THE CITY OF
CANTON
WILLIAM J. HEALY II, MAYOR

AMERICAN SOCIETY of HIGHWAY ENGINEERS

CUYAHOGA VALLEY SECTION

LED Street Lighting

Presented by the Engineering Department of the City of Canton

November 15, 2011

RESOURCES

- *Illuminating Engineering Society of North America (IESNA)*
- *American Association of State Highway Transportation Officials (AASHTO)*
- *Transportation and Traffic Engineering Handbook*
- *Lighting Research Center*
- *Commission Internationale de l'Eclairage (CIE)*
- *International Dark-Sky Association (IDA)*
- *Institution of Lighting Engineers*
- *IMSA Journal*
- *American Electric Power (AEP Ohio) – gridSMART Ohio*
- *City of Canton – Engineering Department*
- *Electric Power Research Institute (EPRI)*
- *Profitable Green Solutions*
- *Asociacion Argentina de Luminotecnia (AADL)*
- *Internet*

AGENDA

- *Introduction*
- *LED Types & Installations*
- *How the City of Canton is saving Electricity and Re-investing in Efficiency Measures*
- *LED Lighting Test Sites*
- *Instruments*
- *Grid Layout*
- *LED Cobra Head Statistics*

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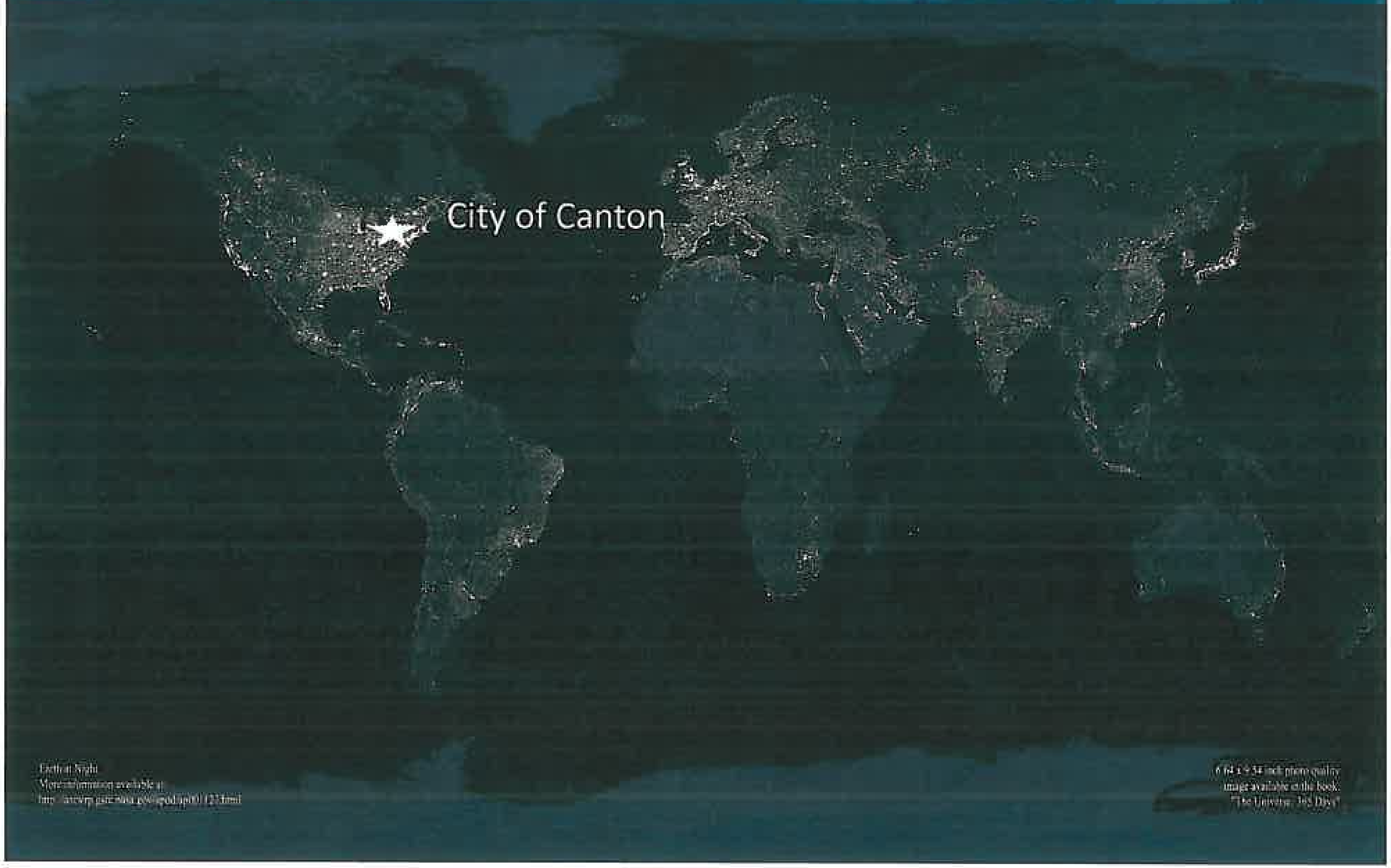

LED's TYPES & INSTALLATIONS

- *LED TYPES*
  - Traffic Signals LED – Red, Green, Yellow, Walk & Don't Walk
  - Indoor - outdoor LED Lighting – Retrofit, Cobra Heads, Parking Garage, Exercise Track
  - Lighted LED Signs – Retrofit
- *LED INSTALLATIONS*
  - Traffic Signals
  - Street Lighting
  - Lighted Sign
  - Parking Garage
  - Exercise Track

TRAFFIC SIGNALS

- *188 Signalized Intersections*
  - 1,364 (3,4,5) Section Traffic Signals
  - 1,010 Pedestrian Signals

