motion detector (requires DMG or CDMG)
- ☐ **PH8** Photoelectric cell, twistlock type includes receptacle
- ☐ **PH9** Shorting cap for single phase (120, 240, 277, 347v) with receptacle
- ☐ **RC** Receptacle, with tool-less orientation, for a twist-lock photocell or shorting cap
- ☐ **SR** Strain relief

Specifications subject to change without notice.
Consult factory for full details.

Finish options

☐ **GY3**	Gray	☐ **BR**	Bronze
☐ **WH**	White	☐ **BK**	Black

- ☐ **EXP** Extrusion painted to match cast housing color selected above (standard extrusion color is anodized aluminum).

Additional colors are available. Consult factory for complete specifications.

LEDGINE

PHILIPS

Lamp

Composed of high performance white LEDs. Color temperature of 4100 Kelvin +/- 300 nominal, 70 CRI. Ambient operating temperature range -40C (-40F) to +40C (104F). L70 lifetime of 100000 hours minimum at 25C ambient (75000 hours for 700 mA models with more than 48 LEDs).

Optical system

Composed of high performance lenses, protected by a flat tempered glass lens. System is rated IP66. Photometric performance is tested according to IES LM-79.

Surge protector

Surge protective device provides single phase protection for line-ground, line-neutral, and neutral-ground in accordance with IEEE / ANSI C62.41.2 guidelines. Surge rating 10 kV, 10 kA.

Driver

Electronic driver, operating range 50-60 Hz. Auto-adjusting to input voltage between 120-277 volt AC (+/- 10%), or 347-480 volt AC. Minimum power factor 0.90, max THD 20%. UL recognized component. IP66 rated. Optional dimming (0-10v) and digital driver features available.

Housing

The upper and lower parts of the housing are made of die cast A360 aluminum alloy. The 4-bolt mounting system includes a reversible bracket made of zinc plated steel. Fits on a 1.66" to 2 3/8" OD by 5" long tenon, fixed by 3/8-16 UNC steel zinc plated bolts. An integral part of the housing permits an adjustment of +/- 5° by steps of 2.5°.

Power door

The housing is complete with a tool-less removable power door including quick disconnects for ease of service. A tool free latch assembly on the power door allows for easy access to the electrical compartment.

Heat sink

The extruded heat sink is made of A6063 aluminum alloy, and is shaped to draw heat away from the LEDs. Product does not use any cooling device with moving parts (has passive cooling device).

LED platform

The LEDGINE LED platform consist of two LED boards with 48, 64, or 80 LUXEON Rebel LEDs each, as required to provide total LEDs from 96 - 160. The LED boards are removable and replaceable.

Wiring

Luminaire wiring is done using a terminal block located inside the housing. Terminal block accepts three wires (#2-14 AWG).

Hardware and seals

All exposed screws shall be stainless steel. All seals and sealing devices are made and/or lined with silicone.

Finish

Application of a polyester powder coat paint. (4 mils/100 microns). The chemical composition provides a highly durable UV and salt spray resistant finish in accordance with the ASTM-B117 standard and humidity proof in accordance with the ASTM-D2247 standard. The specially formulated Lumital powder coat finish is available in standard gray. Additional colors are available. Consult factory for complete specifications.

Vibration resistance

Meets the ANSI C136.31-2001 table 2, American National Standard for Roadway Luminaire Vibration specifications for Bridge/overpass applications (3G).

Certifications and Compliance

CSA, UL or CUL. ISO 9001-2008. All electrical components are RoHS compliant.

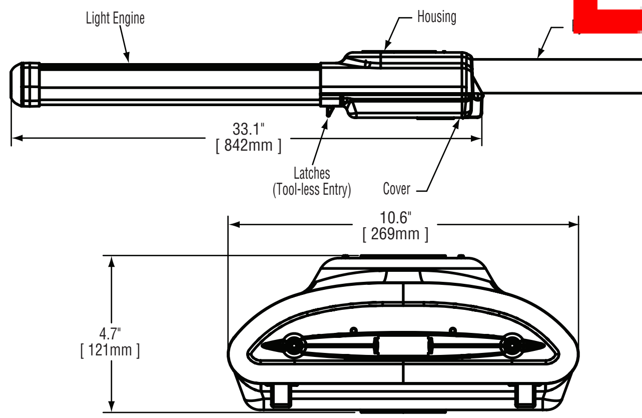
Document order number: RVMTS100R01

Philips Roadway Lighting
10275 W. Higgins Road
Rosemont IL 60018
Tel: 847-390-5111 Fax: 847-332-0305
Customer Support/Technical Service: 847-390-5111
www.philips.com/roadwaylighting
A Division of Genlyte Thomas Group LLC

STR-LWY-2S-HT LEDway® Streetlight – Type II Short

Re[...]/19/11 B

BetaLED Catalog #: STR - LWY - 2S - HT - - D - - - -



Notes:

Product	Family	Optic	Mounting	# of LEDs (x 10)	LED Series	Voltage	Color Options	Drive Current	Factory-Installed Options
									Please type additional options in manually on the lines provided above.
STR	**LWY**	**2S**[1]	**HT**[2]	☐ **10** ☐ **11** ☐ **12**	**D**	☐ **UL** Universal 120–277V ☐ **UH** Universal 347–480V	☐ **SV** Silver[3] ☐ **BK** Black[3] ☐ **BZ** Bronze[3] ☐ **PB** Platinum Bronze[3] ☐ **WH** White[3]	☐ **700** 700mA (Standard) ☐ **525** 525mA ☐ **350** 350mA	☐ **43K** 4300K Color Temperature[4] ☐ **DIM** 0–10V Dimming [5,6,7] ☐ **F** Fuse[8,9] ☐ **HL** Hi/Low (175/350/525, dual circuit input)[10,11] ☐ **N** No Quick Disconnect Harness or Leveling Bubble[12] ☐ **PD** Power Door[13] ☐ **R** NEMA Photocell Receptacle[8] ☐ **SC** Door Safety Tether[14] ☐ **UTL** Utility Option[15]

For additional options, see IP66 spec sheet.

Footnotes

1. IESNA Type II Short distribution
2. Horizontal tenon mount
3. Light engine portion of extrusion is not painted and will remain natural aluminum regardless of color selection
4. Color temperature per fixture; minimum 70 CRI
5. Control by others
6. Refer to dimming spec sheet for availability and additional information
7. Can't exceed the specified drive current. Consult factory if exceeding the drive current is necessary.
8. This option not available with all multi-level options. Refer to multi-level spec sheet for more information
9. When code dictates fusing use time delay fuse
10. Refer to multi level spec sheet for availability and additional information
11. Sensor not included
12. Standard product features unless N option is specified
13. All connections between door and fixture are shipped unconnected from the factory; door release spring included to open door automatically when the latches are released
14. Stainless steel aircraft cable
15. Includes exterior wattage label that reflects watts for the drive current selected. The ability to exceed the selected drive current will be disabled.

LED PERFORMANCE SPECS

# of LEDs	Initial Delivered Lumens – Type II Short @ 6000K	B	U	G	Initial Delivered Lumens – Type II Short @ 4300K	B	U	G	System Watts 120–277V	Total Current @ 120V	Total Current @ 240V	Total Current @ 277V	System Watts 347–480V*	Total Current @ 347V	Total Current @ 480V	L_{70} Hours** @ 25° C (77° F)	50K Hours Lumen Maintenance Factor** @ 15° C (59° F)
		Rating***				Rating***											
350mA Fixture Operating at 25° C (77° F)																	
100	10,283 (10)	3	1	3	9,477 (10)	2	1	2	117	0.97	0.52	0.46	125	0.36	0.27	> 150,000	94%
110	11,244 (11)	3	1	3	10,363 (11)	3	1	3	129	1.08	0.58	0.51	139	0.39	0.30	> 150,000	
120	12,179 (12)	3	1	3	11,224 (12)	3	1	3	140	1.17	0.62	0.55	150	0.43	0.33	> 150,000	
525mA Fixture Operating at 25° C (77° F)																	
100	14,396 (10)	3	2	3	13,268 (10)	3	2	3	168	1.42	0.74	0.65	179	0.52	0.38	139,000	93%
110	15,742 (11)	3	2	3	14,509 (11)	3	2	3	188	1.58	0.83	0.71	198	0.57	0.42	137,000	
120	17,050 (12)	3	2	3	15,714 (12)	3	2	3	202	1.70	0.89	0.76	214	0.62	0.45	133,000	
700mA (Standard) Fixture Operating at 25° C (77° F)																	
100	17,995 (10)	3	2	3	16,585 (10)	3	2	3	231	1.96	1.02	0.86	243	0.71	0.51	116,000	91%
110	19,678 (11)	3	2	3	18,136 (11)	3	2	3	254	2.16	1.12	0.94	267	0.78	0.56	113,000	
120	21,313 (12)	3	2	3	19,643 (12)	3	2	3	272	2.31	1.26	1.01	286	0.84	0.60	108,000	

* Utilizes magnetic step-down transformer

** For recommended lumen maintenance data see TD-13

*** For more information on the IES BUG (Backlight-Uplight-Glare) Rating visit www.iesna.org/PDF/Erratas/TM-15-07BugRatingsAddendum.pdf

NOTE: All data subject to change without notice.

 • 1200 92nd Street • Sturtevant, WI 53177 • 800-236-6800 • www.betaLED.com

Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

General Description

Fixture housing is all aluminum construction. Standard fixture utilizes terminal block for power input suitable for #2–#14 AWG wire and operates at 700mA. Drive current is field switchable. Fixture is designed to mount on 1.25" IP (1.66 s" O.D.) and/or 2" IP (2.375" O.D.) horizontal tenon (minimum 8" [203.2mm] in length) and is adjustable +/- 5º to allow for fixture leveling (includes leveling bubble to aid in this process). Fixture carries a limited five year warranty.

Electrical

Modular design accommodates varied lighting output from high power, white, 6000K (+/- 500K per full fixture), minimum 70 CRI, long life LED sources. Optional 4300K (+/- 300K per full fixture) also available. 120–277V 50/60 Hz, Class 1 LED drivers are standard. 347–480V 50/60 Hz option is available. LED drivers have power factor >90% and THD <20% at full load. Units provided with integral 10kV surge suppression protection standard. Quick disconnect harness suitable for mate and break under load provided on power feed to driver for ease of maintenance. Surge protection tested in accordance with IEEE/ANSI C62.41.2.

Finish

Exclusive Colorfast DeltaGuard® finish features an E-Coat epoxy primer with an ultra-durable silver powder topcoat, providing excellent resistance to corrosion, ultraviolet degradation and abrasion. Bronze, black, white and platinum bronze powder topcoats are also available. The finish is covered by our 10 year limited warranty.

Fixture and finish are endurance tested to withstand 5,000 hours of elevated ambient salt fog conditions as defined in ASTM Standard B 117.

Testing & Compliance

UL listed in the U.S. and Canada for wet locations. Consult factory for CE Certified products. Meets CALTrans 611 Vibration Testing and GR-63-CORE Section 4.4.1/5.4.2 Earthquake Zone 4. Certified to ANSI C136.31-2001 bridge and overpass vibration standards. Dark Sky Friendly. IDA Approved.

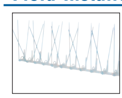
RoHS Compliant.

Product qualified on the Design Lights Products ("DLC") Qualified Products List ("QPL")

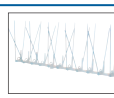
Patents

U.S. and international patents granted and pending. BetaLED is a division of Ruud Lighting, Inc. For a listing of Ruud Lighting, Inc. patents, visit www.uspto.gov.

Field-Installed Accessories

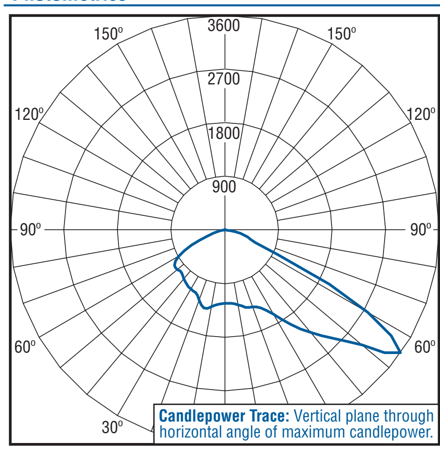


Bird Spikes for Light Engine
XA-BRDSPK120

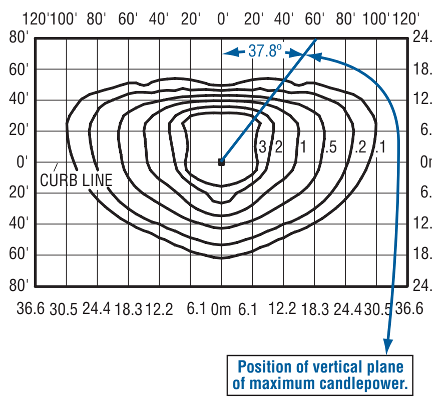


Bird Spikes Kit for Housing
XA-BRDSPKHSG

Photometrics



Independent Testing Laboratories certified test. Report No. ITL64016. Candlepower trace of 6000K, 40 LED LEDway Streetlight luminaire with IESNA Type II Short distribution. Luminaire with 7,108 initial delivered lumens operating at 700mA. **All published luminaire photometric testing performed to IESNA LM-79-08 standards.**



Isofootcandle plot of 6000K, 120 LED LEDway Streetlight luminaire with IESNA Type II Short distribution mounted at 25' A.F.G. Luminaire with 21,313 initial delivered lumens operating at 700mA. Initial FC at grade.

LEDway® EPA & Weight Calculations

Approximate Weight 120–277V*		
100–120 LED fixture		24.0 lbs.
EPA		
Horizontal Tenon Mount		
1 fixture		0.820
EPA		
Round External Mount / Square Internal Mount Horizontal Tenons with Fixture(s)		
PT/PD-1H	Single	1.040
PT/PD-2H(90)	90º Twin	1.379
PT/PD-2H(180)	180º Twin	1.860
PT/PD-3H(90)	90º Triple	2.044
PT/PD-3H(120)	120º Triple	1.824
PT/PD-4H(90)	90º Quad	2.448

* Add 5 lbs. for transformer in 347–480V

NOTE: All data subject to change without notice.

Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

M-250A2 POWR/DOOR® LUMINAIRE

100 HPS

APPLICATIONS
- For residential streets, parking lots and roadways

SPECIFICATION FEATURES

- Powr/Module ballast assembly
- Filtered optics
- Universal two-bolt slipfitter
- Die-cast aluminum housing with polyester powder gray paint finish
- Street Side Adjustable E39 mogul base socket standard where lamp is available in mogul base (E26 Medium base otherwise)
- ALGLAS® finish on reflector
- No-tool PE receptacle
- Plug-in ignitor
- External stainless steel bail latch
- Plastic Pest guard standard (not required for 2 in. pipe)
- UL/cUL listed for wet location available as an option

ORDERING NUMBER LOGIC

M2AR	15	S	1	N	2	G	MS2	1	F
PRODUCT IDENT	WATTAGE	LIGHT SOURCE	VOLTAGE	BALLAST TYPE	PE FUNCTION	LENS TYPE (PRISMATIC) REFRACTOR	IES DISTRIBUTION TYPE	FILTER	OPTIONS
XXXX	XX	X	X	X	X	X	XXX	X	
M2AR = M-250A2	05 = 50 07 = 70 10 = 100 15 = 150 (55 V) 17 = 175 20 = 200 25 = 250	E = Energy Act Compliant Pulse MH (EPMH) S = HPS P = PMH Standard: Lamp not included.	60Hz 0 = 120/208/240/277 Multivolt 1 = 120 2 = 208 3 = 240 4 = 277 5 = 480 7 = 120X240 8 = 240V Ballast 120V PE Receptacle not recon-nectable D = 347 F = 120X347 T = 220 50Hz 6 = 220 R = 230 Y = 240 NOTE: Dual voltage connected for lower voltage	See Ballast Selection Table A = Autoreg G = Mag-Reg with Grounded Socket Shell H = HPF Reactor or Lag M = Mag-Reg N = NPF Reactor or Lag P = CWI with Grounded Socket Shell S = Series (in Top Housing)	1 = None 2 = PE Receptacle NOTE: Receptacle connected same voltage as unit except as noted. Order PE Control separately.	See Photometric Selection Table A = Acrylic G = Glass L = Polycarbonate NOTE: 150 watt Maximum with Acrylic or Polycarbonate Refractors.	See Photometric Selection Table M = Medium L = Long F = Four-(Way) S = Semi-cutoff N = Non-cutoff W = (Four)-Way 2 = Type II 3 = Type III 4 = Type IV	1 = Fiber gasket 2 = Char-coal with elasto-mer gasket	F = Fusing (Not available with multivolt or dual voltage) J = Line Surge Protector, Expulsion Type U = UL/cUL listed (all HPS up to 175W MH max) with glass or polycar-bonate refractor (60Hz only)

R

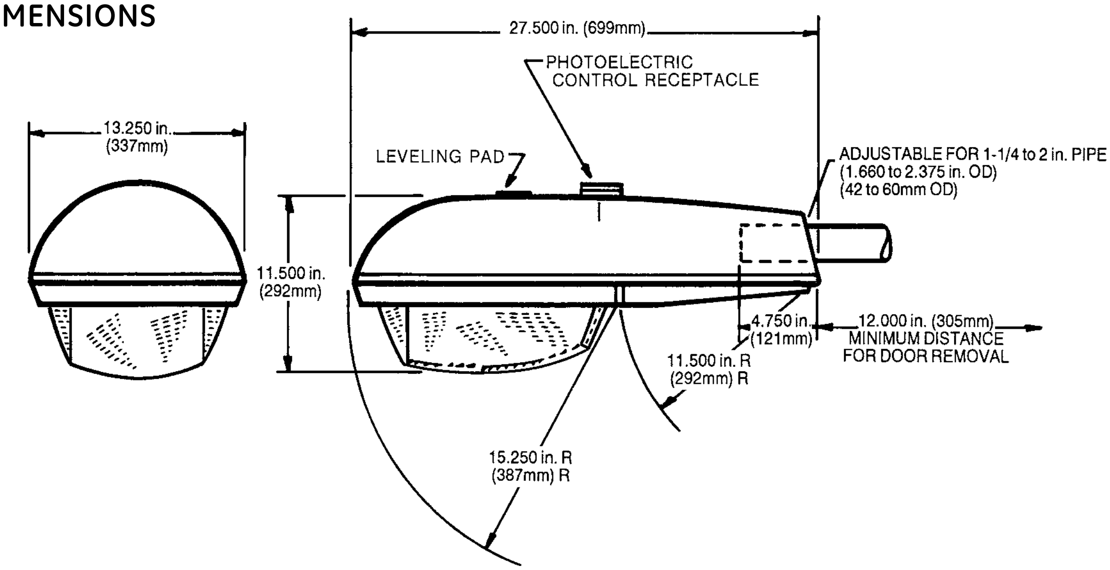
ROADWAY LIGHTING

PHOTOMETRIC SELECTION TABLE

Wattage	Light Source	Lens Type (Prismatic Refractor)	IES Distribution Type Photometric Curve Number 35-17---- (Socket Position) All light sources are clear unless otherwise indicated LN3	LN4	MN2	MN3	MS2	MS3	FW3
50, 70,100, 150 (55 V)	HPS	Acrylic	N/A	N/A	7232(1A)	7233(2A)	7230 (2B)	7231(2.5B)	N/A
50, 70,100, 150 (55 V)	HPS	Glass	N/A	N/A	7236(1A)	7237(2A)	7234(1.5B)	7235(2.5B)	7268(1A)
50, 70,100, 150 (55 V)	HPS	Polycarb.	7254(1A)	7255(2A)	N/A	7252(2B)	7311	N/A	N/A
200, 250,	HPS	Glass	N/A	N/A	N/A	N/A	7263(2DH)	7262(1DH)	N/A
175, 250	EPMH	Glass	N/A	N/A	7283(1A)	7275(2A)	7276(1B)	7277(2B)	7270(1A)
100, 150	PMH	Glass	N/A	N/A	451483(2A)	N/A	N/A	N/A	N/A

NOTE: N/A = Not Available
PMH—Contact Factory

FIXTURE DIMENSIONS



DATA

Approximate Net Weight	20-30 lbs	9-14 kgs
Effective Projected Area	0.7 sq. ft. max	0.07 sq. M max
Suggested Mounting Height	20-40 ft.	6-12 M

REFERENCES

See Page R-48 for start of Accessories.
See Page R-52 for Explanation of Options and Other Terms Used.
See Pole and Bracket Section Page P-2 for pole selection.

BALLAST SELECTION TABLE

		Ballast Type/Voltage												
		60Hz										50Hz		
Wattage	Light Source	Multi-volt	120	208	240	277	480	120X240	347, 120X347	240/120 PE R	220	220	230	240
50	HPS	H,N	H,N	H,N	H,N	H,N	H,N	H,N	H,N	H,N	N/A	N/A	N/A	N/A
70,100,150 (55V)	HPS	A,H,N	A,G,H,M,N,P	A,G,H,M,N	A,G,H,M,N,P	G,H,M,N	G,M	G,M,P	G*,H,M*,N	G,M,N	N/A	H,M,N	H	M††
100/150 (55V)	HPS	N/A	H, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200	HPS	A,P	A,H,N,P	A,H,N,P	A,H,N,P	A,P	A	A,P	P	A,H,N	N/A	N/A	N/A	N/A
250	HPS	A,P	A,H,N,P	A,H,N,P	A,H,N,P	A,P	A,P	A,P	A,P	A,H,N	H	A,H,N	H	A,H
175	EPMH	A	A	A	A	A	A	A	A	A	N/A	N/A	N/A	N/A
**100	PMH	H, N	H, N	H, N	H, N	H, N	H, N	H, N	H, N	H, N	N/A	N/A	N/A	N/A
**150	PMH	N/A	H	H	H	H	N/A	H	H	H	N/A	N/A	N/A	N/A
250	EPMH	A	A	A	A	A	A	A	N/A	A	N/A	N/A	N/A	N/A

NOTE: N/A = Not Available
† Not available in 175W
††150(55V) only
*Not available in 120X347V
C/F = Contact factory
**Medium Base Socket

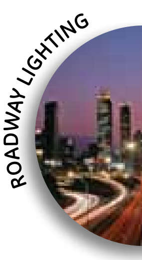
M2AR SUGGESTED CATALOG ORDERING NUMBERS

Catalog Number	Wattage	Light Source	Voltage (60 Hz)	Ballast Type	Refractor Type	Photometric Distribution
M2AR10S1N2AMS21	100	HPS	120	NPF Reactor	Acrylic	MS2
M2AR15S1N2AMS31	150	HPS	120	NPF Reactor	Acrylic	MS3
M2AR25S0A2GMS31	250	HPS	Multivolt	Auto-Regulator	Glass	MS3

All GE suggested catalog ordering numbers come with PE receptacle. PE control must be ordered separately. Order and install SCCL-PECTL if no PE is desired.

Multivolt ballasts can be for either 120, 208, 240, or 277 volt incoming power supply.

R



NIGHTTIME FRIENDLY™

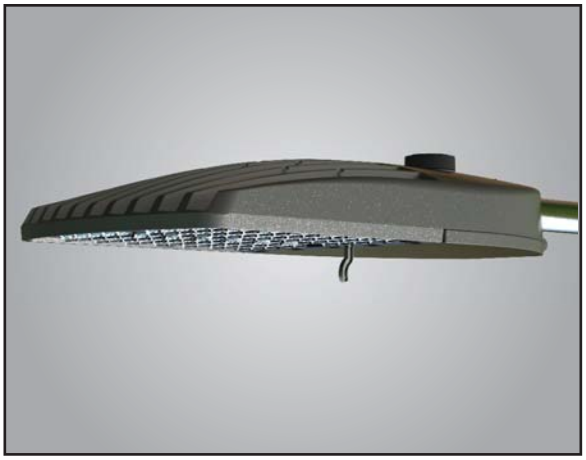
Consistent with LEED® goals
& Green Globes™ criteria
for light pollution reduction

Autobahn *Series ATB1*

Roadway Lighting

70-200W LED

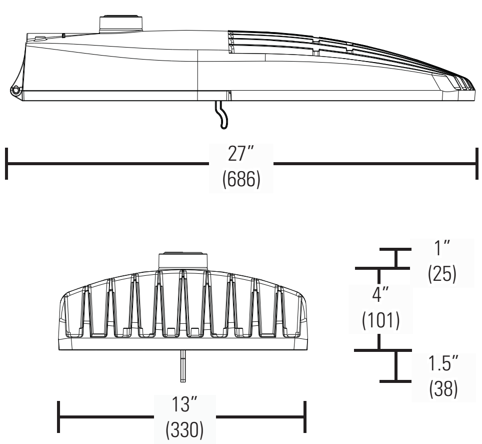
P R O D U C T   O V E R V I E W



Applications:

- Roadways
- Off ramps
- Residental streets
- Parking lots

DIMENSIONS



Effective Projected Area (EPA): The EPA for the ATB1 is 0.9 sq. ft.
Approx. Wt. = 26 lbs.

Features:

OPTICAL

Same Light: Performance is comparable to 70-200W HPS roadway luminaires (as determined by RP-8 recommended illuminance, in average footcandles, for applications common to those wattages)

White Light: Average correlated color temperature (CCT) is 4000K with a CRI of 64; optional 3000K (CRI 84) and 5000K (CRI 66) available

Unique IP65 rated LED light engines meet Full Cutoff and NighttimeFriendly™ criteria and restrict backlight to within sidewalk depth, providing optimal application coverage and optimal pole spacing. Available in Type II or Type III roadway distributions

All performance packages shown will be listed with Lighting Facts and Designlights Consortium; design data are compliant with Lighting Facts tolerances and are accurate as of revision date shown

ELECTRICAL

Long Life: LED light engines are rated >100,000 hours at 40°C, L70. Electronic driver has a rated life of 100,000 hours at a 25°C ambient

Lower Energy: Saves an average of 40-50% over comparable HPS platforms (actual savings will depend on the HPS product's wattage and ballast type)

Surge protection device (standard) meets at least IEEE/ANSI C62.41-1991 Category C1 criteria for MVOLT operation

MECHANICAL

Easy to Maintain: Includes standard AEL lineman-friendly features (such as tool-less entry, tool-less NEMA photocontrol receptacle, terminal block and quick disconnects). Bubble level located inside the electrical compartment for easy leveling at installation. The electrical platform and durable housing materials provide superior longevity and reduce the need for maintenance

Rugged die-cast aluminum housing is polyester powder-coated for durability and corrosion resistance. Rigorous five-stage pre-treating and painting process yields a finish that achieves a scribe creepage rating of nine (9) (per ASTM D1654) after over 1800 hours' exposure to salt fog chamber (operated per ASTM B117)

Four-bolt mast arm mount provides easy, secure installation and is adjustable for arms from 1-1/4" to 2" (1-5/8" to 2-3/8" O.D.) diameter. Wildlife shield is cast into the housing (not a separate piece)

Die-cast trigger latch on doorframe allows for tool-less entry and enables easy and secure opening with one hand

CONTROLS

NEMA photocontrol receptacle is standard; tool-less "lift and turn" receptacle makes photocontrol orientation easy

Dimming version (available with DE option) uses proprietary Acuity Brands components to enable continuous 0-10V dimming down to 10% output via the ROAM® smart controls system (sold separately)

DTL photocontrol for solid-state lighting (available with PCSS option) meets ANSI C136.10 criteria; control has a special filter for LED light to prevent false turn-offs, and is fused for Fail-Off mode to prevent dayburners

WARRANTY & STANDARDS

All electrical components warranted for 5 years

Rated for -40°C to 50°C ambient

CSA Certified to U.S. and Canadian standards

Complies with ANSI: C136.2, C136.10, C136.14, C136.31

Data is considered accurate as of the revision date shown. Information is subject to change without notice.

AEL American Electric Lighting®

Autobahn *Series ATB1*

Roadway Lighting

70-200W LED

C

ORDERING INFORMATION

Example: ATB1 30LED E70 MVOLT R2 DE

BetaLED Catalog

Series		Performance Packages		Voltage		Optics [1]	
ATB1	Autobahn LED Roadway, Size 1	**30LED E35**	30 Chips, 350 mA Driver	**120**	120V	**R2**	Roadway Type II
		30LED E70	30 Chips, 700 mA Driver	**MVOLT**	Multi-volt, 120-277V	**R3**	Roadway Type III
		60LED E35	60 Chips, 350 mA Driver	**347**	347V		
		60LED E70	60 Chips, 700 mA Driver	**480**	480V		

Options [2]

Color Temperature (CCT)

(blank)	4000K (standard)
3K	3000K
5K	5000K

Mounting

(blank)	4-bolt Internal (standard)

Paint [3]

(blank)	Gray (standard)
GI	Graphite
BK	Black
BZ	Bronze
DDB	Dark Bronze
WH	White
UP	Unpainted

Terminal Block

(blank)	Terminal Block (standard)
T2	Wired to L1 and L2 Position
T3	3 Wire Operation (L1, N, L2 Position)

Misc.

BF	Fitted to Withstand 3G Vibration

Controls

(blank)	NEMA Photocontrol Receptacle (standard)
NR	No Photocontrol Receptacle
PCSS	Solid State Lighting Photocontrol (120-277V)
SH	Shorting Cap
DE	Dimming Enabled (0-10V) [4]

Notes:

1. Nighttime Friendly™ optics
2. Only one option may be selected from each category
3. Other colors available; please contact your local American Electric Lighting representative
4. DE option not available with 30LED E35 package. Dimming controlled via ROAM system (sold separately). Contact factory for details.

Data is considered accurate as of the revision date shown. Information is subject to change without notice.

AEL American Electric Lighting®
An Acuity Brands Company

American Electric Lighting
Acuity Brands Lighting, Inc.
One Lithonia Way, Conyers, GA 30012
Phone: 770-922-9000
www.americanelectriclighting.com

DESIGN DATA

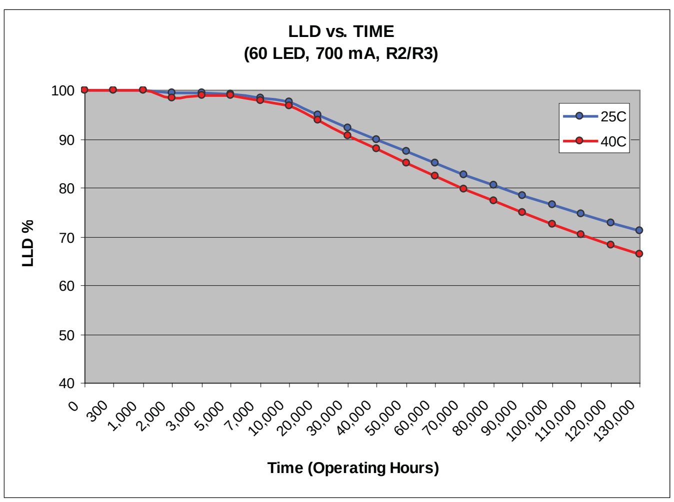
Performance Package	Optic	IES BUG Rating			Input Watts	3000K CCT (opt)				4000K CCT (std)				5000K CCT (opt)				L70 Life (hrs)*		Driver Life (hrs, 25C)
		B	U	G		Delivered Lumens	Efficacy (LPW)	CRI	Equiv. HPS	Delivered Lumens	Efficacy (LPW)	CRI	Equiv. HPS	Delivered Lumens	Efficacy (LPW)	CRI	Equiv. HPS	@ 25°C	@ 40°C	
30LED E35 30 Chips, 350 mA	R2	1	2	1	37	2652	72	84	70W	3348	90	64	70W	3542	96	66	70W	>100k	>100k	100k
	R3	1	2	1		2716	73			3365	91			3634	98					
30LED E70 30Chips, 700 mA	R2	1	3	1	75	4679	62	84	100W	6034	80	64	100W	6257	83	66	100W	>100k	>100k	100k
	R3	1	2	1		4776	64			6175	82			6435	86					
60LED E35 60 Chips, 350 mA	R2	2	3	2	72	5240	73	84	100W	6790	94	64	100W	6958	97	66	100W	>100k	>100k	100k
	R3	2	2	2		5370	75			6901	96			7167	100					
60LED E70 60 Chips, 700 mA	R2	3	3	2	146	9243	63	84	150W	11,370	78	64	200W	12,290	84	66	200W	>100k	>100k	100k
	R3	3	2	3		9444	65			11,983	82			12,730	87					

* Manufacturer's projected life calculations are correlated from LM-80 chip data and in situ luminaire thermal testing.

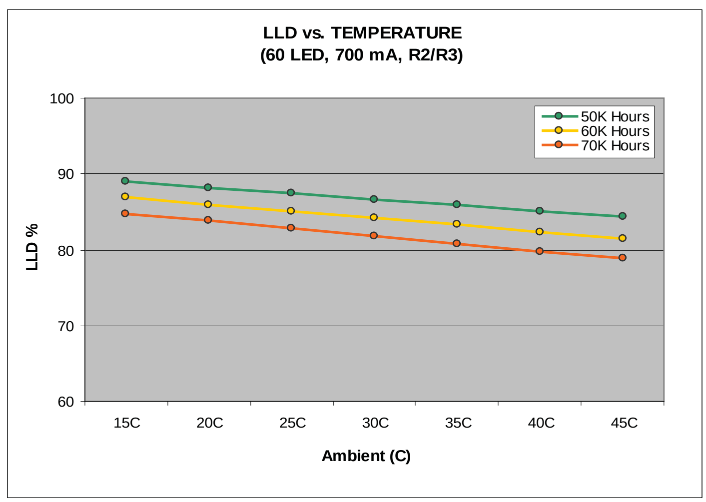
Use these factors to estimate differences in lumen output with variations in ambient temperature. Values shown in the table above are taken in a 25°C ambient; therefore 25°C = 1.00.

Lumen Ambient Temperature (LAT) Factors							
Performance Package	15°C	20°C	25°C	30°C	35°C	40°C	45°C
All	1.02	1.01	1.00	0.99	0.98	0.97	0.94

Use this chart to estimate lamp lumen depreciation (LLD) for specific ambient temperatures (25°C and 40°C) at varying operating hours.



Use this chart to estimate lamp lumen depreciation (LLD) for a specific number of operating hours (50k, 60k, or 70k hours) in varying ambient temperatures.



Data is considered accurate as of the revision date shown. Information is subject to change without notice.

Autobahn *Series ATB1*

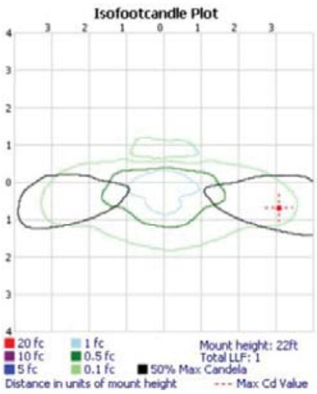
Roadway Lighting

70-200W LED

C

P H O T O M E T R I C S

ATB1 30LED E35 R2

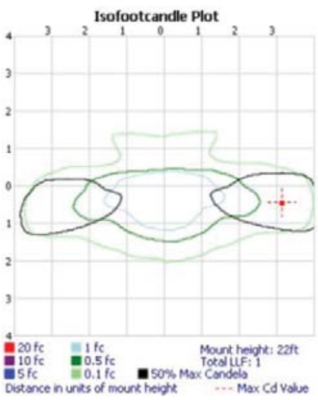


Test No. LTL19976 tested in accordance with IESNA LM-79-08.

ATB1 30LED E35 R3

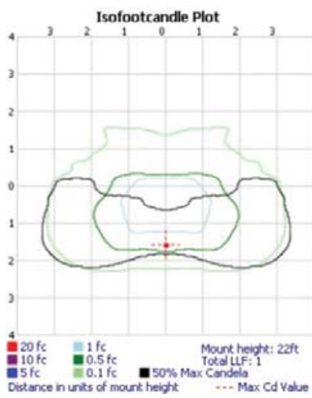
Test No. LTL19975 tested in accordance with IESNA LM-79-08.

ATB1 30LED E70 R2



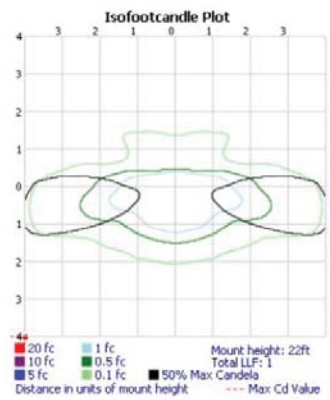
Test No. LTL19722 tested in accordance with IESNA LM-79-08.

ATB1 30LED E70 R3



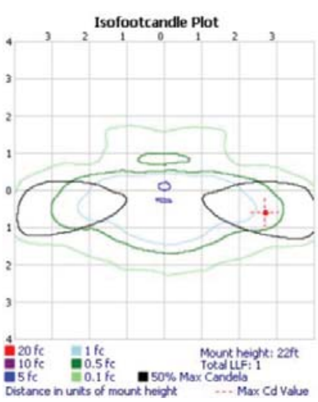
Test No. LTL20002 tested in accordance with IESNA LM-79-08.

ATB1 60LED E35 R2



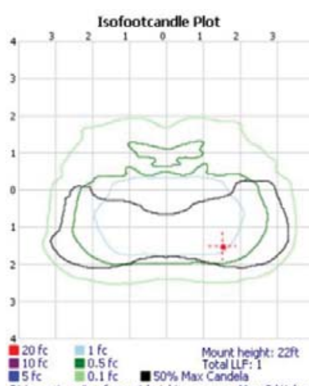
Test No. LTL19734 tested in accordance with IESNA LM-79-08.

ATB1 60LED E70 R2



Test No. LTL19733 tested in accordance with IESNA LM-79-08.

ATB1 60LED E70 R3



Test No. LTL19765 tested in accordance with IESNA LM-79-08.

Data is considered accurate as of the revision date shown. Information is subject to change without notice.