- *25 Flashers*

  - School Flashers
  - Pedestrian Flashers

- *15 Outdoor Warning Sirens*

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Date	kWh			Total Amount Paid	kWh cost	Traffic Lights Today's Cost	Traffic Light Savings		
	Traffic Lights	Street Lighting	Warning Sirens				kWh	Dollars	Percent
1/30/2005	117,258	N/A	1,903	$7,623.34	$0.0640	$16,618.19	N/A	N/A	N/A
1/30/2006	108,479	N/A	1,903	$7,779.44	$0.0705	$15,374.00	N/A	N/A	N/A
1/30/2007	100,680	N/A	1,903	$7,722.27	$0.0753	$14,268.70	N/A	N/A	N/A
1/30/2008	82,172	N/A	1,903	$6,405.29	$0.0762	$11,645.69	35,086	$4,972.50	29.92%
9/30/2009	55,889	4,550	2,076	$5,938.14	$0.0950	$7,920.77	61,369	$8,697.42	52.34%
10/30/2009	43,573	8,791	2,076	$5,369.93	$0.0986	$6,175.31	73,685	$10,442.88	62.84%
11/30/2009	42,861	8,791	2,249	$5,329.79	$0.0989	$6,074.40	74,397	$10,543.79	63.45%
12/30/2009	42,861	8,791	2,249	$5,328.92	$0.0989	$6,074.40	74,397	$10,543.79	63.45%
1/30/2010	42,861	8,791	2,249	$5,708.92	$0.1059	$6,074.40	74,397	$10,543.79	63.45%
6/30/2010	41,896	8,791	2,249	$5,852.76	$0.1106	$5,937.64	75,362	$10,680.55	64.27%
7/30/2010	35,930	8,791	2,249	$5,312.47	$0.1131	$5,092.12	81,328	$11,526.07	69.36%
8/30/2010	30,939	8,791	2,249	$4,906.87	$0.1169	$4,384.78	86,319	$12,233.41	73.61%
9/30/2010*	30,798	9,979	2,249	$5,030.45	$0.1169	$4,364.79	86,460	$12,253.40	73.73%
10/30/2010	30,803	9,979	2,422	$5,047.17	$0.1168	$4,365.50	86,455	$12,252.69	73.73%
12/30/2010	23,062	9,979	2,422	$4,456.38	$0.1257	$3,268.42	94,196	$13,349.77	80.33%
1/30/2011	22,794	9,915	2,422	$4,658.63	$0.1326	$3,022.65	94,464	$13,595.54	81.81%
2/28/2011	22,329	9,851	2,422	$4,903.91	$0.1417	$3,164.54	94,929	$13,453.65	80.96%

Note: An estimated 20,000 kWh more of energy savings is expected after finalizing the traffic signal LED retrofit. At today's cost (12/2009), this would represent approximately $2,000 monthly savings.

* Street Lighting and Traffic lights at Fulton Rd NW and Stadium Park Dr/I77 Off Ramp were added to electrical bill.

THE CITY OF CANTON
ENGINEERING DEPARTMENT
Daniel J. Moeglin, P.E., S.I., City Engineer

PROFITABLEGREENSOLUTIONS

Complete Emissions Calculator

INSTRUCTIONS: Type in the kWh savings and see the emissions-environmental benefits in green-shaded areas. Insert your own $$ values for the Strategic Benefits in blue text.

Type the amount of electricity your program will save → 1,139,148 kWh/year

Emissions Reductions:	Annual Reductions	Reductions over 10 years
Conversion Factor: 1 kWh is worth 1.37 lbs of CO2 (Source: EPA)		
GreenHouse Gas Reduction (in pounds of CO2)	1,552,659 lbs	15,526,587 lbs
or when converted to Metric Tons of CO2 >>>	704 Metric Tons	7,043 Metric Tons

Equivalent Environmental Benefits (mutually-exclusive):	Annual Reductions	Reductions over 10 years
Acid Rain Emission Reduction	8,544 lbs of SOx	85,436 lbs of SOx
Smog Emission Reductions	4,101 lbs of NOx	41,009 lbs of NOx
Barrels of Oil Not Consumed	1,638 Barrels	16,382 Barrels
Cars off the Road	152.1 Cars	1,521 Cars
Gallons of Gas not Consumed	80,214 Gallons	802,141 Gallons
Acres of pine trees reducing carbon	586.7 Acres	5,867 Acres

Strategic Benefits (quantifiable at site-specific level)	**Annual** Benefits	Benefits over 10 years
Annual Report to **Shareholders,**		0
Community Morale & "Green Image",		0
Productivity Improvements, Cost-Competitiveness		0
Avoided Future Capital Outlay		0
LEED Points, White Certificates, **RECs**		0
FREE Public Press (GREAT), Political/Strategic		0
Legal Risk Reduction, Avoided Penalties		0

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LIGHTED SIGNS

- *85 Lighted Signs*
  - 30 LED – 964W
  - 55 T12(48", 72", 96") and H38 (100W Mercury) – 9,590W
  - Total Load 10,554W

- *After retrofitting with LED Panels*
  - 55 LED – from 9,590W to 1,973W (79.42% Load Reduction)
  - Total Load 2,937W (72.17% Load Reduction)

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STREET LIGHTING

- *975 Poles*
  - Single (10', 12', 14', 16'), Double (16', 18'), and Tear Drop (Gooseneck)
- *1,433 Lights*
  - Single, Double, Brick Pillar and Tear Drop (Gooseneck)

- *Voltage*
  - 120, 208, 240 and 480V
- *Lamp Type and Wattage*
  - 50, 70, 100, 150, 250W - HPS
  - 175, 250 - MH
  - 48, 50 LED (eyebrow, universal) - 55, 65W including driver

STREET LIGHTING

- *1,433 Lights*
  - 883 LED
- *501 Lights to retrofit to LED*
- *52 Lights to convert to CFL*
  - 52 Brick Pillar 50W HPS

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LIGHTING TEST SITES

- 11TH & Cherry Ave. SE – GE Cobra Heads
- North Plaza – Sylvania – Decorative Retrofit
- West Tuscarawas Project – Lumecon – Decorative Retrofit
- West Tusc. & McKinley Ave. – Tear Drop
- Market Ave. North – AEP – EPRI – Leotek

INSTRUMENTS

- Volt Meter
- Amp Meter
- Kill A Watt
- Light Meter Settings – HPS, MH, Incandescent, Fluorescent? IMSA Journal.pdf
- Rover Ph Sc lumens.pdf

Rover.pdf

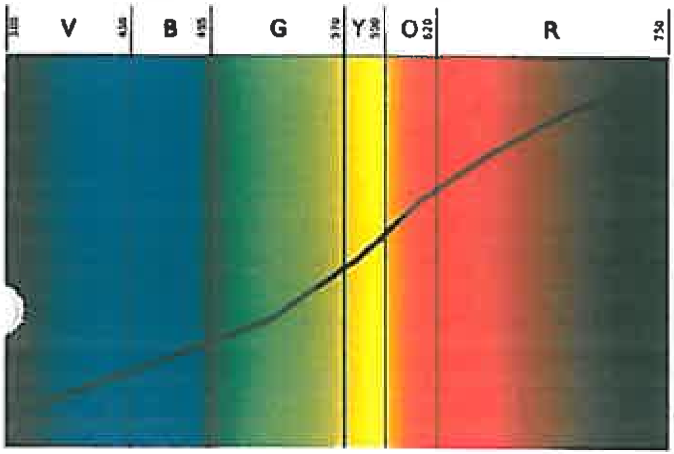

The Performance of LEDs in Low-Visibility Weather Conditions

By Don Lincoln, Product Manager, [illegible]

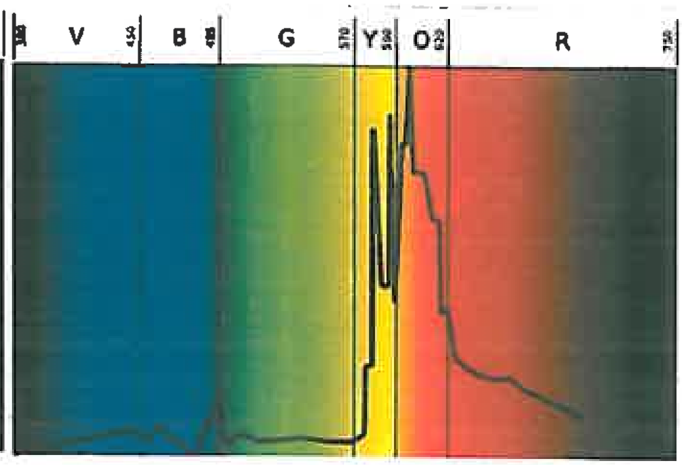
Regarding the superiority of LED lighting in low visibility conditions such as fog, there is a very limited amount of research data available on the subject and some practical field experience from which to draw an explanation. I'm not a physics expert, but I will make my best attempt at summarizing what I have found related to why LEDs are better for use in low-visibility conditions, and fog in particular. This is by no means meant to be an expert technical treatise on the subject, but it is a compilation of some formal and informal research on the subject from numerous sources.