American Electric Lighting
Acuity Brands Lighting, Inc.
One Lithonia Way, Conyers, GA 30012
Phone: 770-922-9000
www.americanelectriclighting.com

LED ROADWAY LIGHTING

leading the LED technology wave

D

Technical Specifications: Satellite Series LED Roadway Luminaire

SAT-72M (72 LEDs)

Electrical

Available Driver Currents	280mA	350mA	450mA	525mA	600mA
Power Consumption*	65W	83W	107W	131W	150W

Input Voltage: Universal Driver 120 to 240 VAC, 50Hz or 60Hz; 277V, 347V, and 480V drivers available upon request.

Fixture

Weight	11.4 kg	25 lb
Width (maximum)	350 mm	13.8 in
Length (maximum)	608 mm	23.9 in
Height (maximum)	156 mm	6.14 in
EPA	0.065 m^2	0.699 ft^2
Cover Lens	*Acrylic (optional Polycarbonate)*	
Housing	Single piece, die-cast aluminum	
Mounting	1.625″ to 2.375″ / 42 to 60 mm OD tenons	

Finish

Standard	Unfinished Aluminum
Optional	*Specific colors with powder coated finish available upon request.*

*Figure 1 – Luminaire side profile**
** SAT-96M illustrated*

Performance / Photometrics

Available Driver Currents	280mA	350mA	450mA	525mA	600mA
Fixture Efficacy	79 Lm/W	70 Lm/W	67 Lm/W	64 Lm/W	60 Lm/W
Fixture Output (Type II)*	5,100 Lm	6,000 Lm	7,200 Lm	8,350 Lm	9,150 Lm
Telcordia MTBF (in Millions)**	2.3 hrs	2.1 hrs	1.7 hrs	1.6 hrs	1.5 hrs

LED L70 @ 350mA	>100,000 hours
Distribution	IES Type II, IES Type III
	European wide, European narrow
Color Temperature (CCT)	5,000 K
	Other colors available upon request.
Color Rendering Index (CRI) at 70 (+/- 5%)	

Operating Conditions

Temperature (ambient)	-40°C to +60°C	-40°F to +140°F

Photocell Options

Photocell Receptacle with shorting cap
Photocell – 20 yr design life option available
No Photocell Receptacle – solid casting

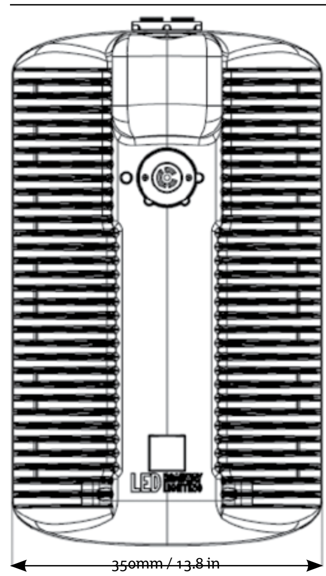


Figure 2 – Luminaire top

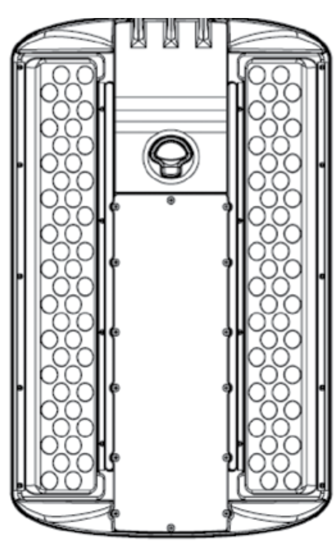


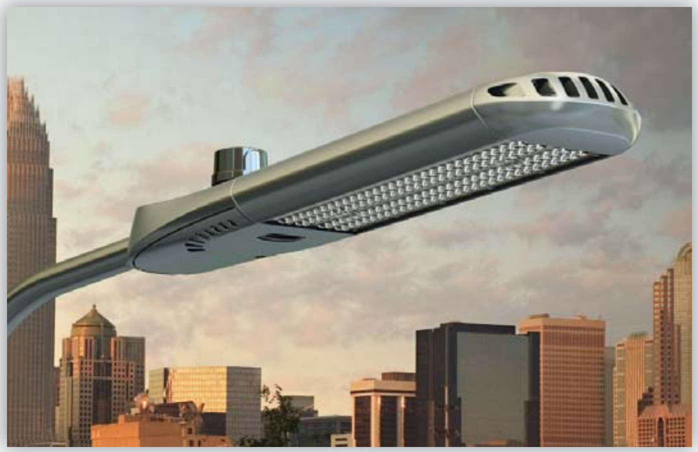
Figure 3 – Luminaire bottom

* Values shown are average values and are subject to +/- 5% tolerance
** Power supply MTBF values are based on independent laboratory testing to Telcordia SR-332. Values shown are in millions of hours.

Prepared By	Catalog #	
Project	Comments	Date

LightingScience®

Changing the way the world experiences light.



Benefits

- Sustainable Design:
  - Custom arrayed optics to reduce the use of plastics.
  - No tertiary optical losses.
  - Use of recycled and recyclable corrosion resistant materials.
  - Full cutoff optics meet Dark Sky requirements
- Holistic Thermal Design:
  - Underdriving LEDs to improve efficiency and system life.
  - Use of premium grade alloys for enhanced thermal conduction.
  - Electronics are isolated and sealed from the optical chamber.
- Fits standard 1 1/4" to 2" mast arm.
- Typical Applications Include:

- Roadways
- City Streets
- Campuses
- Residential Streets
- Parking Lots

Prolific™ RoadWay

Features[1]		LSR1	LSR2	LSR3	LSR4
Lumen Output (at operating temperature)		4354	5890	9365	11716
Input Power (Watts)		50	75	100	150
Efficacy (lm/w)		87	79	92	81
Color Temperature (CCT)		4000K, 5000K			
Color Rendering Index (CRI)		65			
Rated Life L70		60,000 Hours			
Housing		Die Cast and Extruded Aluminum			
Finish		Gray, Black, Bronze			
Optical Distribution		Type II, Type III, Type II Streetside Optimized, Type III Streetside Optimized Type IV, Type V			
Mounting Options		Fits Standard 1 1/4" to 2" Mast Arm, 4-Bolt Internal			
EPA	LSR1, LSR2	.77			
	LSR3, LSR4	1.0			
Dimensions	LSR1, LSR2	28.10" x 8.0" x 4.3" 714mm x 203mm x 109mm			
	LSR3, LSR4	37.10" x 8.0" x 4.3" 942mm x 203mm x 109mm			
Operating Temperature		-40°C to +40°C (-40°F to +104°F)			
Voltage		120-277 VAC @ 50-60 Hz, DCV[2]			
Weight		LSR1, LSR2: 22lbs LSR3, LSR4: 25lbs			
Warranty		5 Year Limited			
Certification		RoHS 3G Vibration Rating[3]			
Environment		IP67 optics WET			

[1] All values are nominal. Values based on 5000CCT at 25°C unless noted. Consult website for complete IES & LM-79 data.
[2] DCV available with LSR1 & LSRR2 only
[3] 4-Bolt mounting required for 3G vibration rating

US LSR 6_23_11

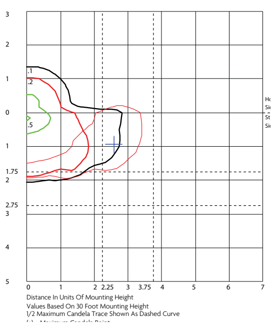
Specifications are typical values and may change without notification.

North America Australia Asia Europe 877-999-5742 www.lsgc.com

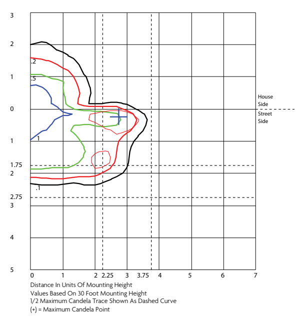
Prolific™ RoadWay

E

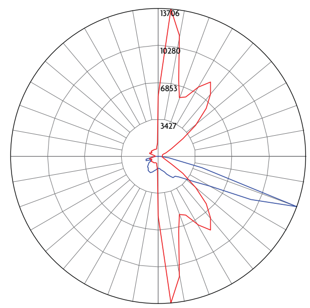
Type II



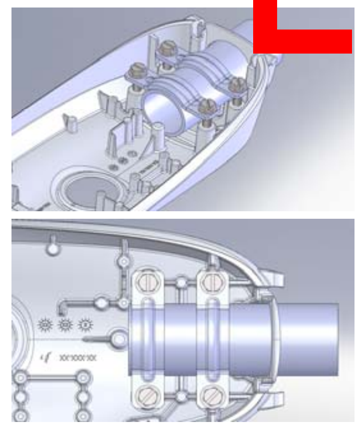
Type III



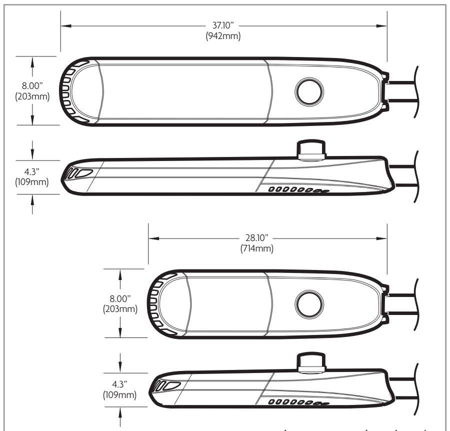
Type III



Maximum candela = 13706.34 Located at Horizontal Angle = 85, Vertical Angle = 70
Vertical Plane Through Horizontal Angles (85–265) (Through Max. Cd.) : BLUE
Horizontal Cone Through Vertical Angle (70) (Through Max. Cd.) : RED



LSR4 4 Bolt Dimensions



Dimensions shown in inches (mm)

Zonal Lumen Summary

Zone	Lumens	%Luminaire
FL 0–30	634	5.9
FM 30–60	3,100	28.7
FH 60–80	3,585	33.1
FVH 80–90	110	1.0
BL 0–30	655	6.1
BM 30–60	1,771	16.4
BH 60–80	844	7.8
BVH 80–90	115	1.0
UL 90–100	0	0
UH 100–180	0	0

Ordering Information

Example: LSR1 CW R2 2B PCR PC HS BK

Product	Color Temperature	Optical Distribution	Voltage	Mounting	Receptacle
LSR1 Lighting Science Roadway 1 (50W)	**CW** White 5000K	**R2** Type II	**MVOLT**	**2B** 2-Bolt Internal (standard)	**PCR** Photocontrol Receptacle (standard)
LSR2 Lighting Science Roadway 2 (75W)	**NW White** 4000K	**R3** Type III		**4B** 4-Bolt Internal[1]	**NR** No Photocontrol Receptacle
LSR3 Lighting Science Roadway 3 (100W)		**R2SS** Type II Streetside Optimized			
LSR4 Lighting Science Roadway 4 (150W)		**R3SS** Type III Streetside Optimized			
		R4 Type IV			
		R5 Type V			

Options	Accessories	Finish
PC Twist-lock Photocontrol	**HS** House Side Sheild	**GR** Gray (Standard)
SH Shorting Cap		**BK** Black
		BZ Bronze

[1] Required for 3G Vibration Rating
All mounting hardware included with each unit.

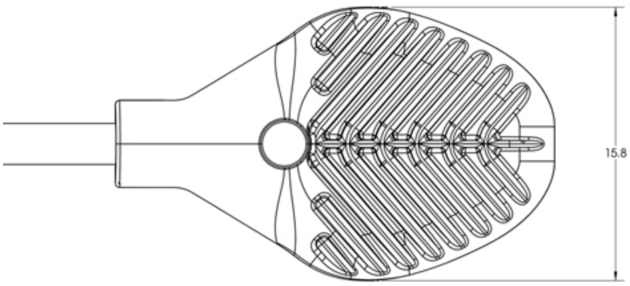
LightingScience®
1227 S. Patrick Drive BLDG 2A | Satellite Beach, FL 32937
Phone: 877-999-5742 | www.lsgc.com

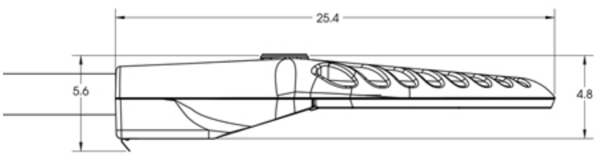
 Specifications are typical values and may change without notification.

RX1 LEDGINE (40 LED's) (RX140) Specification Sheet

F

Project Name:	Location:	MFG: Philips Hadco
Fixture Type:	Catalog No.:	Qty:





Ordering Guide

Example: RX140 A 2 W A M N N S N

Product Code	RX140	RX1 LEDGINE (40 LED's)	
Finish	A B H I	Black White Bronze Gray	
Optics	2 3 4 5	Type II Type III Type IV Type V	
Color Temperature	W N C	3000K 4000K 5700K	
Voltage	A	120-277 VAC	
Drive Current	M	Multi Tap (350, 530, 700mA)	*1
Photo Control	N R	None Twist-lock Receptacle	
Dimming Control	N DZ W	None Custom Dimming Schedule Wireless Controls	 *2 *3
Surge Suppression	S A	Standard Built In <3kV Additional 10kV BIL	
House Side Shield	N H	None House Side Shield	

*1 M Multi Tap only available in RX140 - ships at 530mA.
*2 Consult Factory for DZ Custom Dimming Schedule (0-10V).
*3 Consult Factory for W Wireless Controls.

Specifications

APPLICATIONS:
The RX1 is the perfect LED solution for roadway lighting and is the ideal luminaire for both new and retrofit installations. Other application locations include: residential streets, city streets, campuses and parking lots. The performance, energy savings, and uniformity of this luminaire allow for it to be a one to one replacement for standard HID cobra-head style luminaires.

CONSTRUCTION:
Containing no mercury or other hazardous chemicals, the RX1 is RoHS compliant and fully recyclable. The housing is constructed of low copper die-cast aluminum with a traditional cobra-head style, low profile and EPA. The housing is a unique thermal dissipating design with wide angular channels that allow for natural removal of dirt and debris. Two tool-less clips allow for access to the driver and wiring compartment. The hinged door is removable for serviceability and upgradability. The LEDGINE has a precision designed, injection molded optic plate behind a single tempered glass lens. The lens and lens frame gaskets are robotically applied. The LED optics chamber is IP66 rated. The luminaire is designed to mount to a 1.5" to 2.5" O.D. or 1.25" to 2" NPS horizontal tenon or arm, minimum 6" long. Complies with ANSI C136.3 and ANSI C136.14. A bubble level is built in as well as mounting steps that allow for a +5° to -5° tilt, in 2.5° increments. There is a single clamp mounting system (NOTE: can be modified for two clamps - consult factory). Mounting clamps are made of HSLA steel and are zinc plated. Fasteners are made of stainless steel. A large terminal block is directly in line with incoming power wires and accepts up to 6 gauge wire. There is an option for a 360° rotatable twist lock photocell receptacle. Tenon guard protects against birds and similar intruders.

LED SPECIFICATIONS:
Refer to IES files for energy consumption and delivered lumens for each option. Based on in-situ thermal testing and data from Philips Lumileds and Philips Advance, expected to reach 80,000 hours with >L70 lumen maintenance @ 25°C. The Philips LEDGINE uses Philips Lumileds Rebel LEDs. Color temperatures available are ANSI Bins 3000K, 4000K, and 5700K CCT. Multiple distributions are available including Type 2, 3, 4 and 5.

ELECTRONIC DRIVER:
Integral Philips Lighting Electronics Advance XITANIUM LED drivers. Standard drivers provide universal voltage input from 120-277VAC, 50-60Hz. All XITANIUM LED drivers are RoHS compliant. The LED drivers have <3kV surge suppression built in, 10kV is an additional option (see Ordering Guide). The LED driver is installed on the enclosure door, keeping it mechanically and thermally separated from the canopy which doubles as the LED array heat sink. This allows LED driver case temperatures to remain well below the maximum rated temperature for enhanced reliability and lifetime. IP66 rated. Multi Tap driver available for RX140 only - ships at 530mA.

FINISH:
Thermoset polyester powdercoat is electrostatically applied after a five-stage conversion cleaning process and bonded by heat fusion thermosetting. Laboratory tested for superior weatherability and fade resistance in accordance with ASTM B-117-64 and ANSI/ASTM G53-77 specifications. Powdercoat is 3.0 - 6.0 mil thickness. Textured finish.

RX1 LEDGINE (40 LED's) (RX140) Specification Sheet

F

Project Name:	Location:	MFG: Philips Hadco
Fixture Type:	Catalog No.:	Qty:

OPTIONS:
There is an option for a 360° rotatable twist lock photocell receptacle. Optional surge suppression current rating available for the RX1 is 10 kV BIL. Enclosure for surge suppression device is constructed of high temperature, flameproof material with an 85°C maximum surface temperature rating. The device consists of a thermally protected transient overvoltage circuit and is designed for use with universal voltage ballasts and drivers. Custom 0-10V dimming schedule (DZ) is available by contacting the factory. As an alternative, Wireless Controls options are also available - contact the factory for details.

IP RATING:
IP66: Dust-tight and sealed against direct jets of water. No Ingress of dust. Will withstand 26.4 gallons of water per minute. Water projected in powerful jets shall not enter the enclosure in harmful quantities. The LED optics chamber is IP66 rated. The LED driver is IP66 rated.

CERTIFICATIONS:
UL8750 and UL1598 compliant. ETL listed to U.S. safety standards for wet locations. cETL listed to Canadian safety standards for wet locations. Manufactured to ISO 9001:2008 Standards. Vibration tested to ANSI C136.31 for Bridge Applications.

WARRANTY:
5 year extended warranty

Width:
15.8"

Height :
4.8"

Length:
25.4

EPA:
.54 sq ft

Max. Weight:
19.5 lbs

IESNA Classifications:
Full Cutoff

M-250A2 POWR/DOOR® LUMINAIRE 150 HPS

APPLICATIONS
- For residential streets, parking lots and roadways

SPECIFICATION FEATURES
- Powr/Module ballast assembly
- Filtered optics
- Universal two-bolt slipfitter
- Die-cast aluminum housing with polyester powder gray paint finish
- Street Side Adjustable E39 mogul base socket standard where lamp is available in mogul base (E26 Medium base otherwise)
- ALGLAS® finish on reflector
- No-tool PE receptacle
- Plug-in ignitor
- External stainless steel bail latch
- Plastic Pest guard standard (not required for 2 in. pipe)
- UL/cUL listed for wet location available as an option

ORDERING NUMBER LOGIC

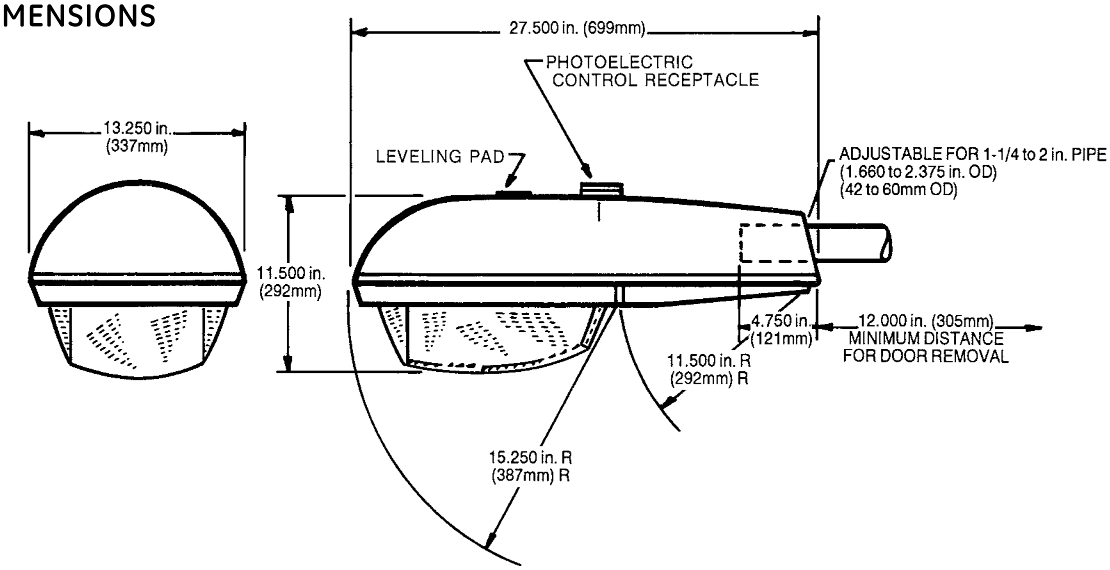
M2AR	15	S	1	N	2	G	MS2	1	F
PRODUCT IDENT	WATTAGE	LIGHT SOURCE	VOLTAGE	BALLAST TYPE	PE FUNCTION	LENS TYPE (PRISMATIC) REFRACTOR	IES DISTRIBUTION TYPE	FILTER	OPTIONS
XXXX	XX	X	X	X	X	X	XXX	X	
M2AR = M-250A2	05 = 50 07 = 70 10 = 100 15 = 150 (55 V) 17 = 175 20 = 200 25 = 250	E = Energy Act Compliant Pulse MH (EPMH) S = HPS P = PMH Standard: Lamp not included.	60Hz 0 = 120/208/240/277 Multivolt 1 = 120 2 = 208 3 = 240 4 = 277 5 = 480 7 = 120X240 8 = 240V Ballast 120V PE Receptacle not recon-nectable D = 347 F = 120X347 T = 220 50Hz 6 = 220 R = 230 Y = 240 NOTE: Dual voltage connected for lower voltage	See Ballast Selection Table A = Autoreg G = Mag-Reg with Grounded Socket Shell H = HPF Reactor or Lag M = Mag-Reg N = NPF Reactor or Lag P = CWI with Grounded Socket Shell S = Series (in Top Housing)	1 = None 2 = PE Receptacle NOTE: Receptacle connected same voltage as unit except as noted. Order PE Control separately.	See Photometric Selection Table A = Acrylic G = Glass L = Polycarbonate NOTE: 150 watt Maximum with Acrylic or Polycarbonate Refractors.	See Photometric Selection Table M = Medium L = Long F = Four-(Way) S = Semi-cutoff N = Non-cutoff W = (Four)-Way 2 = Type II 3 = Type III 4 = Type IV	1 = Fiber gasket 2 = Char-coal with elasto-mer gasket	F = Fusing (Not available with multivolt or dual voltage) J = Line Surge Protector, Expulsion Type U = UL/cUL listed (all HPS up to 175W MH max) with glass or polycar-bonate refractor (60Hz only)

PHOTOMETRIC SELECTION TABLE

Wattage	Light Source	Lens Type (Prismatic Refractor)	IES Distribution Type Photometric Curve Number 35-17---- (Socket Position) All light sources are clear unless otherwise indicated						
			LN3	LN4	MN2	MN3	MS2	MS3	FW3
50, 70,100, 150 (55 V)	HPS	Acrylic	N/A	N/A	7232(1A)	7233(2A)	7230 (2B)	7231(2.5B)	N/A
50, 70,100, 150 (55 V)	HPS	Glass	N/A	N/A	7236(1A)	7237(2A)	7234(1.5B)	7235(2.5B)	7268(1A)
50, 70,100, 150 (55 V)	HPS	Polycarb.	7254(1A)	7255(2A)	N/A	7252(2B)	7311	N/A	N/A
200, 250,	HPS	Glass	N/A	N/A	N/A	N/A	7263(2DH)	7262(1DH)	N/A
175, 250	EPMH	Glass	N/A	N/A	7283(1A)	7275(2A)	7276(1B)	7277(2B)	7270(1A)
100, 150	PMH	Glass	N/A	N/A	451483(2A)	N/A	N/A	N/A	N/A

NOTE: N/A = Not Available
PMH—Contact Factory

FIXTURE DIMENSIONS



DATA

Approximate Net Weight	20-30 lbs	9-14 kgs
Effective Projected Area	0.7 sq. ft. max	0.07 sq. M max
Suggested Mounting Height	20-40 ft.	6-12 M

REFERENCES

See Page R-48 for start of Accessories.
See Page R-52 for Explanation of Options and Other Terms Used.
See Pole and Bracket Section Page P-2 for pole selection.

BALLAST SELECTION TABLE

		Ballast Type/Voltage												
		60Hz										50Hz		
Wattage	Light Source	Multi-volt	120	208	240	277	480	120X240	347, 120X347	240/120 PE R	220	220	230	240
50	HPS	H,N	H,N	H,N	H,N	H,N	H,N	H,N	H,N	H,N	N/A	N/A	N/A	N/A
70,100,150 (55V)	HPS	A,H,N	A,G,H,M,N,P	A,G,H,M,N	A,G,H,M,N,P	G,H,M,N	G,M	G,M,P	G*,H,M*,N	G,M,N	N/A	H,M,N	H	M††
100/150 (55V)	HPS	N/A	H, N	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A
200	HPS	A,P	A,H,N,P	A,H,N,P	A,H,N,P	A,P	A	A,P	P	A,H,N	N/A	N/A	N/A	N/A
250	HPS	A,P	A,H,N,P	A,H,N,P	A,H,N,P	A,P	A,P	A,P	A,P	A,H,N	H	A,H,N	H	A,H
175	EPMH	A	A	A	A	A	A	A	A	A	N/A	N/A	N/A	N/A
**100	PMH	H, N	H, N	H, N	H, N	H, N	H, N	H, N	H, N	H, N	N/A	N/A	N/A	N/A
**150	PMH	N/A	H	H	H	H	N/A	H	H	H	N/A	N/A	N/A	N/A
250	EPMH	A	A	A	A	A	A	A	N/A	A	N/A	N/A	N/A	N/A

NOTE: N/A = Not Available
† Not available in 175W
††150(55V) only
*Not available in 120X347V
C/F = Contact factory
**Medium Base Socket

M2AR SUGGESTED CATALOG ORDERING NUMBERS

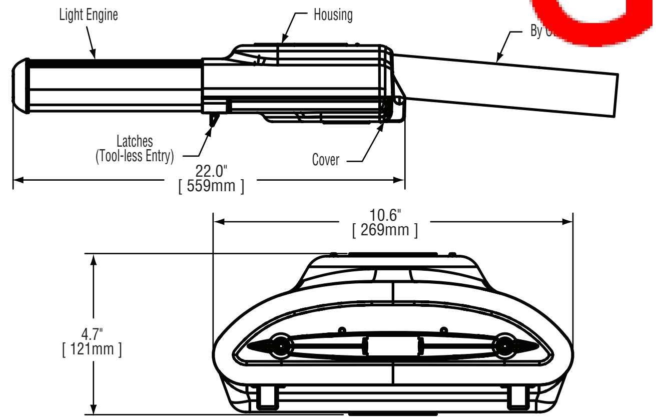
Catalog Number	Wattage	Light Source	Voltage (60 Hz)	Ballast Type	Refractor Type	Photometric Distribution
M2AR10S1N2AMS21	100	HPS	120	NPF Reactor	Acrylic	MS2
M2AR15S1N2AMS31	150	HPS	120	NPF Reactor	Acrylic	MS3
M2AR25S0A2GMS31	250	HPS	Multivolt	Auto-Regulator	Glass	MS3

All GE suggested catalog ordering numbers come with PE receptacle. PE control must be ordered separately. Order and install SCCL-PECTL if no PE is desired.

Multivolt ballasts can be for either 120, 208, 240, or 277 volt incoming power supply.

STR-LWY-2M-HT   LEDway® Streetlight – Type II Medium   Re : 4/18/11

BetaLED Catalog #: STR - LWY - 2S - HT - - D - - - -



Notes:

Product	Family	Optic	Mounting	# of LEDs (x 10)	LED Series	Voltage	Color Options	Drive Current	Factory-Installed Options (Please type additional options in manually on the lines provided above.)
STR	LWY	2M[1]	HT[2]	☐ 04 ☐ 05 ☐ 06	D	☐ **UL** Universal 120–277V ☐ **UH** Universal 347–480V	☐ **SV** Silver[3] ☐ **BK** Black[3] ☐ **BZ** Bronze[3] ☐ **PB** Platinum Bronze[3] ☐ **WH** White[3]	☐ **700** 700mA (Standard) ☐ **525** 525mA ☐ **350** 350mA	☐ **43K** 4300K Color Temperature[4] ☐ **DIM** 0–10V Dimming[5,6,7] ☐ **F** Fuse[8,9] ☐ **HL** Hi/Low (175/350/525, dual circuit input)[10,11] ☐ **N** No Quick Disconnect Harness or Leveling Bubble[12] ☐ **PD** Power Door[13] ☐ **R** NEMA Photocell Receptacle[8] ☐ **SC** Door Safety Tether[14] ☐ **UTL** Utility Option[15] For additional options, see IP66 spec sheet.

Footnotes

1. IESNA Type II Medium distribution
2. Horizontal tenon mount
3. Light engine portion of extrusion is not painted and will remain natural aluminum regardless of color selection
4. Color temperature per fixture; minimum 70 CRI
5. Control by others
6. Refer to dimming spec sheet for availability and additional information
7. Can't exceed the specified drive current. Consult factory if exceeding drive current is necessary.
8. This option not available with all multi-level options. Refer to multi-level spec sheet for more information
9. When code dictates fusing use time delay fuse
10. Refer to multi level spec sheet for availability and additional information
11. Sensor not included
12. Standard product features unless N option is specified
13. All connections between door and fixture are shipped unconnected from the factory; door release spring included to open door automatically when the latches are released
14. Stainless steel aircraft cable
15. Includes exterior wattage label that reflects watts for the drive current selected. The ability to exceed the selected drive current will be disabled.

LED PERFORMANCE SPECS

# of LEDs	Initial Delivered Lumens – Type II Medium @ 6000K	B	U	G	Initial Delivered Lumens – Type II Medium @ 4300K	B	U	G	System Watts 120–277V	Total Current @ 120V	Total Current @ 240V	Total Current @ 277V	System Watts 347–480V*	Total Current @ 347V	Total Current @ 480V	L_{70} Hours** @ 25° C (77° F)	50K Hours Lumen Maintenance Factor** @ 15° C (59° F)
		Rating***				Rating***											
350mA Fixture Operating at 25° C (77° F)																	
40	3,914 (04)	1	1	1	3,607 (04)	1	1	1	45	0.38	0.21	0.19	52	0.15	0.15	> 150,000	94%
50	4,836 (05)	1	1	1	4,457 (05)	1	1	1	61	0.50	0.27	0.24	69	0.19	0.18	> 150,000	
60	5,769 (06)	2	1	2	5,317 (06)	2	1	2	71	0.58	0.31	0.27	79	0.22	0.20	> 150,000	
525mA Fixture Operating at 25° C (77° F)																	
40	5,479 (04)	2	1	2	5,050 (04)	2	1	2	67	0.57	0.30	0.26	74	0.21	0.19	149,000	93%
50	6,771 (05)	2	2	2	6,240 (05)	2	2	2	89	0.74	0.39	0.33	97	0.27	0.23	142,000	
60	8,077 (06)	2	2	2	7,444 (06)	2	2	2	104	0.87	0.45	0.39	112	0.32	0.26	139,000	
700mA (Standard) Fixture Operating at 25° C (77° F)																	
40	6,849 (04)	2	2	2	6,312 (04)	2	2	2	92	0.78	0.40	0.35	100	0.29	0.23	129,000	91%
50	8,463 (05)	2	2	2	7,800 (05)	2	2	2	120	1.00	0.52	0.44	128	0.37	0.29	119,000	
60	10,096 (06)	3	2	3	9,305 (06)	2	2	2	139	1.17	0.60	0.51	148	0.43	0.32	118,000	

* Utilizes magnetic step-down transformer

** For recommended lumen maintenance data see TD-13

*** For more information on the IES BUG (Backlight-Uplight-Glare) Rating visit www.iesna.org/PDF/Erratas/TM-15-07BugRatingsAddendum.pdf

NOTE: All data subject to change without notice.

Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

General Description

Fixture housing is all aluminum construction. Standard fixture utilizes terminal block for power input suitable for #2–#14 AWG wire and operates at 700mA. Drive current is field switchable. Fixture is designed to mount on 1.25" IP (1.66" O.D.) and/or 2" IP (2.375" O.D.) horizontal tenon (minimum 8" [203.2mm] in length) and is adjustable +/- 5º to allow for fixture leveling (includes leveling bubble to aid in this process). Fixture carries a limited five year warranty.

Electrical

Modular design accommodates varied lighting output from high power, white, 6000K (+/- 500K per full fixture), minimum 70 CRI, long life LED sources. Optional 4300K (+/-300K per full fixture) also available. 120–277V 50/60 Hz, Class 1 LED drivers are standard. 347–480V 50/60 Hz option is available. LED drivers have power factor >90% and THD <20% at full load. Units provided with integral 10kV surge suppression protection standard. Quick disconnect harness suitable for mate and break under load provided on power feed to driver for ease of maintenance. Surge protection tested in accordance with IEEE/ANSI C62.41.2.

Finish

Exclusive Colorfast DeltaGuard® finish features an E-Coat epoxy prim[illegible] with an u[illegible]-durable silver powder topcoat, providing excellent resistance to corros[illegible]et degradation and abrasion. Bronze, black, white and platinum bronze powder topcoats are also available. The finish is covered by our 10 year limited warranty.

Fixture and finish are endurance tested to withstand 5,000 hours of elevated ambient salt fog conditions as defined in ASTM Standard B 117.

Testing & Compliance

UL listed in the U.S. and Canada for wet locations. Consult factory for CE Certified products. Meets CALTrans 611 Vibration Testing and GR-63-CORE Section 4.4.1/5.4.2 Earthquake Zone 4. Certified ANSI C136.31-2001 bridge and overpass vibration standards. Dark Sky Friendly. IDA Approved.

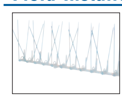
RoHS Compliant.

Product qualified on the Design Lights Consortium ("DLC") Qualified Products List ("QPL")

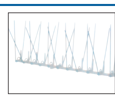
Patents

U.S. and international patents granted and pending. BetaLED is a division of Ruud Lighting, Inc. For a listing of Ruud Lighting, Inc. patents, visit www.uspto.gov.

Field-Installed Accessories

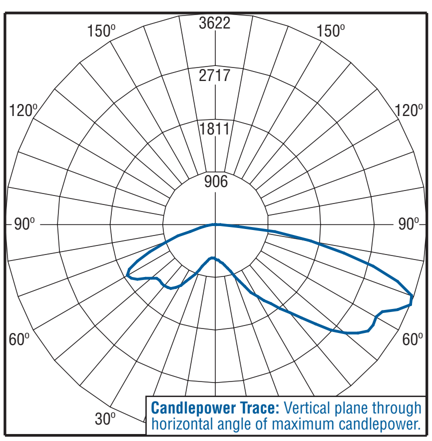


Bird Spikes for Light Engine
XA-BRDSPK60



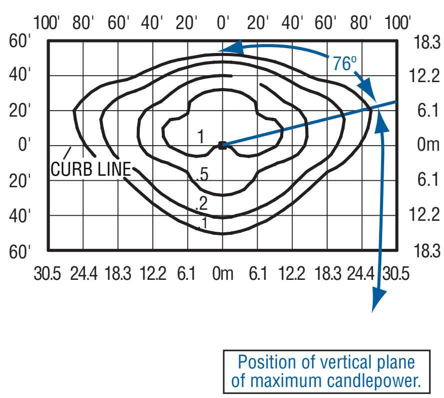
Bird Spikes Kit for Housing
XA-BRDSPKHSG

Photometrics



Candlepower Trace: Vertical plane through horizontal angle of maximum candlepower.

Independent Testing Laboratories certified test. Report No. ITL64223. Candlepower trace of 6000K, 40 LED LEDway Streetlight luminaire with IESNA Type II Medium distribution. Luminaire with 6,665 initial delivered lumens operating at 700mA. **All published luminaire photometric testing performed to IESNA LM-79-08 standards.**



Position of vertical plane of maximum candlepower.

Isofootcandle plot of 6000K, 40 LED LEDway Streetlight luminaire with IESNA Type II Medium distribution mounted at 25' A.F.G. Luminaire with 6,849 initial delivered lumens operating at 700mA. Initial FC at grade.

LEDway® EPA & Weight Calculations

Approximate Weight 120–277V*		
40–60 LED fixture		16.0 lbs.
EPA		
Horizontal Tenon Mount		
1 fixture		0.685
EPA		
Round External Mount / Square Internal Mount Horizontal Tenons with Fixture(s)		
PT/PD-1H	Single	0.905
PT/PD-2H(90)	90º Twin	1.189
PT/PD-2H(180)	180º Twin	1.590
PT/PD-3H(90)	90º Triple	1.774
PT/PD-3H(120)	120º Triple	1.590
PT/PD-4H(90)	90º Quad	2.178

* Add 5 lbs. for transformer in 347–480V

NOTE: All data subject to change without notice.

Made in the U.S.A. of U.S. and imported parts.
Meets Buy American requirements within the ARRA.

"The Leader in Electro-Optics Technology"

LEOTEK

a subsidiary company of LITEON

Job Name:______________________

Type:______________________

Complete Catalog Number:______________________

H

LED GREEN Cobra™ Street Light

Ordering Example

GC1 — 30E — MV — NW — 2 — GY — [ ]

GC1	30E	MV	NW	2	GY	
GC1 – LED Street Light GCD1 – LED Street Light Dimmable GCA1[1] – LED Street Light GCAD1[1] – LED Street Light Dimmable	Number/ Type of LEDs 20E 30E 40E 60E 80E	Voltage **MV** - 120 -277V **HV** - 347 -480V	Nominal Color Temperature[2] **NW** – 4300K	Light Distribution **2** - Type 2 **3** - Type 3	Finish[3] **GY** - Gray	Accessories/Options **BSK** - Bird Spider Kit **SPB** - Square Pole Bracket **RPB** - Round Pole Bracket **PTB** - Pole-Top Bracket **HSS**[4] – House Side Shield **350** - Factory set 350mA Drive Current **530** - Factory set 530mA Drive Current **FDC**[5]- Fixed Drive Current

Notes:
1. Meets Buy American Provision of ARRA
2. NW standard. Consult factory for other color temperatures.
3. Gray standard. Consult factory for other finishes.
4. Flush mounted shield easily field installed. Cuts light off ½ mounting height behind luminaire.
5. Non-field adjustable drive current. Specify setting - 350mA, 530mA, or 700mA.