From what I can gather from the available literature, the advantage of LEDs in fog can be attributed to the inherent directionality of the beam of light emitted and the inherent bichromatic wavelength characteristics of white LED light and the frequency of that wavelength in comparison to other light sources.

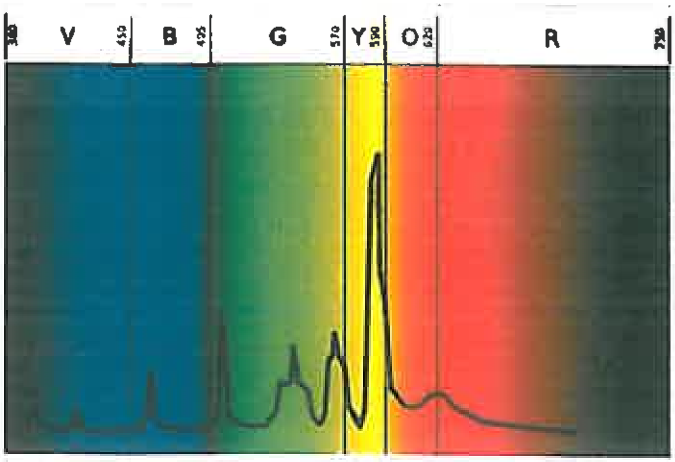
The visible spectrum of light ranges from about 400 to 700 nm in wavelength, and each of the different types of light sources has its own characteristic pattern of peaks that equate to where on the spectrum the majority of their energy is emitted as visible light. Sodium light sources emit energy primarily in the yellow and orange bands of the visible spectrum, and this is why the light appears yellow to our eye. White LEDs, which are the kind that we use in our high output fixtures, are actually blue LEDs with a small amount of a yellow phosphor mixed in to yield what appears to be white light. So the white LED light exhibits a bichromatic pattern primarily in the blue and green bands. I have included the spectral signatures of a few different types of light sources for comparison:



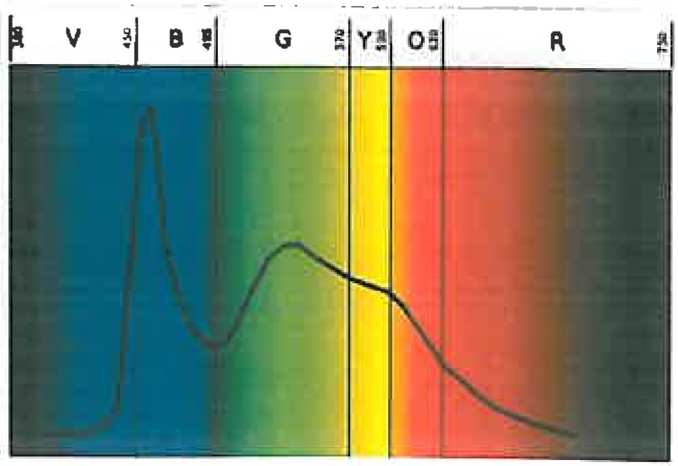
Tungsten Bulb



High Pressure Sodium



Metal Halide



White LED

The difference between LED lighting and all other light sources is the predominant wavelength at which it emits energy, and how water droplets interact or affect a beam of light at that wavelength, especially as the size of those water droplets changes. Light in the violet region of the spectral range has a shorter wavelength than light in the red region. Water vapor particles in the atmosphere will generally pass light that is in the yellow-orange-red range, but it will tend to scatter blue light. This appears to be due to the fact that water particles are generally of similar size to the blue wavelength, which is

Continued on page 36

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und 400nm[1]. This phenomenon is called Rayleigh scatng, and is the reason why the sky is blue (now I know!), and is the reason why the sun appears yellow, as this is the visible light that makes it to the ground.

However, in foggy conditions, the size of the water vapor particles is increased to the point where they are no longer of similar size to the blue light wavelengths, and are now of similar size to the yellow-orange-red wavelengths, and will tend to scatter and extinguish light in these bands, but will pass blue light.[2] This is why sunlight will sometimes appear bluish or greenish through a fog. Given this, light sources that primarily already emit light energy within the blue wavelength of the visible spectrum will perform much better in foggy conditions than other light sources. It should also be noted that as with any relatively new technology, there is also some conflicting research that shows that it is the yellow and red LED lights that are more visible, and not blue or green ones.[3]

Peter Hochstein (founder of Relume) also believes that forward light scatter also contributes to the superior performance of LEDs:

"From a purely physical optics standpoint, distributed sources [LEDs] generally do a better job in reducing interfering backscatter compared to single higher intensity sources. But the real question is more likely the forward scatter - which sically uncontrolled light that interferes with vision. In regard, the LEDs are better, as the extreme cut-off that we can achieve [directionality] virtually eliminates ALL light above the horizon. Achieving such cut-offs with either MH or HPS lamps is difficult, especially if the lamp is to cover much more than one mounting height. The merits of effective cut-off or dark sky compliance are easily seen with existing HPS lamps in Troy, MI. The new lamps along Big Beaver by the Somerset Mall are a mixture of cut-off and non cut-off [drop lens] fixtures. In relatively dense fog, the advantages that the cut-off fixtures provide are immediately apparent as the driver isn't trying to look past the bright veil of scattered light from the drop lens luminaires."

In practical terms, what Peter is saying is that the advantage that LEDs have in these conditions is the same advantage that they have in any circumstance, in that it is a directional emission source as opposed to a spherical one. Imagine trying to light your way down a foggy pathway using a bare tungsten bulb. The difficulty is that you cannot see your way through the mass of scattered light being thrown out in all directions from the bulb, and the result is that what little light that is making it to the pathway and reflected back to the observer would be obscured by the much brighter "glob" of scattered light from the bulb itself. Now imagine lighting the same pathway using a directional light source, such as the narrow conical beam of light from an LED light source. You do not get the same scattered glob of light surrounding the "bulb" because the bulb is only emitting light from a relatively small percentage of the dome surface area of the LED. To use a weak analogy, it is the difference between slicing a watermelon with a knife rather than a bowling ball.