Luminaire Specifications

Housing: Die cast aluminum housing with universal four-bolt slip fitter mounts to 1$^1/_4$" to 2" (1$^5/_8$" to 2$^3/_8$" O.D.) diameter mast arm. All hardware is stainless steel. Cooling fins maintain LED junction temperature assuring long LED life and efficiency. Electrical components are accessed without tools and are mounted on removable power door. Power door features quick electrical disconnects to terminal block and LED board. Photocontrol receptacle is standard and can be aimed without tools. Photocontrol is provided by others.

Light Emitting Diodes: Hi-flux/Hi-power white LEDs produce a minimum of 70% of initial intensity at 70,000 hours of life. LEDs are tested in accordance with IESNA LM-80 testing procedures. They have a mean correlated color temperature of 4300K (standard). LEDs are 100% mercury and lead free.

Optical Systems: Micro-lens systems produce IESNA Type 2 or Type 3 distributions. Luminaire is classified as Full-Cutoff with 0% total lumens above 90°.

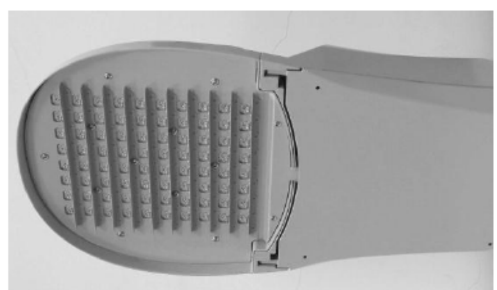
Electrical: Power supply features a minimum power factor of .90 and <20% Total Harmonic Distortion (THD). EMC meets or exceeds FCC CFR Part 15. Transient voltage complies with ANSI C62.41 Cat. A. Power supply is field adjustable to 350mA, 530mA, or 700mA drive current. Standard factory setting is 700mA. Integral surge protector is tested per ANSI/IEEE C62.45 procedures based on ANSI/IEEE C62.41.2 definitions for standard and optional waveforms for Location Category C-High.

Finish: Housing receives a fade and abrasion resistant, epoxy polyester powder coat, light gray finish standard.

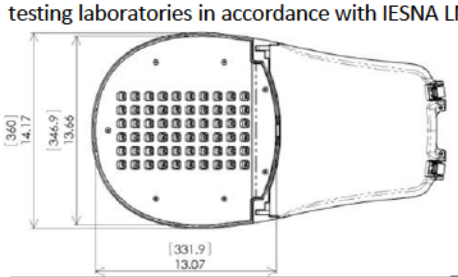
Listings/Ratings/Warranties/Patents: Luminaires are UL listed for use in wet locations in the United States and Canada. Optical systems maintain an IP66 rating. Five-year limited warranty is standard on all components. Patents pending.

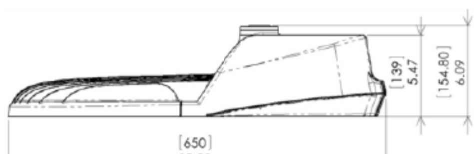
Photometry: All luminaires are photometrically tested by certified independent testing laboratories in accordance with IESNA LM-79 testing procedures.

Removable "power door" opens without tools and hangs securely during wiring.



Optional House Side Shield plate with back light strips is factory or field installable.





Weight	EPA*
21 lbs. (9kg)	0.9ft^2

*Effective Projected Area (consult factory for multiple units)

LEOTEK USA
726 South Hillview Drive
Milpitas, CA 95035
Toll Free: (888) 806-1188
Fax: (408) 980-0538

GREEN Technology
www.leotek.com
www.liteon.com

GCA1 units are manufactured in USA and meet Buy American requirements within the ARRA.

RoHS Compliant

CN.051311

Information provided subject to change without notice.

STREETWORKS™

energy solutions

DESCRIPTION

The OVF LED area luminaire provides uncompromising optical performance and outstanding versatility for a wide variety of area and roadway applications. Patented modular LightBAR™ technology delivers uniform and energy-conscious illumination to walkways, parking lots, and roadways. UL/cUL Listed for wet locations.

Catalog #		Type
Project		
Comments		Date
Prepared by		

SPECIFICATION FEATURES

Construction
Heavy-duty cast aluminum housing and removable door 3G vibration rated to ensure strength of construction and longevity in application. Die-cast aluminum door frame features integral hinges for toolless maintenance access.

Optics
Choice of thirteen (13) patented, high-efficiency AccuLED Optics™ manufactured from injection-molded acrylic. Optics are precisely designed to shape the distribution maximizing efficiency and application spacing. AccuLED Optics create consistent distributions with the scalability to meet customized application requirements. Offered standard in 4000K (+/- 275K) CCT and 70 CRI nominal.

Electrical
LED drivers hard mount to die-cast aluminum back casting for optimal heat sinking and operation efficiency. 120-277V 50/60Hz, 347V 60Hz or 480V 60Hz operation. Shipped standard with the Cooper Lighting proprietary circuit module designed to withstand 10kV of transient line surge. Thermal management incorporates both conduction and natural convection to transfer heat rapidly away from the LED source and retain optimal efficiency and light output. OVF LED luminaire is suitable for temperature operation from -30°C to 40°C (-22°F to 104°F). Standard three position tunnel type compression terminal block. 60,000 life with > 70% lumen maintenance. LightBARs feature IP66 enclosure rating.

Mounting
Two-bolt/one bracket slipfitter with cast-in pipe stop and leveling steps. Fixed-in-place birdguard seals around 1-1/4" or 2" mounting arms.

Finish
Components finished in a standard grey 5 stage Super TGIC polyester powder coat paint, 2.5 mil nominal thickness for superior protection against fade and wear. Consult your Cooper Lighting representative for a complete selection of standard colors including black and bronze. RAL and custom color matches available.

Warranty
OVF LED features a five-year limited warranty.

OVF LED
ROADWAY LARGE COBRAHEAD

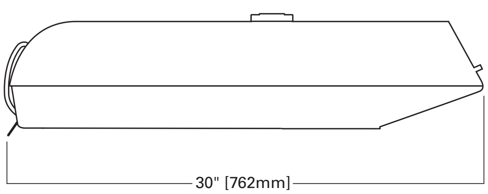
1 - 6 LightBARs

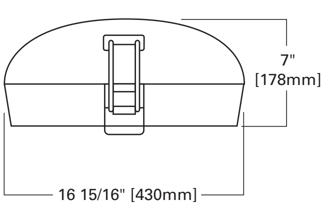
LED

ROADWAY LUMINAIRE

SustainabLEDesign™

DIMENSIONS





CERTIFICATION DATA
UL/cUL Listed
ISO 9001
IP66 LightBARs
3G Vibration Rated
ARRA Compliant

ENERGY DATA
Electronic LED Driver
>0.9 Power Factor
<20% Total Harmonic Distortion
120-277V/50 & 60Hz, 347V/60Hz, 480V/60Hz
-30°C Minimum Temperature
40°C Ambient Temperature Rating

EPA
Effective Projected Area: (Sq. Ft.) .87

SHIPPING DATA
Approximate Net Weight:
35 lbs.

SYSTEMS ISO CERTIFIED

POWER AND LUMENS BY BAR COUNT

Number of LightBARs				DISTRIBUTION											
	Power [Watts]	Current @ 120V [A]	Current @ 277V [A]	T2A	T3A	T3S	T4S	SL2	SL3	SL4	5MQ	5WQ	5XQ	RWQ	SLR/SLL
	7 LED LIGHTBAR														
C01	27	0.23	0.13	1,819	1,798	1,757	1,811	1,805	1,746	1,734	1,923	1,930	1,868	1,834	1,660
C02	54	0.46	0.21	3,509	3,469	3,391	3,495	3,484	3,368	3,347	3,711	3,724	3,605	3,540	3,203
C03	77	0.65	0.29	5,291	5,230	5,112	5,269	5,252	5,078	5,046	5,594	5,614	5,436	5,337	4,829
C04	101	0.86	0.37	6,983	6,902	6,747	6,954	6,932	6,703	6,660	7,383	7,410	7,174	7,043	6,373
C05	131	1.11	0.50	8,362	8,265	8,079	8,327	8,300	8,026	7,975	8,841	8,872	8,590	8,434	7,631
C06	154	1.30	0.58	10,119	10,002	9,777	10,077	10,045	9,712	9,651	10,699	10,737	10,396	10,206	9,235
	21 LED LIGHTBAR														
B01	27	0.23	0.13	2,237	2,211	2,161	2,228	2,220	2,147	2,133	2,365	2,374	2,298	2,256	2,041
B02	51	0.43	0.20	4,317	4,267	4,171	4,299	4,285	4,143	4,117	4,564	4,580	4,435	4,354	3,940
B03	73	0.62	0.28	6,508	6,433	6,288	6,481	6,460	6,246	6,207	6,881	6,906	6,686	6,564	5,939
B04	95	0.81	0.35	8,589	8,490	8,299	8,554	8,526	8,244	8,192	9,081	9,114	8,824	8,663	7,839
B05	124	1.05	0.48	10,285	10,166	9,938	10,242	10,209	9,871	9,809	10,874	10,913	10,566	10,373	9,386
B06	146	1.24	0.56	12,446	12,302	12,026	12,395	12,355	11,946	11,871	13,159	13,207	12,786	12,554	11,359

LUMEN MULTIPLIER

Ambient Temperature	Lumen Multiplier
10°C	1.04
15°C	1.03
25°C	1.00
40°C	0.96
50°C	0.92

ORDERING INFORMATION

SAMPLE NUMBER: OVFB06LEDEUT3S

OVF		LED						

Product Family
OVF=Luminaire

Number of LightBARs [1, 2]
B01=[1] 21 LED LightBAR
B02=[2] 21 LED LightBARs
B03=[3] 21 LED LightBARs
B04=[4] 21 LED LightBARs
B05=[5] 21 LED LightBARs
B06=[6] 21 LED LightBARs
C01=[1] 7 LED LightBAR
C02=[2] 7 LED LightBARs
C03=[3] 7 LED LightBARs
C04=[4] 7 LED LightBARs
C05=[5] 7 LED LightBARs
C06=[6] 7 LED LightBARs

Lamp Type
LED=Solid State Light-Emitting Diodes

Ballast Type
E=Electronic

Voltage
U=Universal (120-277V)
8=480V
9=347V

Distribution
T2A=Type II Area
T3A=Type III Area
T3S=Type III Short
T4S=Type IV Short
SL2=Type II w/Spill Control
SL3=Type III w/Spill Control
SL4=Type IV w/Spill Control
5MQ=Type V Square Medium
5WQ=Type V Square Wide
5XQ=Type V Square Extra Wide
RWQ=Rectangular Wide
SLL=90 Degree Spill Light Eliminator Left
SLR=90 Degree Spill Light Eliminator Right

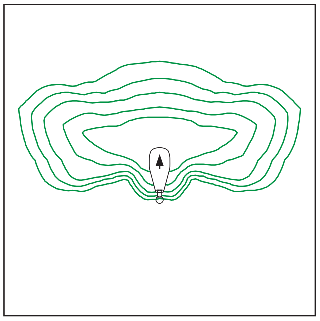
Colors
WH=White
BK=Black
BZ=Bronze
A=Raw Aluminum Unfinished

Options [3]
LCF=LightBAR Cover Plate Matches Housing Finish
R90=Optics Rotated Right 90 Degrees
L90=Optics Rotated Left 90 Degrees
4=NEMA Photocontrol Receptacle
K=Level Indicator
U=UL Listed/CSA Certified
7060=70 CRI 6000K CCT [4]
8030=80 CRI 3000K CCT [4]
2L=Bi-Level Switching [6]
HA=50 Degree C High Ambient Temperature Rating

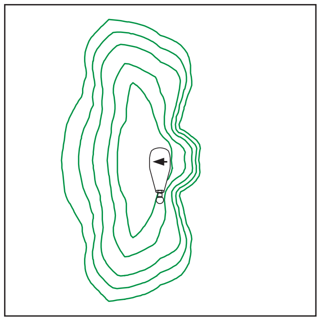
Accessories [5]
OA/RA1016=NEMA Photocontrol - Multi-Tap
OA/RA1013=Photocontrol Shorting Cap
OA/RA1014=120V Photocontrol
OA1223=10kV Circuit Module Replacement

NOTE: **1** 21 LED LightBAR powered at 350mA, 7 LED LightBAR powered at 1 A.
2 Standard 4000K CCT and nominal 70 CRI.
3 Add as suffix.
4 Consult factory for lead times and lumen multiplier.
5 Order separately.
6 Low-level output varies by bar count. Consult factory. Requires 2 or more LightBARs.

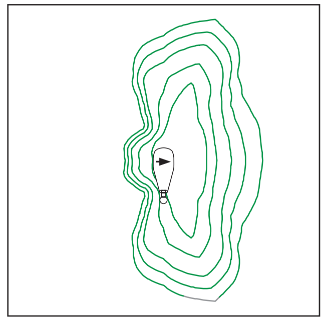
OPTIC ORIENTATION



Standard



Optics Rotated Left @ 90° [L90]



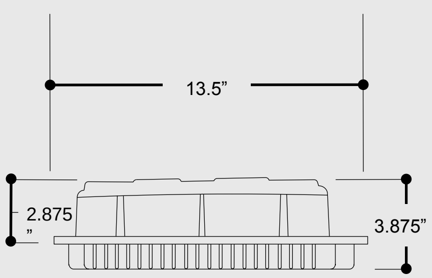
Optics Rotated Right @ 90° [R90]

EcoFit® LED Light Engine

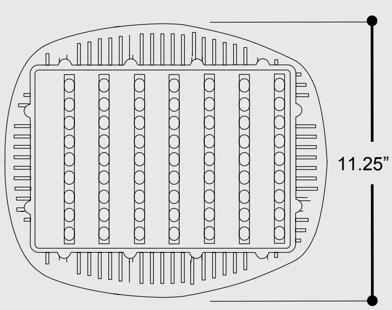
The smart solution. The right fit.™

Made in the USA

Meets ARRA Guidelines
Manufactured in Lee's Summit, MO



Product weight = 13 pounds.



Universal Application

Roadway

Parking Lot – shoebox, pendant, post-top (*with adapter plate*)

Parking Garage – housing required

Indoor High Bay – housing required

Independent Performance Tests

EcoFit provides 3rd party validation from the most recognized testing laboratories available on **www.ecofitlighting.com**.

- **Photometrics (**LM-79**)**
- **Thermal management (**LM-80**)**
- **Safety (**UL 8750/1598, CSA C22.2**)**
- **Corrosion (**ASTM-B117**)**
- **ISO 9000-2001 manufacturer**
- **RoHS compliant**
- **Ingress protection (**IP-66**)**
- **Pole vibration (**ANSI-C136.3**)**
- **Mechanical stress**
- **Surge Protection (**IEEE C62.45**)**
- **Transient protection (**IEEE C62.41**)**
- **Noise (**47CFR-15B**)**

Approvals and Endorsements

Design Lights Consortium approved

DOE Lighting Facts listed (all models)

Cree LED City/University approved

International Dark Sky Association approved

PG&E Pre-qualified vendor

SCE Pre-qualified vendor

Specifications subject to change without notice.

U.S. Patents D611647, D611648. Other U.S. and International patents pending.

Revision 4.0 (3/11)

EcoFit Lighting
8527 Bluejacket Street
Lenexa, Kansas 66214
(866) 789-9449
www.ecofitlighting.com

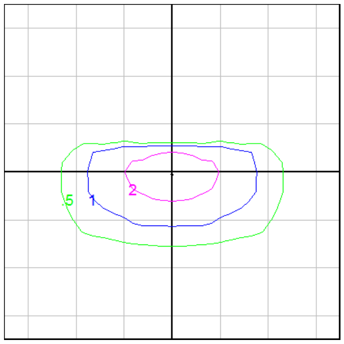
EcoFit® LED Light Engine

The smart solution. The right fit.™

Photometrics

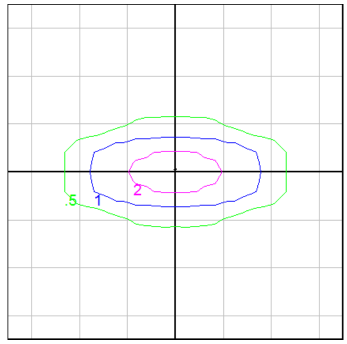
Isofootcandle Plots
Initial footcandles at grade
63/525mA unit example

Type III



Gridlines represent units of mounting height
Values based on 20 foot mounting height

Type V



Gridlines represent units of mounting height
Values based on 20 foot mounting height

Standard Features

- **0-10V dimming**
- **Overtemp protection**
- **Lightning Arrestor** (10kV/5kA)
- **Warranty –** 5 year on power supply, LEDs, 10 year on chassis/housing

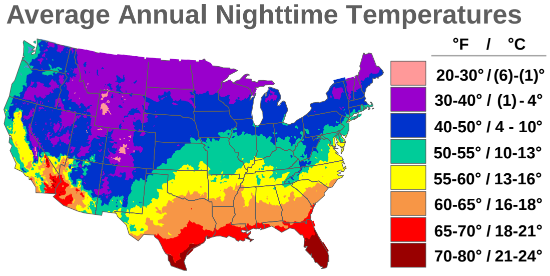
LED & Electrical Performance

Model	Drive Current (mA)	CRI	Input Power (W)	Input Current (120V)	Input Current (240V)	Type III Delivered Lumens	Type III Total System Efficacy (Lm/W)	Type V Delivered Lumens	Type V Total System Efficacy (Lm/W)
30	350	≥80	37	0.317A	0.185A	2,265	61	2,262	60
30	525	≥81	56	0.481A	0.235A	3,005	54	2,973	52
42	350	≥81	48	0.408A	0.223A	3,144	65	3,180	65
42	525	≥81	73	0.620A	0.322A	4,145	57	4,192	56
63	350	≥81	70	0.588A	0.308A	4,533	64	4,488	65
63	525	≥ 82	106	0.892A	0.450A	5,900	56	5,784	55

1 Input voltage (120-277 VAC.), 480V also available.
2 Operating frequency 50-60 Hz
3 Power factor > 0.90, THD < 20%.
4 All BUG Ratings are B2-U1-G1 or below.

LED Junction Temperature (T_J) & Projected L_{70} Life

Average Annual Nighttime Temperatures



Source: National Climatic Data Center, U.S. Department of Commerce

L70 Lifetime Expectancy (LM 80 Test Data)

Model		Average Nighttime Outdoor Temperature							
LEDs	Drive Current	<32°F (0°C)	41°F (5°C)	50°F (10°C)	59°F (15°C)	68°F (20°C)	77°F (25°C)	86°F (30°C)	95°F (35°C)
30	350	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000
30	525	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000
42	350	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000	>100,000
42	525	>100,000	>100,000	>100,000	>100,000	90,000	80,000	80,000	65,000
63	350	>100,000	>100,000	>100,000	>100,000	90,000	80,000	80,000	65,000
63	525	>100,000	95,000	85,000	75,000	75,000	70,000	65,000	60,000

[1] See www.EcoFitLighting.com for independent test results showing T_J at various outdoor temperatures.
[2] L_{70} life projections provided by Cree are based on LED junction temperature levels after reaching thermal equilibrium.