Beyond all of this, there have been some real-world studies done on the effectiveness of LED light versus other light sources in low-visibility conditions. The FAA has some ongoing and as-yet unpublished research being conducted on this, and that one of the primary reasons why many airfields are converting much of their signal and runway directional lighting to LED is because of its visibility in foggy and rainy conditions as reported by pilot observation surveys.

Finally, there was an informal study of the use of LED highway warning lights in low visibility conditions by the North Carolina DOT, which showed that the LED lights were the only source capable of being visible at distances in excess of 1,500 feet in fog.

FOOTNOTES:

1 http://www.worsleyschool.net/science/files/bluelight/scattering.html

2 "Apparent Anomalous Extinction in Fog," M. Gazzi, et al, *Atmospheric Environment*, Vol. 35, Sept. 2000, pp. 5151-5156.

3 http://resources.metapress.com/pdf-preview.axd?code=wv520545578k6341&size=larger

IMSA

Fire Alarm Notebook . . .

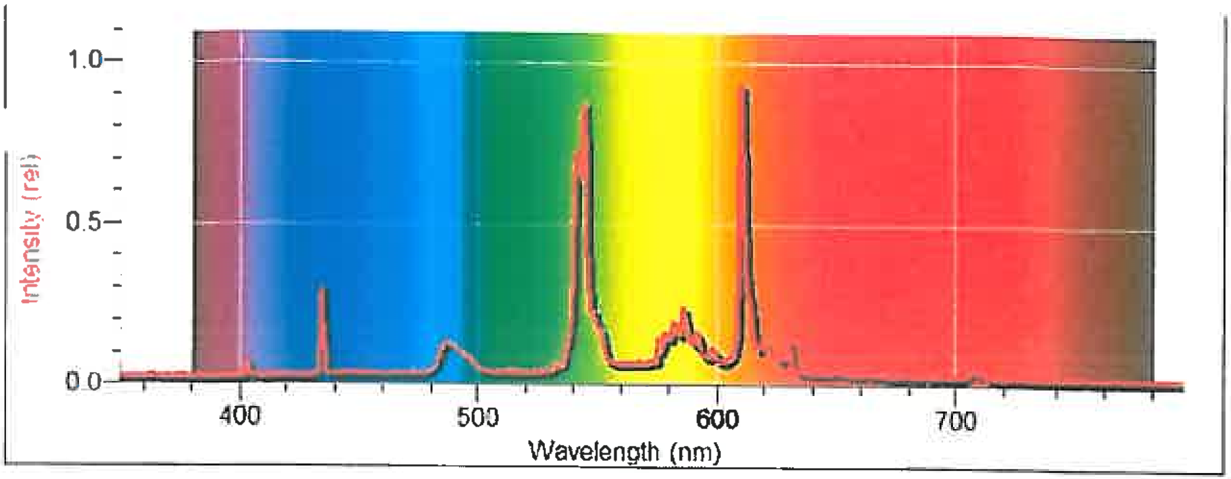
Continued from page 18

in your restored auditorium must interface with the lighting control system to meet this requirement of the *International Building Code*, or whatever similar requirement may exist in the building code that applies to your particular jurisdiction.

Fire alarm systems provide a host of valuable building ety services, in addition to detecting the presence of ostile fire and warning occupants and emergency responders. By interfacing properly with other building systems, the fire alarm system helps make the building safer both before and during a fire emergency.

IMSA member Dean K. Wilson, P.E., FSFPE, C.F.P.S., now retired on disability, formerly worked as a Senior Engineer in the Erie (PA.) office of the fire protection engineering and code consulting firm, Hughes Associates, Inc. (www.haifire.com.). The opinions expressed in this article are strictly his own. You can reach him by e-mail at deanwilson@roadrunner.com or by telephone at 814-397-5558.

IMSA



FLUORESCENT LIGHT EMISSION SPECTRUM

Photopic and Scotopic lumens - 4: When the photopic lumen fails us

When should we use scotopic lumens? Never. There are *no practical situations involving lighting or lighting design* where the occupants or users of a space are sufficiently dark adapted and using only their peripheral vision so that the *scotopic* luminous efficiency function would be a useful predictor of the visual effect of radiant power. But clearly, never using the scotopic lumen *does not* mean we should always use the photopic lumen. The first important case where we really should not be using the photopic lumen is when we are adapted to twilight light levels and our visual system is functioning between scotopic and photopic modes – so called mesopic vision. Figure one shows a schematic representation of the huge range of adaptation in which we can function.

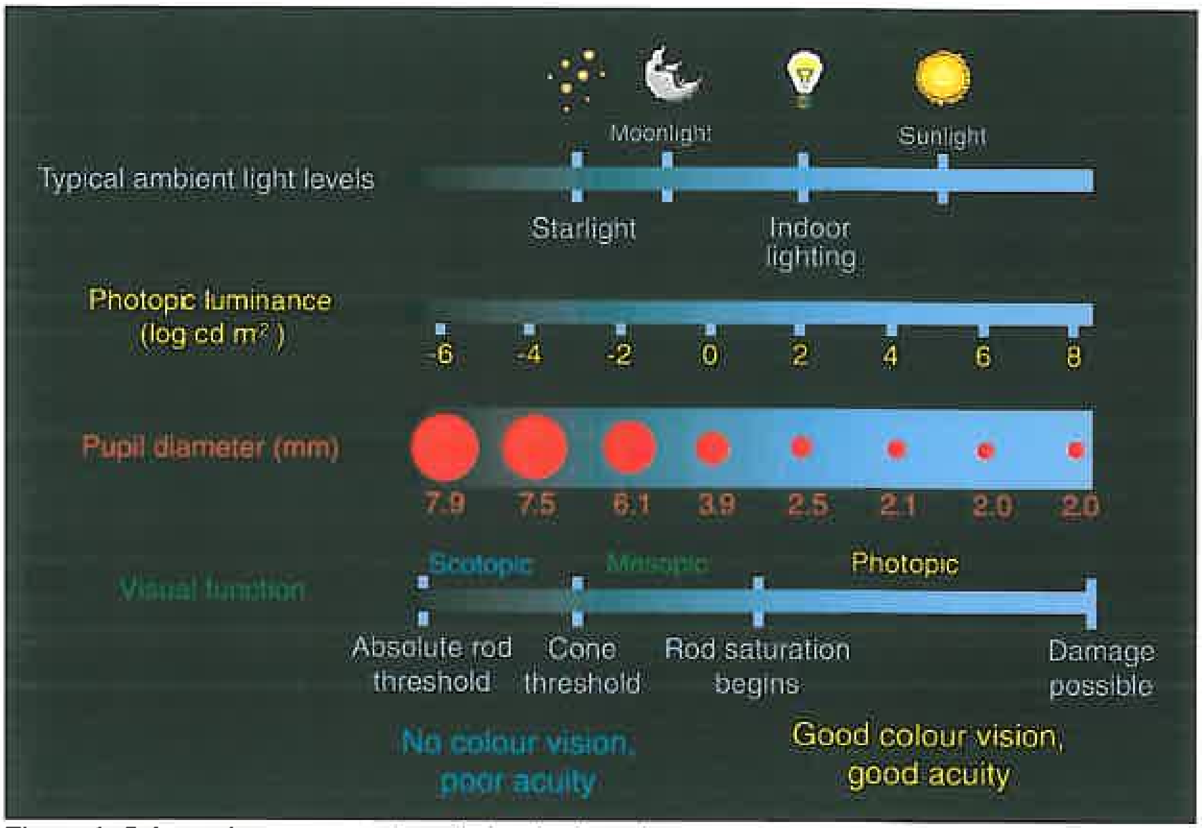


Figure 1. Schematic representation of visual adaptation.