Ordering Information

D - 2/3 - 120/240 - 350 - CXPE - 30 - 4600 - CE

Product Series

Distribution
- **2/3** = Type II/III
- **5** = Type V

Input Voltage
- **120-240** = Universal (120-240 VAC)
- **277** = 277 VAC

LED Drive Current
- **350** = 350mA
- **525** = 525mA

LED Supplier
- **CXPE** = Cree X-PE

LED Quantity
- **30** = 30 LEDs
- 42 = 42 LEDs
- 63 - 63 LEDs

LED Color Temperature
- **4600** = 4600K (Neutral) Nominal

Other color temperatures available by request.**

Housing
- AP = Adaptor Plate
- **CE** = Ceiling
- **FL** = Floodlight
- **CO** = Cobra Head

Appendix B: Electrical Measurements

Table B1. Electrical measurements. Nominal values are from manufacturer specification sheets. Metered values are from measurements taken with a Fluke 434 Power Quality Analyzer using i5s low-level (5A) current clamps.

				Active Power (W)		
Area/ID	**Source**	**Manufacturer**	**Product Family**	**Nominal**	**Metered**	**Accuracy**
250 HPS	HPS	GE	M-400A Powr/Door	298	246.9	20.7%
A	LED	Philips Lumec	RoadView	300	264.8	13.3%
A	LED	Philips Lumec	RoadView	300	262.6	14.2%
B	LED	BetaLED	LEDway	272	269.7	0.9%
B	LED	BetaLED	LEDway	272	265.4	2.5%
100 HPS	HPS	GE	M-250A2 Powr/Door			
C	LED	Acuity American Electric	Autobahn	105	109.3	-3.9%
D	LED	LED Roadway Lighting	Satellite	107	113.3	-5.6%
E	LED	Lighting Science Group	Prolific Roadway	100	98.4	1.6%
F	LED	Philips Hadco	LEDGINE	96	96.9	-0.9%
150 HPS	HPS	GE	M-250A2 Powr/Door			
G	LED	BetaLED	LEDway	139	136.1	2.1%
H	LED	Leotek	Green Cobra	132	132.1	-0.1%
I	LED	Cooper Streetworks	OVF LED	154	164.5	-6.4%
J	LED	EcoFit	LED Light Engine	106	113.2	-6.4%

Appendix C: Measured Illuminance Summary Results

The tables providing measurement results list both AASHTO and IES design criteria. The City of Philadelphia usually follows AASHTO criteria, but often targets an average maintained illuminance of 2.0 fc. Measurements of initial illuminance do not indicate that a product will meet design criteria over time, but they can show non-compliance.

Table C1a. Kelly Drive: Measured initial horizontal illuminance. Red values already fail to meet AASHTO criteria. The measurements were taken the first evening following installation (i.e., they are initial measurements).

	AASHTO Criteria	IES RP-8-00 Criteria	HPS A	LED A	HPS B	LED B
Car Lanes						
Mean	**1.2**	**1.3**	3.25	3.88	2.50	3.59
Avg:Min	**3.0**	**3.0**	2.73	3.26	3.02	4.54
Minimum	**-**	**-**	1.19	1.19	0.83	0.79
Maximum	-	-	5.96	7.40	4.83	5.51
Max:Min	-	-	5.01	6.22	5.84	6.98

Table C1b. Kelly Drive: Predicted maintained horizontal illuminance, based on initial measured values. Red values fail to meet AASHTO criteria.

	AASHTO Criteria	IES RP-8-00 Criteria	HPS A	LED A	HPS B	LED B
Light Loss Factor			**0.77**	**0.63**	**0.77**	**0.63**
Car Lanes						
Mean	**1.2**	**1.3**	2.50	2.45	1.92	2.26
Avg:Min	**3.0**	**3.0**	2.73	3.26	3.02	4.54
Minimum	**-**	**-**	0.92	0.75	0.64	0.50
Maximum	**-**	**-**	4.59	4.66	3.72	3.47
Max:Min	**-**	**-**	5.01	6.22	5.84	6.97

Table C2a. **N 3rd Street: Measured horizontal illuminance.** Red values already fail to meet AASHTO criteria. The measurements were taken the first evening following installation (i.e., they are initial measurements). HPS measurements were not taken for Area C or Area F.

	AASHTO Criteria	IES RP-8-00 Criteria	LED C	HPS D	LED D	HPS E	LED E	LED F
Car Lanes								
Mean	**0.8**	**0.9**	2.58	2.62	3.91	3.17	2.86	1.74
Avg:Min	**4.0**	**4.0**	1.54	1.49	1.48	1.73	1.28	2.64
Minimum	**-**	**-**	1.67	1.76	2.64	1.83	2.24	0.66
Maximum	-	-	4.00	3.52	5.76	5.18	4.06	3.82
Max:Min	-	-	2.39	2.01	2.18	2.83	1.81	5.79
Sidewalk								
Mean	**0.8**	**0.5**	0.48	1.42	1.76	1.51	2.43	0.64
Avg:Min	**4.0**	**4.0**	1.43	1.43	2.39	2.00	1.50	1.75
Minimum	**-**	**-**	0.33	0.99	0.73	0.75	1.63	0.36
Maximum	**-**	-	0.86	2.37	2.29	2.37	3.70	0.98
Max:Min	**-**	-	2.58	2.38	3.11	3.15	2.27	2.69

Table C2b. **N 3rd Street: Predicted maintained horizontal illuminance, based on initial measured values.** Red values fail to meet AASHTO criteria. HPS measurements were not taken for Area C or Area F.

	AASHTO Criteria	IES RP-8-00 Criteria	LED C	HPS D	LED D	HPS E	LED E	LED F
Light Loss Factor			**0.63**	**0.77**	**0.63**	**0.77**	**0.63**	**0.63**
Car Lanes								
Mean	**0.8**	**0.9**	1.63	2.02	2.46	2.44	1.80	1.10
Avg:Min	**4.0**	**4.0**	1.54	1.49	1.48	1.73	1.28	2.64
Minimum	**-**	**-**	1.05	1.36	1.66	1.41	1.41	0.42
Maximum	-	-	2.52	2.71	3.63	3.99	2.56	2.41
Max:Min	-	-	2.40	2.00	2.18	2.83	1.81	5.79
Sidewalk								
Mean	**0.8**	**0.5**	0.30	1.09	1.11	1.16	1.53	0.40
Avg:Min	**4.0**	**4.0**	1.45	1.43	2.41	2.01	1.49	1.78
Minimum	**-**	**-**	0.21	0.76	0.46	0.58	1.03	0.23
Maximum	**-**	-	0.54	1.82	1.44	1.82	2.33	0.62
Max:Min	**-**	-	2.61	2.39	3.14	3.16	2.27	2.72

Table C3a. **Kensington Avenue: Measured horizontal illuminance.** Red values already fail to meet AASHTO criteria. The measurements were taken the first evening following installation (i.e., they are initial measurements). HPS measurements were not taken for Area G or Area J.

	AASHTO Criteria	IES RP-8-00 Criteria	LED G	HPS H	LED H	HPS I	LED I	LED J
Car Lanes								
Mean	**1.0**	**0.9**	3.31	2.41	4.16	3.04	5.95	4.49
Avg:Min	**4.0**	**4.0**	2.05	1.63	1.31	1.63	1.12	1.26
Minimum	**-**	**-**	1.62	1.48	3.18	1.87	5.31	3.58
Maximum	-	-	5.41	5.01	5.32	6.05	6.83	5.29
Max:Min	-	-	3.34	3.39	1.67	3.24	1.29	1.48
Bicycle Lanes								
Mean	**1.0**	**0.5**	5.42	3.44	4.06	4.80	5.86	4.63
Avg:Min	**4.0**	**4.0**	1.18	1.62	1.19	1.38	1.15	1.05
Minimum	**-**	**-**	4.61	2.12	3.40	3.49	5.09	4.41
Maximum	-	-	6.71	4.66	4.59	6.05	6.68	5.03
Max:Min	-	-	1.46	2.20	1.35	1.74	1.31	1.14
Sidewalk								
Mean	**1.0**	**0.5**	5.05	5.36	6.07	4.70	3.86	1.53
Avg:Min	**4.0**	**4.0**	1.57	2.21	1.34	1.46	1.16	1.12
Minimum	**-**	**-**	3.22	2.43	4.53	3.22	3.34	1.37
Maximum	**-**	-	8.02	9.16	8.36	5.59	4.58	1.85
Max:Min	**-**	-	2.49	3.78	1.85	1.73	1.37	1.35

Table C3b. Kensington Avenue: Predicted maintained horizontal illuminance, based on initial measured values. Red values fail to meet AASHTO criteria. HPS measurements were not taken for Area G or Area J.

	AASHTO Criteria	IES RP-8-00 Criteria	LED G	HPS H	LED H	HPS I	LED I	LED J
Light Loss Factor			**0.63**	**0.77**	**0.63**	**0.77**	**0.63**	**0.63**
Car Lanes								
Mean	**1.0**	**0.9**	2.09	1.86	2.62	2.34	3.75	2.83
Avg:Min	**4.0**	**4.0**	2.04	1.63	1.31	1.63	1.12	1.25
Minimum	**-**	**-**	1.02	1.14	2.00	1.44	3.35	2.26
Maximum	-	-	3.41	3.86	3.35	4.66	4.30	3.33
Max:Min	-	-	5.01	5.01	5.01	5.01	5.01	5.01
Bicycle Lanes								
Mean	**1.0**	**0.5**	3.41	2.65	2.56	3.70	3.69	2.92
Avg:Min	**4.0**	**4.0**	1.18	1.62	1.19	1.38	1.15	1.05
Minimum	**-**	**-**	2.90	1.63	2.14	2.69	3.21	2.78
Maximum	-	-	4.23	3.59	2.89	4.66	4.21	3.17
Max:Min	-	-	1.46	2.20	1.35	1.73	1.31	1.14
Sidewalk								
Mean	**1.0**	**0.5**	3.18	4.13	3.82	3.62	2.43	0.96
Avg:Min	**4.0**	**4.0**	1.57	2.21	1.34	1.46	1.16	1.12
Minimum	**-**	**-**	2.03	1.87	2.85	2.48	2.10	0.86
Maximum	**-**	-	5.05	7.05	5.27	4.30	2.89	1.17
Max:Min	**-**	-	2.49	3.77	1.85	1.74	1.37	1.35

Appendix D: Calculated Illuminance Summary Results

Method One

The calculations in Tables D2–D4 use a pole spacing corresponding to the field measurements for each individual area (see Table D1). They are most directly comparable to the measured results. The two main factors contributing to discrepancies between measured and calculated values are differences between rated and actual lumen output and contributions from luminaires not included in the calculation (e.g., floodlights on an adjacent property), although many other factors may also play a role. Due to the different area illuminated by each source type, *it is inappropriate to compare performance between areas*, although comparisons between LED and HPS for a given area are valid.

Table D1. Pole spacing (feet) used for calculation method one.

Area		A	B	C	D	E	F	G	H	I	J
Pole Spacing (ft)	1-2	121.0	113.5	92.0	102.0	106.0	101.0	52.5	52.5	52.5	52.0
	2-3*	71.0	82.0	92.0	60.0	72.0	123.5	55.0	58.0	46.0	52.0
	3-4	90.5	112.0	110.0	89.0	100.0	108.0	52.5	52.5	52.5	54.0

* Pole interval used for measurements and calculations.

Table D2a. Kelly Drive: Calculated initial horizontal illuminance, using pole spacings reported in Table D1. Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS A	LED A	HPS B	LED B
Car Lanes					
Mean	**1.2**	3.36	3.87	3.04	3.13
Avg:Min	**3.0**	4.73	4.78	4.11	8.24
Minimum	**-**	0.71	0.81	0.74	0.38
Maximum	**-**	6.43	9.22	6.12	6.12
Max:Min	**-**	9.06	11.38	2.23	16.11

Table D2b. Kelly Drive: Calculated maintained horizontal illuminance, using pole spacings reported in Table D1. Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS A	LED A	HPS B	LED B
Light Loss Factor		**0.77**	**0.63**	**0.77**	**0.63**
Car Lanes					
Mean	**1.2**	2.59	2.44	2.34	1.97
Avg:Min	**3.0**	4.73	4.78	4.11	8.24
Minimum	**-**	0.55	0.51	0.57	0.24
Maximum	**-**	4.95	5.81	4.71	3.86
Max:Min	**-**	9.06	11.38	2.23	16.11

Table D3a. **N 3rd Street: Calculated initial horizontal illuminance, using pole spacings reported in Table D1.** Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS C	LED C	HPS D	LED D	HPS E	LED E	HPS F	LED F
Car Lanes									
Mean	**0.8**	1.66	2.36	2.30	3.13	2.00	2.45	1.21	1.33
Avg:Min	**4.0**	2.24	1.41	1.29	1.45	1.64	1.34	2.33	2.56
Minimum	**-**	0.74	1.67	1.78	2.16	1.22	1.83	0.52	0.52
Maximum	**-**	2.41	3.13	2.72	4.38	2.60	3.11	2.25	2.75
Max:Min	**-**	3.26	1.87	1.53	2.03	2.13	1.70	4.33	5.29
Sidewalk									
Mean	**0.8**	0.83	0.98	1.04	1.18	0.97	1.58	0.62	0.51
Avg:Min	**4.0**	2.08	1.46	1.65	2.03	1.73	1.53	2.95	3.00
Minimum	**-**	0.40	0.67	0.63	0.58	0.56	1.03	0.21	0.17
Maximum	**-**	1.31	1.82	1.37	1.79	1.31	1.89	1.11	0.85
Max:Min	**-**	3.28	2.72	2.17	3.09	2.34	1.83	5.29	5.00

Table D3b. **N 3rd Street: Calculated maintained horizontal illuminance, using pole spacings reported in Table D1.** Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS C	LED C	HPS D	LED D	HPS E	LED E	HPS F	LED F
Light Loss Factor		**0.77**	**0.63**	**0.77**	**0.63**	**0.77**	**0.63**	**0.77**	**0.63**
Car Lanes									
Mean	**1.2**	1.28	1.49	1.77	1.97	1.54	1.54	0.93	0.84
Avg:Min	**3.0**	2.24	1.41	1.29	1.45	1.64	1.34	2.33	2.56
Minimum	**-**	0.57	1.05	1.37	1.36	0.94	1.15	0.40	0.33
Maximum	**-**	1.86	1.97	2.09	2.76	2.00	1.96	1.73	1.73
Max:Min	**-**	3.26	1.87	1.53	2.03	2.13	1.70	4.33	5.29
Sidewalk									
Mean	**0.8**	0.64	0.62	0.80	0.74	0.75	1.00	0.48	0.32
Avg:Min	**4.0**	2.08	1.46	1.65	2.03	1.73	1.53	2.95	3.00
Minimum	**-**	0.31	0.42	0.49	0.37	0.43	0.65	0.16	0.11
Maximum	**-**	1.01	1.15	1.05	1.13	1.01	1.19	0.85	0.54
Max:Min	**-**	3.28	2.72	2.17	3.09	2.34	1.83	5.29	5.00

Table D4a. **Kensington Avenue: Calculated <u>initial</u> horizontal illuminance, using pole spacings reported in Table D1.** No values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS G	LED G	HPS H	LED H	HPS I	LED I	HPS J	LED J
Car Lanes									
Mean	**1.0**	3.15	4.00	3.09	4.32	3.64	5.29	3.26	4.01
Avg:Min	**4.0**	1.63	1.17	1.71	1.28	1.52	1.13	1.59	1.13
Minimum	**-**	1.93	3.43	1.81	3.38	2.39	4.69	2.05	3.56
Maximum	**-**	5.21	4.52	5.32	5.52	5.50	5.92	5.10	4.39
Max:Min	**-**	2.70	1.32	2.94	1.63	2.30	1.26	2.49	1.23
Bicycle Lanes									
Mean	**1.0**	5.16	5.26	5.02	4.08	5.97	4.98	5.33	4.28
Avg:Min	**4.0**	1.55	1.24	1.67	1.23	1.25	1.12	1.43	1.04
Minimum	**-**	3.33	4.25	3.01	3.33	4.79	4.45	3.74	4.13
Maximum	**-**	7.06	6.03	7.19	4.77	7.32	5.50	6.96	4.42
Max:Min	**-**	2.12	1.42	2.39	1.43	1.53	1.24	1.86	1.07
Sidewalk									
Mean	**1.0**	4.98	4.37	4.82	4.04	5.21	3.22	5.06	1.22
Avg:Min	**4.0**	1.09	1.37	1.08	1.22	1.09	1.06	1.11	1.04
Minimum	**-**	4.56	3.18	4.47	3.30	4.77	3.04	4.57	1.17
Maximum	**-**	5.49	5.52	5.27	4.52	6.06	3.39	5.77	1.26
Max:Min	**-**	1.20	1.74	1.18	1.37	1.27	1.12	1.26	1.08

Table D4b. **Kensington Avenue: Calculated maintained horizontal illuminance, using pole spacings reported in Table D1.** Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS G	LED G	HPS H	LED H	HPS I	LED I	HPS J	LED J
Light Loss Factor		**0.77**	**0.63**	**0.77**	**0.63**	**0.77**	**0.63**	**0.77**	**0.63**
Car Lanes									
Mean	**1.0**	2.43	2.52	2.38	2.72	2.80	3.33	2.51	2.53
Avg:Min	**4.0**	1.63	1.17	1.71	1.28	1.52	1.13	1.59	1.13
Minimum	**-**	1.49	2.16	1.39	2.13	1.84	2.95	1.58	2.24
Maximum	**-**	4.01	2.85	4.10	3.48	4.24	3.73	3.93	2.77
Max:Min	**-**	5.01	5.01	5.01	5.01	5.01	5.01	5.01	5.01
Bicycle Lanes									
Mean	**1.0**	3.97	3.31	3.87	2.57	4.60	3.14	4.10	2.70
Avg:Min	**4.0**	1.55	1.24	1.67	1.23	1.25	1.12	1.43	1.04
Minimum	**-**	2.56	2.68	2.32	2.10	3.69	2.80	2.88	2.60
Maximum	**-**	5.44	3.80	5.54	3.01	5.64	3.47	5.36	2.78
Max:Min	**-**	2.12	1.42	2.39	1.43	1.53	1.24	1.86	1.07
Sidewalk									
Mean	**1.0**	3.83	2.75	3.71	2.55	4.01	2.03	3.90	0.77
Avg:Min	**4.0**	1.09	1.37	1.08	1.22	1.09	1.06	1.11	1.04
Minimum	**-**	3.51	2.00	3.44	2.08	3.67	1.92	3.52	0.74
Maximum	**-**	4.23	3.48	4.06	2.85	4.67	2.14	4.44	0.79
Max:Min	**-**	1.20	1.74	1.18	1.37	1.27	1.12	1.26	1.08

Method Two

The calculations in Tables D5–D7 use a pole spacing corresponding to the nominal (i.e., rounded) average for each of the three sites: 100 feet for Kelly Drive and N 3rd Street, 55 feet for Kensington Avenue. These calculations are not comparable to the measured results, but provide a basis for comparing the LED luminaires against one another, much as would be done when trying to select a single product for an application.