There are no precise boundaries between the three modes of vision (scotopic, mesopic, and photopic) but approximate adaptation luminances can be identified where one mode transitions to the next. The adaptation range is expressed in terms of *photopic* luminance (cd/m^2), but if we make the assumption that we are viewing a diffuse object with a reflectance of 0.30 then the transition points along the range can be expressed in terms of *photopic* illuminance.

Rod threshold, beginning of scotopic range:	10^{-6} fc
Cone threshold, end of scotopic beginning of mesopic range:	10^{-3} fc
End of mesopic range:	1 fc

Looking at the transition points it is clear that some outdoor lighting applications (between 0.001 and 1.0 *photopic* fc) actually have occupants in an adaptation state where mesopic is the mode of vision. Now it's easy to get confused. Notice that it is possible to use the *photopic* luminous efficiency function (and thus photopic lumens, illuminance, and luminance) over the entire adaptation range, whether that efficiency function describes our state of vision, or not. We simply treat it as a mathematical indictor. Doing this simply makes it easier to discuss wide ranges of adaptation. So then why not simply use photopic for the whole shebang? If the only effect was a linear one of scale, then you could make a photopic function work over a wide range of adaptations. But there are two problems: one easy to overcome, the other difficult. Not only does visual effectiveness as a function of wavelength change with adaptation level (the shape and placement of the curve against the wavelength axis), but the very definition of "visual effectiveness" needs to change for low adaptation states. So it seems we need a mesopic lumen.

The idea of developing a mesopic lumen rests on the same basic ideas that underpin the scotopic and photopic lumen:

1. Define "visual effectiveness" for the mesopic mode of vision,
2. Measure the function that gives the visual effectiveness at different wavelengths
3. Make assumptions about linear additivity,
4. Weight the radiant power of a source at each wavelength with this function,
5. Sum the visually-effective-weighted radiant power at all wavelengths to give the mesopic lumens produced by that source.

The difficulty is defining "visual effectiveness". For determining photopic visual effectiveness it was decided (reasonably) to use only the very center of our field of view, the fovea, and to define visual effectiveness in terms of the relative brightness produced by radiant power at different wavelengths. Similarly for scotopic visual effectiveness, except the periphery of the visual field was used. Recall that there are lots of choices for defining visual effectiveness, among these are:

Relative brightness
Threshold detection
Recognition
Conspicuity
Reaction time
Visual performance

At the time, it was thought that relative brightness was the most fundamental and useful aspect of vision that could be described, and that once a lumen was defined, other experiments would determine how much light (in terms of lumens or lumen density) would be required for things like detection, recognition, conspicuity, and various forms of visual performance. The photopic lumen has been a kind of bridge between the radiant power of light sources and the degree to which we can perform the complicated visual tasks we accomplish *at high light levels with foveal vision*. That is how the photopic lumen has been used—roughly speaking—for the illuminance level recommendations we use indoors.

But we must do something else to define this unit of light when we are adapted in the mesopic range. Once we are adapted in either the scotopic or photopic range, the data that equal brightness experiments give is relatively unchanged as the light level is changed *within that range*. But a mesopic function *cannot* be unchanged; it must somehow transition between the scotopic and photopic functions. Recall that the scotopic and photopic luminous efficiency functions appear as shown in Figure 2 when plotted together.

The differences between these curves are clear: they indicate a maximum sensitivity at different wavelengths and the scotopic curve reaches a greater maximum (since we are more sensitive to radiant power when we are dark adapted). If we want a mesopic lumen, we must seek a curve that is "between" these two. But there is no single curve between these two; there are many, and the curve to be used would depend on where in the mesopic range the observer is adapted.

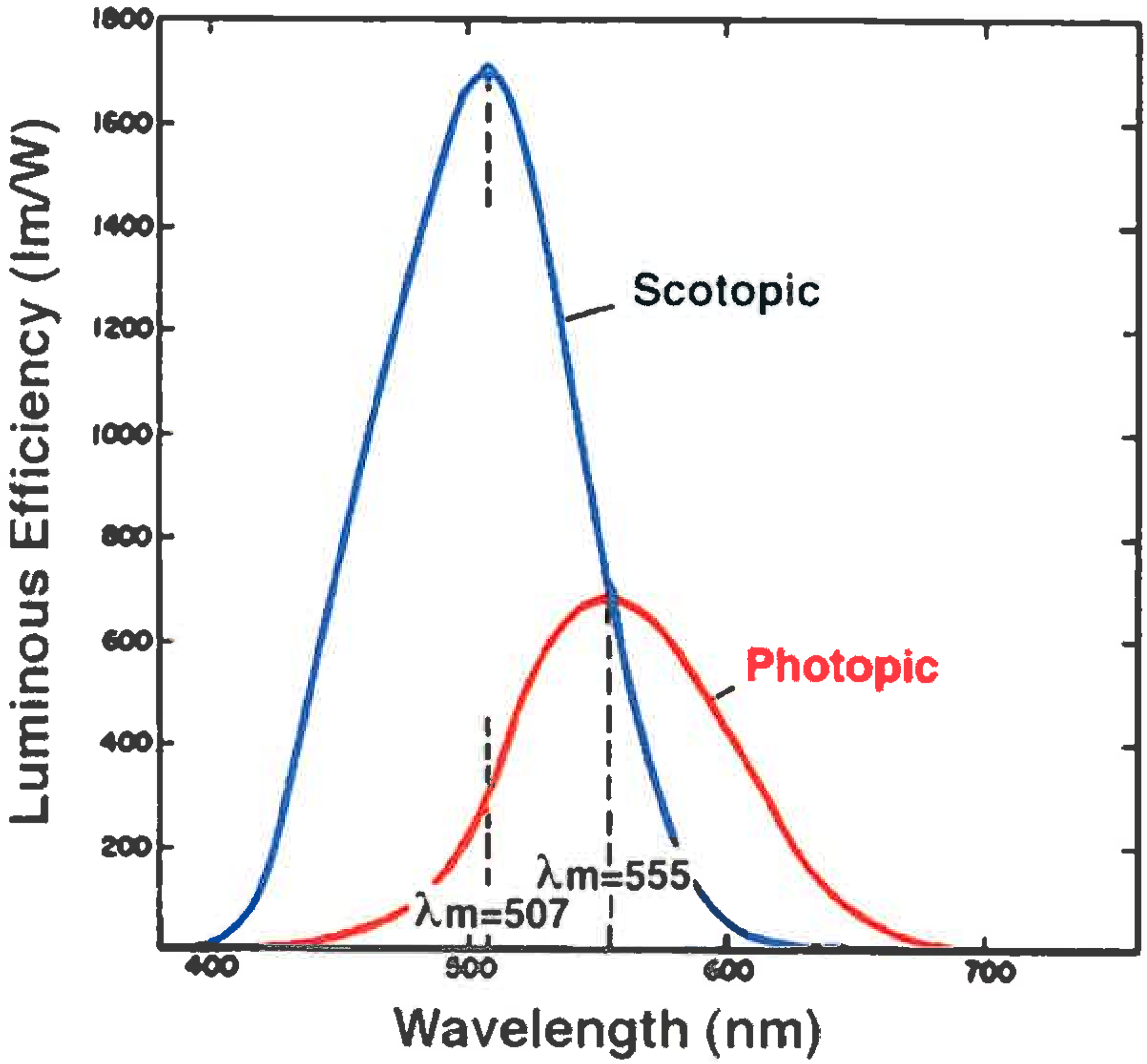


Figure 2. The photopic and scotopic luminous efficiency functions of wavelength.

There are two current ideas and sets of experimental results for defining the transition between photopic and scotopic. One generated by a consortium of research institutions in Europe – the MOVE model – and one generated by researchers at the Lighting Research Center – the LRC model. In both models the mesopic luminous efficiency function is a blend of the photopic and scotopic functions: $v_m(\lambda) = (1\text{-}x)\ v'(\lambda) + x\ v(\lambda)$ where ranges from 0.0 to 1.0 as the adaptation state changes from scotopic to photopic. It has become customary to express the adaptation state in terms of photopic luminance; using it, as mentioned above, as a kind of mathematical placeholder. This means that the blending parameter is a function of photopic adaptation luminance: $x(L_{photopic})$. Not surprisingly, the data that gives this blending parameter varies depending on how "visual effectiveness" is defined. Different data obtains from experiments that assume visual effectiveness is, say, reaction time or whether it is some type of visual performance.

Figure 3 shows a plot of the MOVE (solid lines) and LRC, indicated here by Rea, (dashed lines) blending parameter. The blue lines plot the parameter for a source with relatively high radiant power in the short wavelengths and the yellow lines plot the parameter for a source with low short wavelength power.

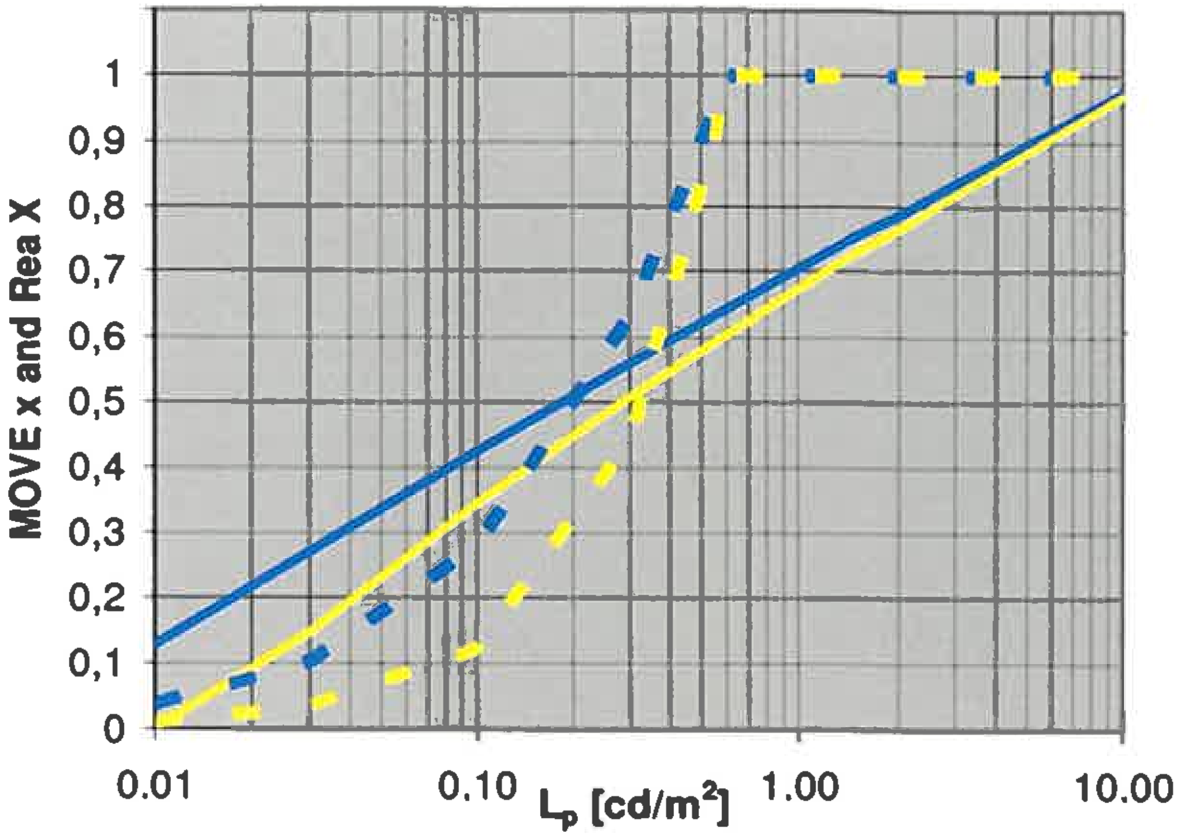


Figure 3. Two concepts and proposals for the mesopic blending parameter.

Clearly the spectral power distribution of a source affects the blending and therefore the final mesopic lumens that result. There has not yet been an international agreement on which body of experimental work to use to define mesopic vision, but the International Commission on Illumination (CIE) has an active committee working on this matter

But even if we agree on how to blend the photopic and scotopic functions to define a mesopic function, the practical business of using all this still becomes very complicated. It is clear that the very definition of light would change as our adaptation state within the mesopic region changes. There would not be *a* mesopic lumen, but rather there would be *many* mesopic lumens. There would not be *a* mesopic lumen rating for a lamp, but *many* mesopic lumen ratings. Most everyone would agree that this is not practical.

What is likely to result is that in practical applications there will be no mesopic lumen lamp ratings. The complicated process of determining the adaptation state, assessment of a lamp's spectral power distribution, subsequent blending of v(λ) and v'(λ), and the final mesopic result will be handled by computer calculations. Even with this aid, it will be unlike what we do now. If we change the amount of radiant power involved by changing lamp size, luminaire distribution, or pole spacing in a parking lot, the resulting change in say, mesopic illuminance, will not be linear function of the power we put on the pavement, but a complicated result of the changed adaptation state.