Table D5a. Kelly Drive: Calculated initial horizontal illuminance, using 100-foot pole spacings. Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED A	LED B
Car Lanes				
Mean	**1.2**	2.57	2.89	2.65
Avg:Min	**3.0**	4.59	5.56	7.57
Minimum	**-**	0.56	0.52	0.35
Maximum	-	5.88	8.67	6.00
Max:Min	-	10.50	16.67	17.14

Table D5b. Kelly Drive: Calculated maintained horizontal illuminance, using 100-foot pole spacings. Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED A	LED B
Light Loss Factor		**0.77**	**0.63**	**0.63**
Car Lanes				
Mean	**1.2**	1.98	1.82	1.67
Avg:Min	**3.0**	4.59	5.56	7.57
Minimum		0.43	0.33	0.22
Maximum		4.53	5.46	3.78
Max:Min		10.50	16.67	17.14

Table D6a. **N 3rd Street: Calculated <u>initial</u> horizontal illuminance, using 100-foot pole spacings.** Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED C	LED D	LED E	LED F
Car Lanes						
Mean	**0.8**	1.54	2.19	1.99	1.79	1.69
Avg:Min	**4.0**	2.37	1.54	1.79	1.17	1.90
Minimum	**-**	0.65	1.42	1.11	1.53	0.89
Maximum	-	2.36	3.04	2.80	2.10	2.93
Max:Min	-	3.63	2.14	2.52	1.37	3.29
Sidewalk						
Mean	**0.8**	0.77	0.92	0.79	1.15	0.65
Avg:Min	**4.0**	2.20	1.53	2.82	2.50	2.32
Minimum		0.35	0.60	0.28	0.46	0.28
Maximum		1.25	1.76	1.13	1.62	0.91
Max:Min		3.57	2.93	4.04	3.52	3.25

Table D6b. **N 3rd Street: Calculated <u>maintained</u> horizontal illuminance, using 100-foot pole spacings.** Red values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED C	LED D	LED E	LED F
Light Loss Factor		**0.77**	**0.63**	**0.63**	**0.63**	**0.63**
Car Lanes						
Mean	**0.8**	1.19	1.38	1.25	1.13	1.06
Avg:Min	**4.0**	2.37	1.54	1.79	1.17	1.90
Minimum	**-**	0.50	0.89	0.70	0.96	0.56
Maximum	-	1.82	1.92	1.76	1.32	1.85
Max:Min	-	3.63	2.14	2.52	1.37	3.29
Sidewalk						
Mean	**0.8**	0.59	0.58	0.50	0.72	0.41
Avg:Min	**4.0**	2.20	1.53	2.82	2.50	2.32
Minimum	**-**	0.27	0.38	0.18	0.29	0.18
Maximum	-	0.96	1.11	0.71	1.02	0.57
Max:Min	-	3.57	2.93	4.04	3.52	3.25

Table D7a. Kensington Avenue: Calculated <u>initial</u> horizontal illuminance, using 55-foot pole spacings. No values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED G	LED H	LED I	LED J
Car Lanes						
Mean	**1.0**	3.16	3.98	4.39	4.60	3.81
Avg:Min	**4.0**	1.65	1.17	1.23	1.25	1.14
Minimum	**-**	1.92	3.41	3.58	3.69	3.33
Maximum	-	5.18	4.49	5.56	5.59	4.17
Max:Min	-	2.70	1.32	1.55	1.51	1.25
Bicycle Lanes						
Mean	**1.0**	5.12	5.23	4.17	4.32	4.06
Avg:Min	**4.0**	1.54	1.25	1.17	1.22	1.06
Minimum	**-**	3.32	4.20	3.57	3.54	3.83
Maximum	-	6.98	6.01	4.71	5.17	4.23
Max:Min	-	2.10	1.43	1.32	1.46	1.10
Sidewalk						
Mean	**1.0**	4.85	4.34	4.15	2.83	1.16
Avg:Min	**4.0**	1.09	1.37	1.17	1.13	1.04
Minimum	**-**	4.47	3.16	3.56	2.50	1.12
Maximum	-	5.36	5.47	4.53	3.15	1.20
Max:Min	-	1.20	1.73	1.27	1.26	1.07

Table D7b. Kensington Avenue: Calculated <u>maintained</u> horizontal illuminance, using 55-foot pole spacings. No values fail to meet AASHTO criteria.

	AASHTO Criteria	HPS	LED G	LED H	LED I	LED J
Light Loss Factor		**0.77**	**0.63**	**0.63**	**0.63**	**0.63**
Car Lanes						
Mean	**1.0**	2.43	2.51	2.77	2.90	2.40
Avg:Min	**4.0**	1.65	1.17	1.23	1.25	1.14
Minimum	**-**	1.48	2.15	2.26	2.32	2.10
Maximum	-	3.99	2.83	3.50	3.52	2.63
Max:Min	-	5.01	5.01	5.01	5.01	5.01
Bicycle Lanes						
Mean	**1.0**	3.94	3.29	2.63	2.72	2.56
Avg:Min	**4.0**	1.54	1.25	1.17	1.22	1.06
Minimum	**-**	2.56	2.65	2.25	2.23	2.41
Maximum	-	5.37	3.79	2.97	3.26	2.66
Max:Min	-	2.10	1.43	1.32	1.46	1.10
Sidewalk						
Mean	**1.0**	3.73	2.73	2.61	1.78	0.73
Avg:Min	**4.0**	1.09	1.37	1.17	1.13	1.04
Minimum	**-**	3.44	1.99	2.24	1.58	0.71
Maximum	-	4.13	3.45	2.85	1.98	0.76
Max:Min	-	1.20	1.73	1.27	1.26	1.07

Appendix E: Example Questionnaire Form, General Population

Name & Email (Optional, if you would like more information):

____

Age: 18-29 / 30-39 / 40-49 / 50-59 / 60+

Gender: M / F

Do you live on this street? Yes / No

Questionnaire:

1. The amount of light on this block is:
   a. Far too little
   b. Too little
   c. Just right
   d. Too much
   e. Far too much

2. Compared to other nearby streets (the typical lighting in Philadelphia), the lighting on this block makes me feel safer:
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

3. Compared to other nearby streets (the typical lighting in Philadelphia), I prefer the color of the light on this block:
   a. Strongly Disagree
   b. Disagree
   c. Agree
   d. Strongly Agree

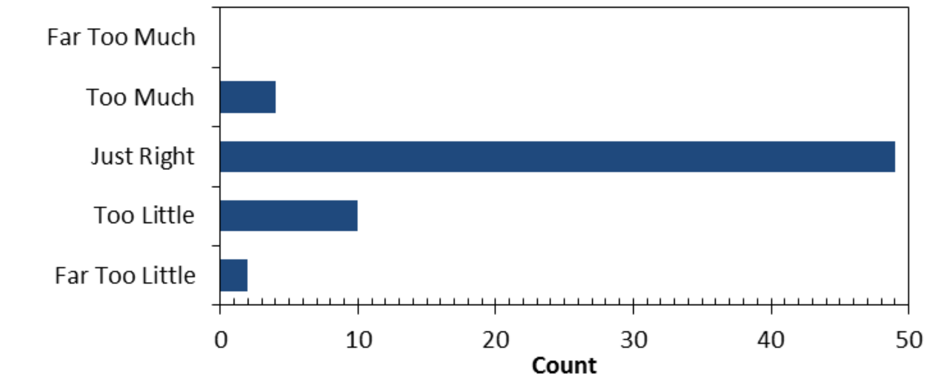
4. Compared to the lighting that is typical of other streets in Philadelphia, the lighting on this block is:
   a. Much better
   b. Slightly better
   c. Slightly worse
   d. Much worse

   The factor most heavily influencing my opinion is:
   a. How comfortable the lighting is
   b. The amount of light
   c. The color of the light
   d. Other: ______________________________

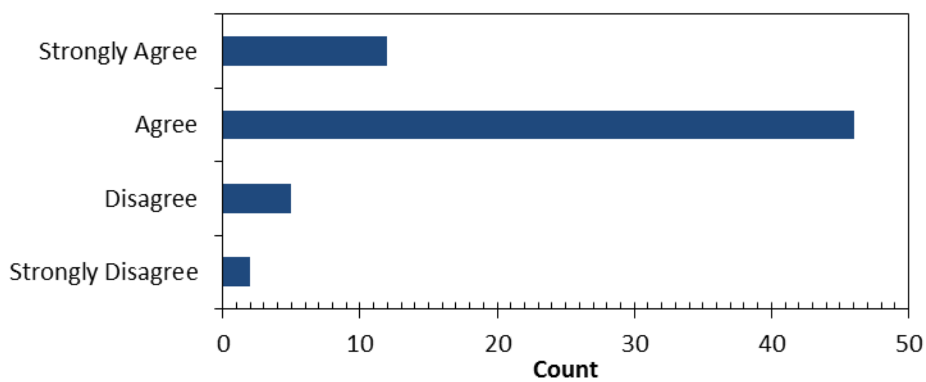
Appendix F: Histogram of Questionnaire Responses, General Population

N 3rd Street

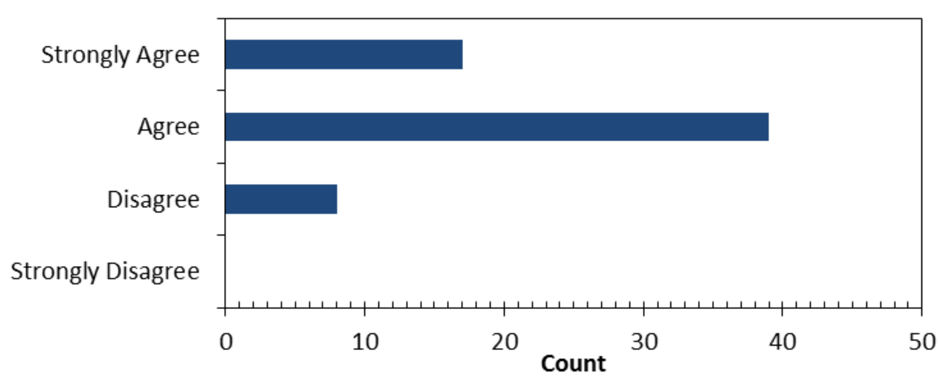
1. The amount of light on this block is:



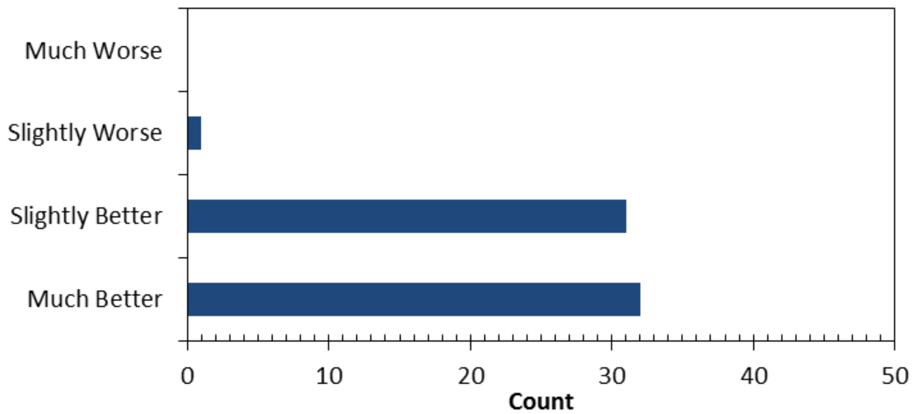
2. Compared to other nearby streets (the typical lighting in Philadelphia), the lighting on this block makes me feel safer:



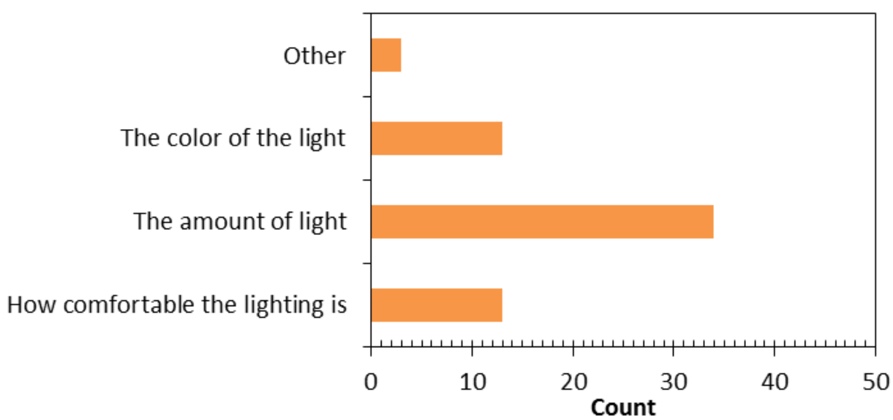
3. Compared to other nearby streets (the typical lighting in Philadelphia), I prefer the color of the light on this block:



4. Compared to the lighting that is typical of other streets in Philadelphia, the lighting on this block is:

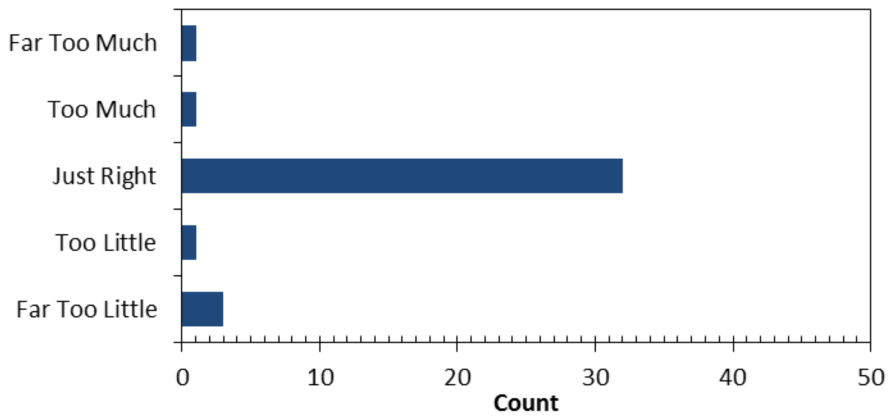


The factor most heavily influencing my opinion is:

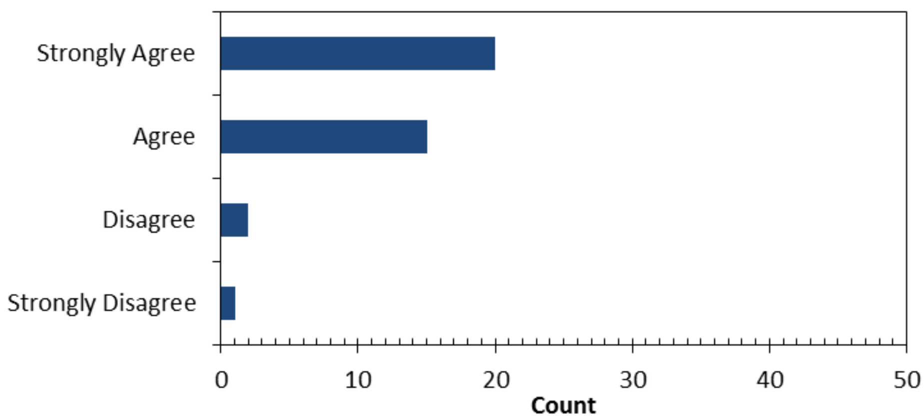


Kensington Avenue

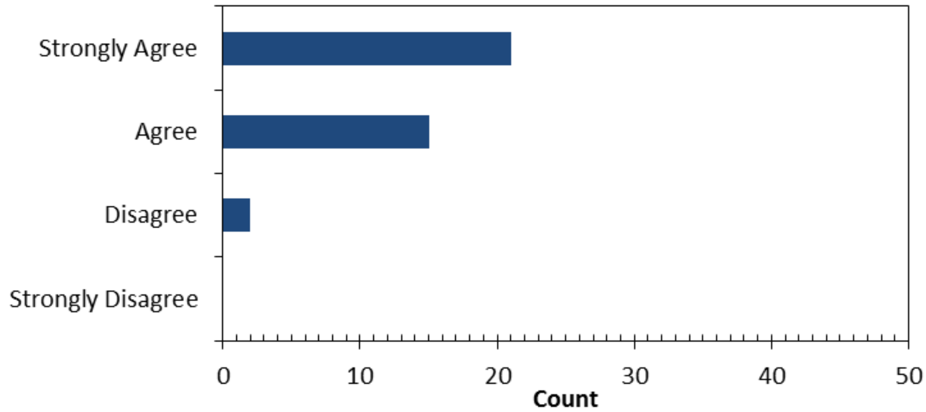
1. The amount of light on this block is:



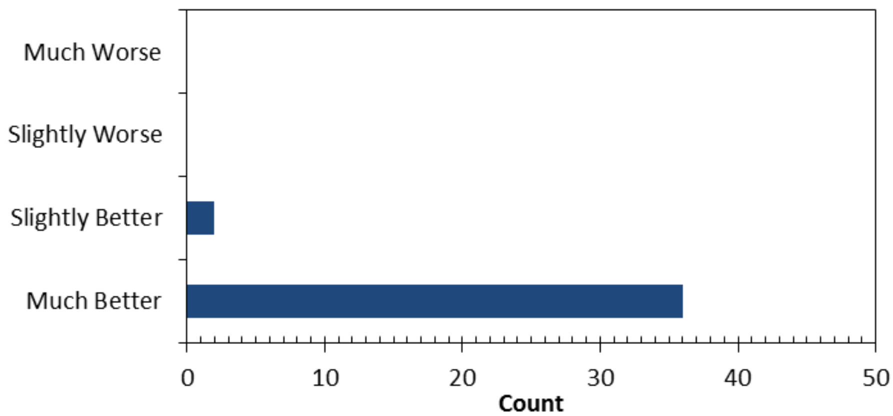
2. Compared to other nearby streets (the typical lighting in Philadelphia), the lighting on this block makes me feel safer:



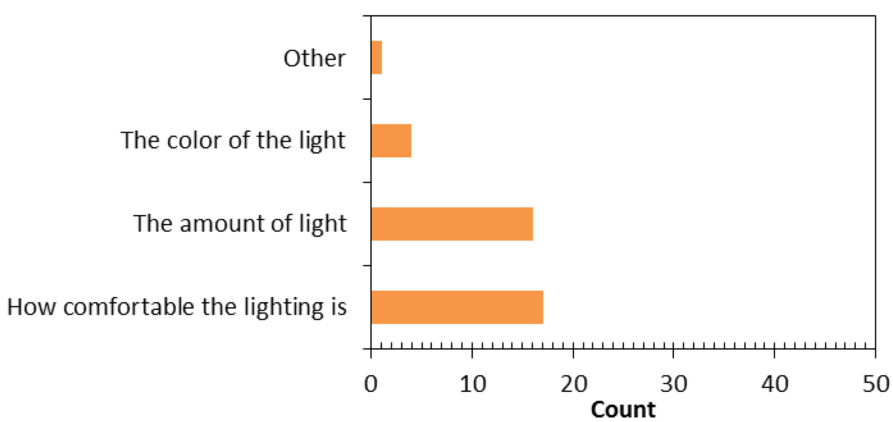
3. Compared to other nearby streets (the typical lighting in Philadelphia), I prefer the color of the light on this block:



4. Compared to the lighting that is typical of other streets in Philadelphia, the lighting on this block is:



The factor most heavily influencing my opinion is:



Appendix G: Example Questionnaire Form, Lighting Professionals

Philadelphia Street Lighting Questionnaire

Thank you for your participation in this event! The feedback you provide is very valuable.