We should be careful about wishing for mesopic lumens; we may get them! Next we will consider the other important occasion when the photopic lumen fails us: general, wide-field brightness assessment.

Learn More. Here are some references related to mesopic vision and mesopic photometry.

The entire May 2006 (Vol 26, No 3) issue of Ophthalmic and Physiological Optics is devoted to the experimental and practical issues of mesopic vision and photometric systems. Of particular interest are the following articles.

Andrew Stockman and Lindsay T. Sharpe:
Into the twilight zone: the complexities of mesopic vision and luminous efficiency
Ophthalmic and Physiological Optics, May 2006, Vol 26, No 3, pp 225-239.

Ken Sagawa:
Toward a CIE supplementary system of photometry: brightness at any level including mesopic vision
Ophthalmic and Physiological Optics, May 2006, Vol 26, No 3, pp 240-245.

Géza Várady and Peter Bodrogi:
Mesopic spectral sensitivity functions based on visibility and recognition contrast thresholds
Ophthalmic and Physiological Optics, May 2006, Vol 26, No 3, pp 246—253.

A complete description of the MOVE mesopic photometry proposal is found in:
M Elohoma and L Halonen:
New Model of Mesopic Photometry and its Application to Road Lighting
Leukos, April 2006, Vol 2, No 4, pp

On-line. There are many things on-line related to mesopic photometry. These are among the most complete and accessible.

http://lrt.sagepub.com/cgi/reprint/36/2/85

http://www.lightinglab.fi/CIETC1-58/mphotometry.html

http://www.balkanlight.eu/abstracts_pdf/i11.pdf

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6V23-4FSCV5M-1&_user=918210&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000047944&_version=1&_urlVersion=0&_userid=918210&md5=4f44e117c62107901306b7fd9b6813f7

http://www.sciencedirect.com/science?_ob=ArticleURL&_udi=B6T0W-4M1D9XC-2&_user=918210&_rdoc=1&_fmt=&_orig=search&_sort=d&view=c&_acct=C000047944&_version=1&_urlVersion=0&_userid=918210&md5=96fe428050b2c73d36a5257a6a29eb82

User Manual
for
Mobile Light Measurement System (Rover)

Version 1.0

May 19, 2010

GRID LAYOUT

- *Spacing*
- *Platform for Light Meter*
- *Formulas*
- *Excel Spreadsheet* *Market Ave. N.xls* *West Tusc..xlsx*
  - *Weather Report*
  - *Grid Orientation*
  - *Instrument Settings*
- *AutoCAD* *AutoCAD.pdf*

Date/Time: 03/23/2009 10:00 PM
Location: SantaClara Dr & Market Ave. N
Pole #: AEP 748A2-126
Pole/Luminarie Description: 200W HPS Cobra Head, wood pole, luminaire mounted at 27' 2" above roadway and 17' arm
Grid size: 110' x 40' , 10' between readings E-W x 10' between readings N-S
Notes: Pole located at SE corner of grid, meter settings: HPS and lux

NW NE

2.00																	2.00	2.00	3.00	3.00
2.00																	2.00	2.00	3.00	2.00
2.00																	2.00	1.00	3.00	2.00
2.00																	2.00	1.00	3.00	2.00
4.00																	2.00	2.00	3.00	2.00
7.00																	3.00	2.00	3.00	3.00
9.00																	4.00	3.00	4.00	3.00
9.00																	7.00	4.00	4.00	3.00
12.00																	10.00	7.00	5.00	3.00
12.00																	14.00	11.00	6.00	4.00
13.00																	25.00	13.00	9.00	5.00
12.00																	25.00	13.00	9.00	5.00

SW SE

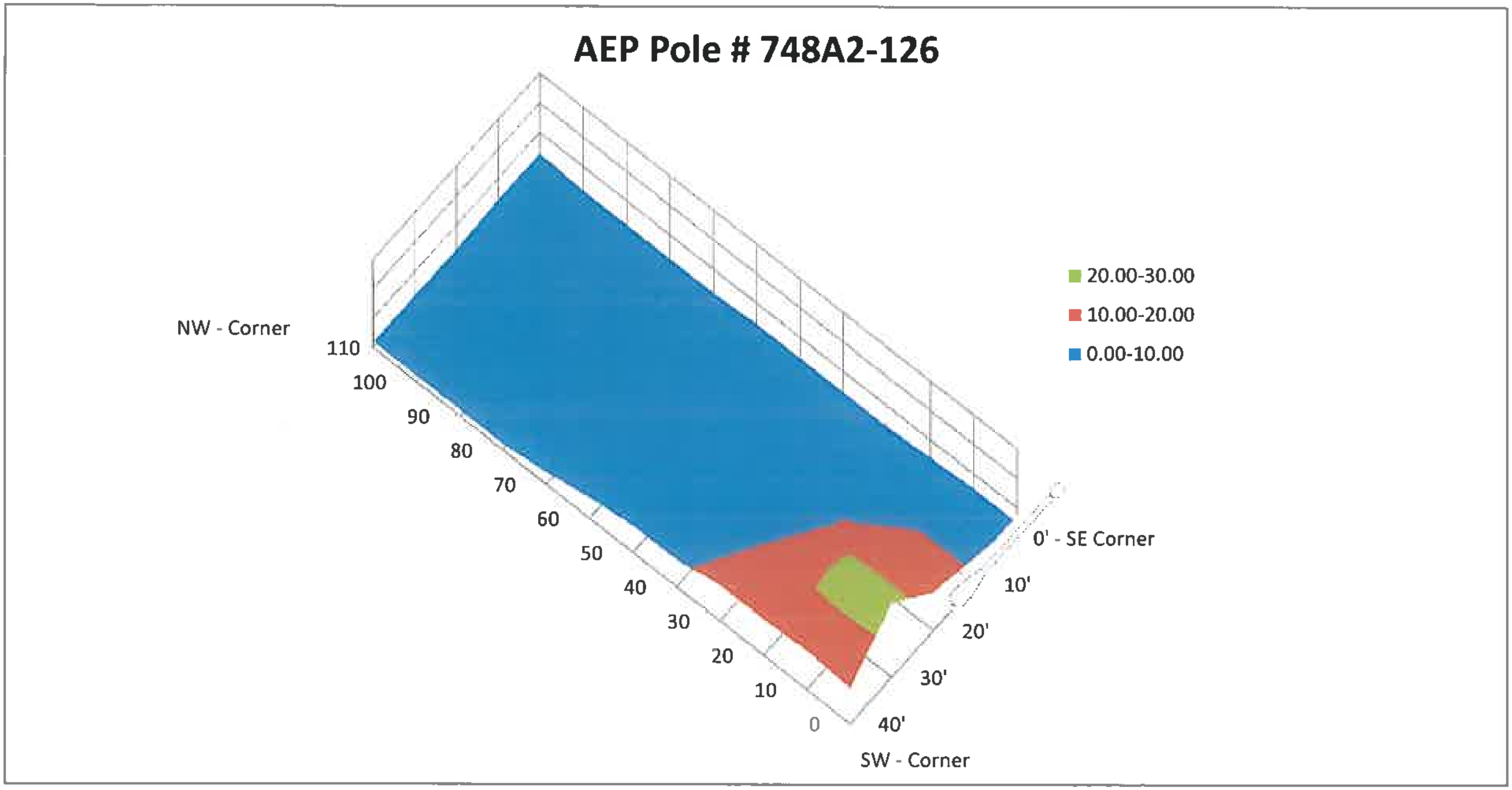
	Lux		fc
Emin	1.00		0.09
Emax	25.00		2.32
Avg	5.52		0.51