Instructions

Tonight you will visit a number of different areas—each with a different luminaire installed—to evaluate the lighting. The areas are labeled on the included maps.

At each area, you will respond with your opinion regarding the same nine statements. For each statement, you are asked to circle one number on the scale. The endpoints of the scale are the extremes.

Please be sure to label the area you are viewing on each response form (e.g., "C" for 3rd Street between George and Cambridge).

Each area/luminaire should be evaluated independently (that is, on its own merits). The objective is not to rank the areas/products relative to one another.

You are asked to provide a holistic impression of the performance. Although you will be a pedestrian, your expected experience as a driver or resident may come into play. You may wish to use your lighting acumen to evaluate each area relative to the ideal solution that perfectly meets the needs of the application. You are especially asked to focus on the actual performance, rather than what you might expect by looking at the luminaire.

The make and model of each luminaire is intentionally unidentified to facilitate objective, unbiased observations. If you are able to identify a product, please do not share that information with other participants. Additionally, please do not discuss the lighting with other participants until all the areas have been viewed.

General Information (optional):

If you would like to receive more information, please provide your name and email below.

Name: _______________________________

Email: _______________________________

If you would like to receive a copy of your responses, please provide the Participant ID Number that is on the top of each response form.

Participant ID Number: ________________

Questionnaire Form 1

Participant ID Number: _____________ Area ID: ___________

A. COLOR

The lighting in this area allows me to easily distinguish between objects:

Disagree The color appearance of all the objects in this area is distorted or all the colors are too similar.

0 — 1 — 2 — 3 — 4 — 5

Agree The color appearance of objects in this area is distinct and natural.

The color of the light in this area helps to create a pleasing atmosphere:

Disagree The light is too warm (yellow).

0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10

Agree (at 5)

Disagree The light is too cool (blue).

B. QUANTITY

Overall, there is an appropriate amount of light on the street surface:

Disagree There is *not enough* light; visibility and safety are compromised.

0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10

Agree (at 5)

Disagree There is *too much* light; it is uncomfortable and/or wasteful.

Overall, there is an appropriate amount of light on the sidewalk surface (if applicable):

Disagree There is *not enough* light; visibility and safety are compromised.

0 — 1 — 2 — 3 — 4 — 5 — 6 — 7 — 8 — 9 — 10

Agree (at 5)

Disagree There is *too much* light; it is uncomfortable and/or wasteful.

There is an appropriate amount of light beyond the target area (on buildings or adjacent sites):

Disagree There is *too much* light; this area exemplifies light trespass.

0 — 1 — 2 — 3 — 4 — 5

Agree There is no spill light / light trespass.

C. DISTRIBUTION

The light appears evenly distributed across the road surface:

Disagree There are severe hot spots and /or striations; the road surface appears patchy.

0 — 1 — 2 — 3 — 4 — 5

Agree The surface is perfectly uniform.

The lighting in this area is uncomfortable due to glare:

Disagree I am not bothered at all.

0 — 1 — 2 — 3 — 4 — 5

Agree I have to squint or shield the light.

Participant ID Number: _____________ Area ID: ___________

D. OVERALL IMPRESSION

Compared to the typical street lighting in Philadelphia, the lighting in this area is:

Much worse
The typical lighting is better.

0 1 2 3 4 5

Much better
This style of lighting should be used more commonly.

The single most influential factor in the rating above was (circle one):

A. The quality of the light
B. The quantity of light
C. The distribution of light
D. Other: _______________

The lighting in this area is:

Terrible
The lighting does not meet any of the needs of the area.

0 1 2 3 4 5

Outstanding
The lighting meets all the needs of the area.

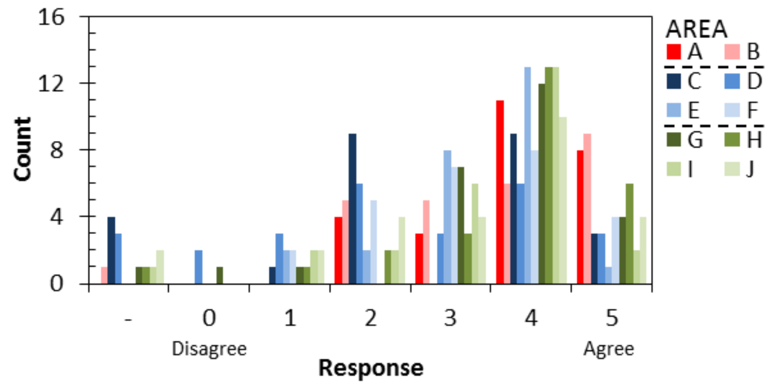
The single most influential factor in the rating above was (circle one):

A. The quality of the light
B. The quantity of light
C. The distribution of light
D. Other: _______________

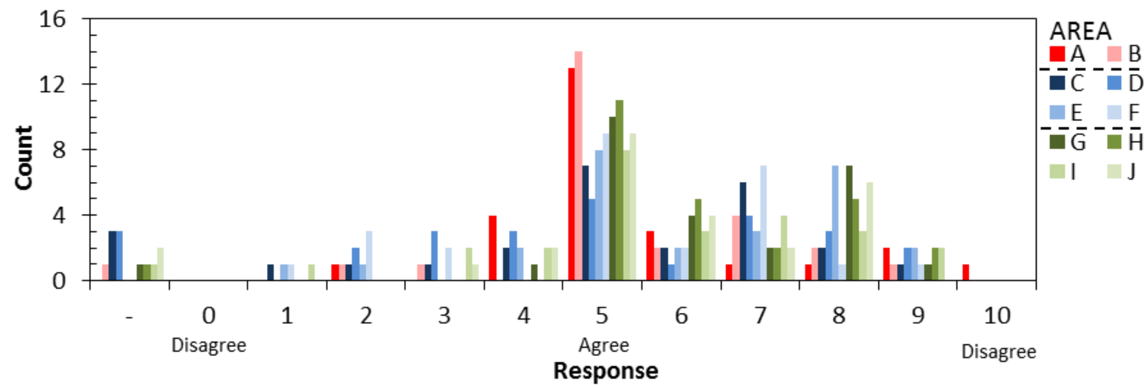
Comments:

Appendix H: Histograms of Questionnaire Responses, Lighting Professionals

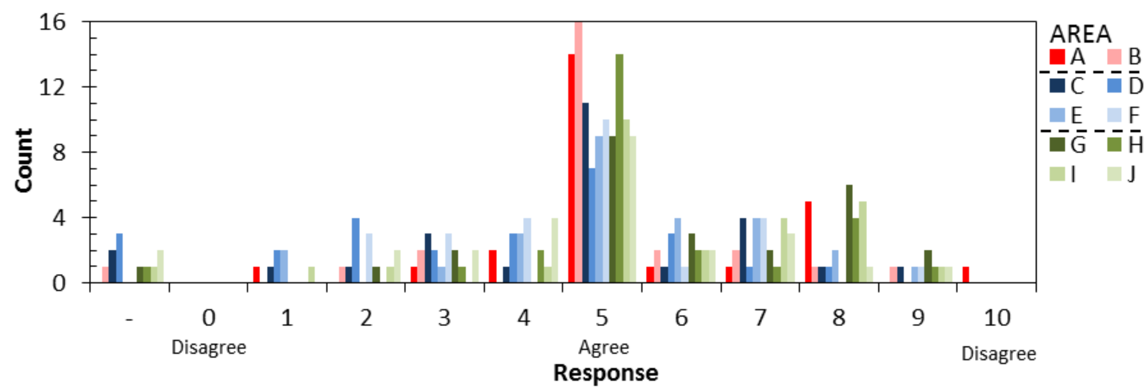
1. The lighting in this area allows me to easily distinguish between objects:



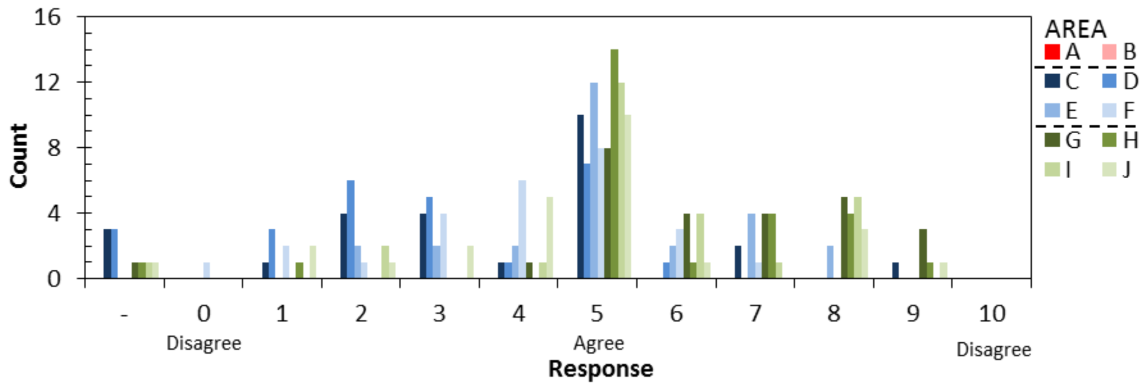
2. The color of the light in this area helps to create a pleasing atmosphere:



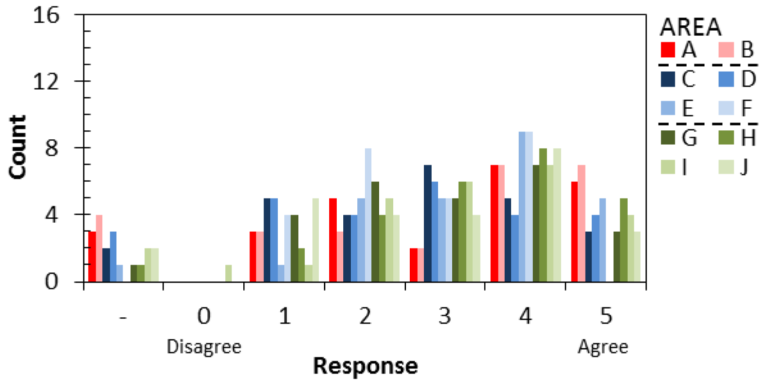
3. Overall, there is an appropriate amount of light on the street surface:



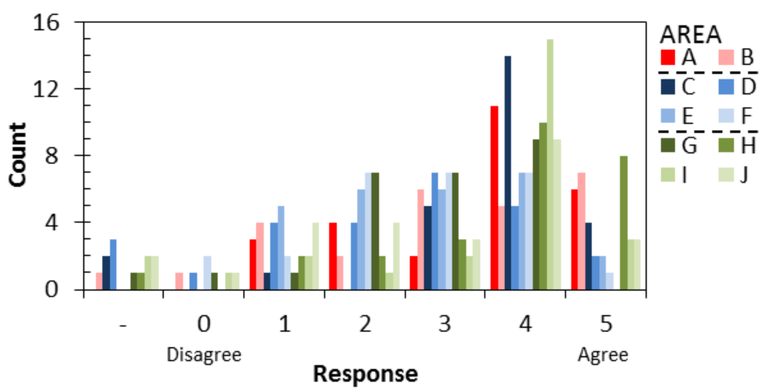
4. Overall, there is an appropriate amount of light on the sidewalk surface (if applicable):



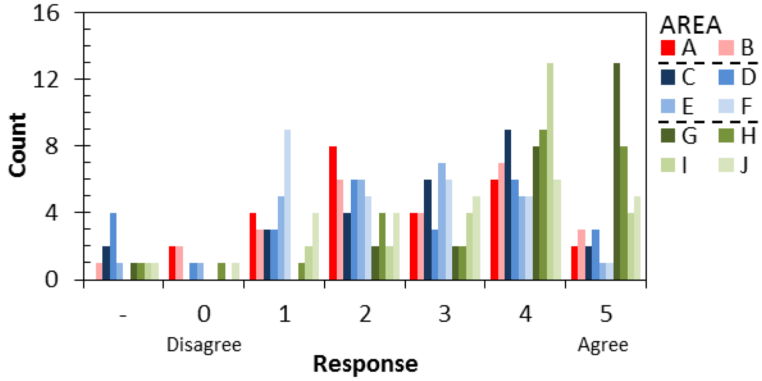
5. There is an appropriate amount of light beyond the target area (on buildings or adjacent sites):



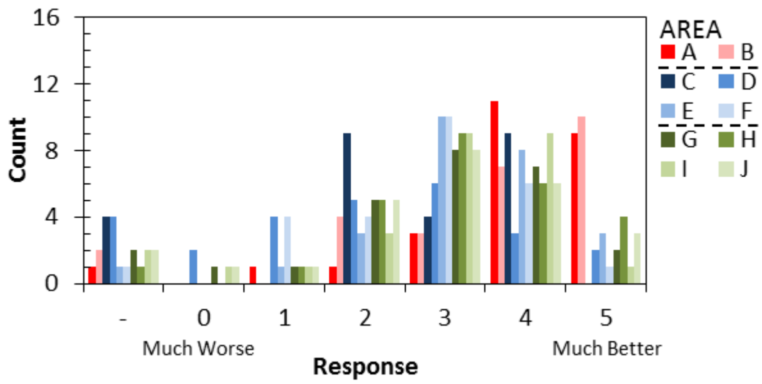
6. The light appears evenly distributed across the road surface:



7. The lighting in this area is uncomfortable due to glare:

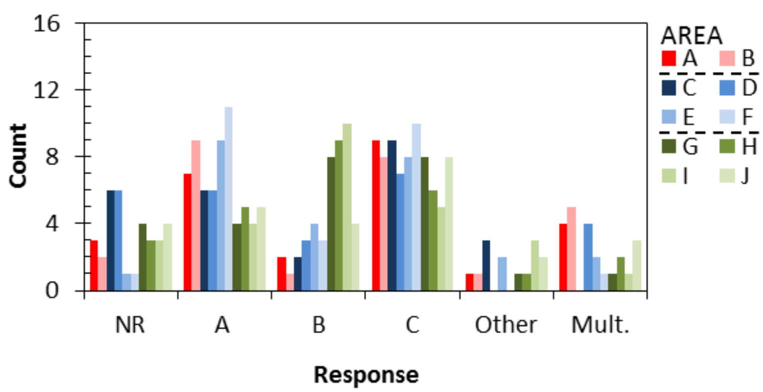


8. Compared to the typical street lighting in Philadelphia, the lighting in this area is:

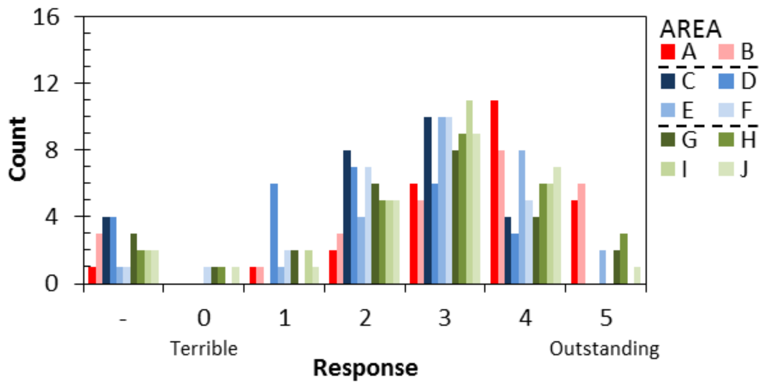


The single most influential factor in the rating above was:

A) The quality of the light B) The quantity of light C) The distribution of light



9. The lighting in this area is:



The single most influential factor in the rating above was:

A) The quality of the light B) The quantity of light C) The distribution of light

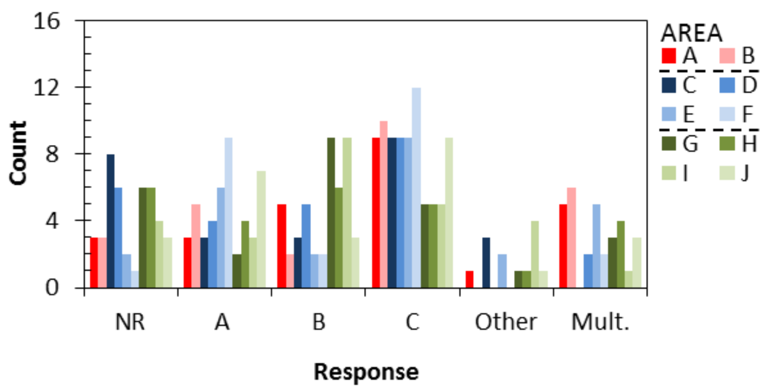


Table H1. **Mode (most frequent) responses from the questionnaire administered to lighting professionals.** The response scale for each question is shown in Appendix G.

	A	B	C	D	E	F	G	H	I	J
The lighting in this area allows me to easily distinguish between objects:	4	5	4	2	4	4	4	4	4	4
The color of the light in this area helps to create a pleasing atmosphere:	5	5	5	5	5	5	5	5	5	5
Overall, there is an appropriate amount of light on the street surface:	5	5	5	5	5	5	5	5	5	5
Overall, there is an appropriate amount of light on the sidewalk surface (if applicable):	-	-	5	5	5	5	5	5	5	5
There is an appropriate amount of light beyond the target area (on buildings or adjacent sites):	4	5	3	3	4	4	2	3	4	4
The light appears evenly distributed across the road surface:	4	3	4	3	2	2	4	4	4	4
The lighting in this area is uncomfortable due to glare:	2	4	4	4	2	1	5	5	4	4
Compared to the typical street lighting in Philadelphia, the lighting in this area is:	4	5	2	3	3	3	3	3	4	3
The lighting in this area is:	4	4	3	2	3	3	3	3	3	3

Table H2. Mean responses from the questionnaire administered to lighting professionals. The response scale for each question is shown in Appendix G.

	A	B	C	D	E	F	G	H	I	J
The lighting in this area allows me to easily distinguish between objects:	3.8	3.7	3.1	2.7	3.3	3.2	3.6	3.8	3.4	3.4
The color of the light in this area helps to create a pleasing atmosphere:	5.5	5.6	5.5	5.4	6.1	5.2	6.2	6.3	5.7	5.9
Overall, there is an appropriate amount of light on the street surface:	5.5	5.2	5.1	4.1	5.3	4.8	6.0	5.6	5.8	5.0
Overall, there is an appropriate amount of light on the sidewalk surface (if applicable):	-	-	4.2	3.2	5.1	4.0	6.5	5.8	5.5	4.7
There is an appropriate amount of light beyond the target area (on buildings or adjacent sites):	3.3	3.5	2.8	2.9	3.4	2.7	2.9	3.4	3.2	2.9
The light appears evenly distributed across the road surface:	3.5	3.2	3.8	2.7	2.8	2.6	2.9	3.8	3.5	3.0
The lighting in this area is uncomfortable due to glare:	2.5	2.8	3.1	2.8	2.5	2.3	4.3	3.6	3.6	3.0
Compared to the typical street lighting in Philadelphia, the lighting in this area is:	4.0	3.9	2.9	2.4	3.3	2.7	3.0	3.2	3.1	3.0
The lighting in this area is:	3.6	3.6	2.8	2.2	3.2	2.6	2.8	3.1	2.8	2.9

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