Emax/Emin	25.00
Avg/Emin	5.52

NW NE

2.00	2.00	2.00	3.00	3.00
2.00	2.00	2.00	3.00	2.00
2.00	2.00	1.00	3.00	2.00
2.00	2.00	1.00	3.00	2.00
4.00	2.00	2.00	3.00	2.00
7.00	3.00	2.00	3.00	3.00
9.00	4.00	3.00	4.00	3.00
9.00	7.00	4.00	4.00	3.00
12.00	10.00	7.00	5.00	3.00
12.00	14.00	11.00	6.00	4.00
13.00	25.00	13.00	9.00	5.00
12.00	25.00	13.00	9.00	5.00

SW

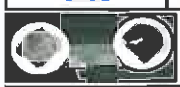

AEP Pole # 748A2-126
NW - Corner
110
100
90
80
70
60
50
40
30
20
10
0
SW - Corner
0' - SE Corner
10'
20'
30'
40'
20.00-30.00
10.00-20.00
0.00-10.00

Date/Time: 04/24/2009 1:30 AM
Location: West Tuscarawas St. in front of Ohio Auto Supply store
Pole #: 829C
Pole/Luminarie Description: 18' double luminaire light pole, prismatic globe 48 W (6 x 8 bars)LED, street side point between two bars
Grid size: 45' x 34' , 9' between readings E-W x 8.5' between readings N-S
Notes: Pole located at SW corner of grid, 3rd readings universal acorn 1 month later

NW | NE

0.46	0.46	0.37	0.28	0.19																0.19
0.46	0.65	0.42	0.42	0.37																0.28
0.65	0.93	0.65	0.65	0.37																0.37
1.12	1.39	1.07	0.65	0.46																0.37
0.65	0.93	0.74	0.60	0.37																0.46

SW | SE



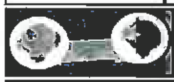
	fc		
Emin	0.19		
Emax	1.39		
Avg	0.60		

Emax/Emin	7.32
Avg/Emin	3.18

NW NE

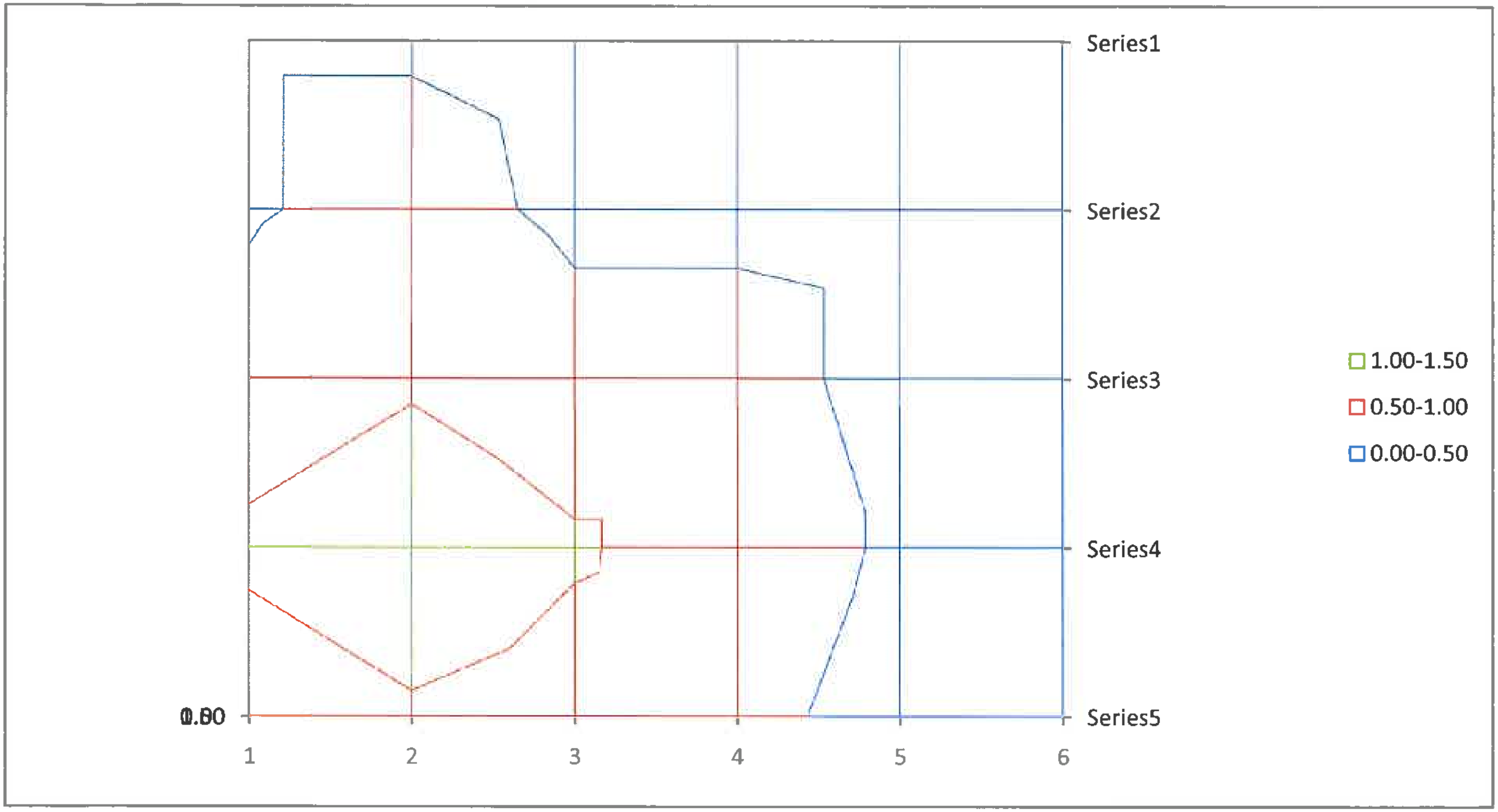
0.46	0.46	0.37	0.28	0.19	0.19
0.46	0.65	0.42	0.42	0.37	0.28
0.65	0.93	0.65	0.65	0.37	0.37
1.12	1.39	1.07	0.65	0.46	0.37
0.65	0.93	0.74	0.60	0.37	0.46

SW SE

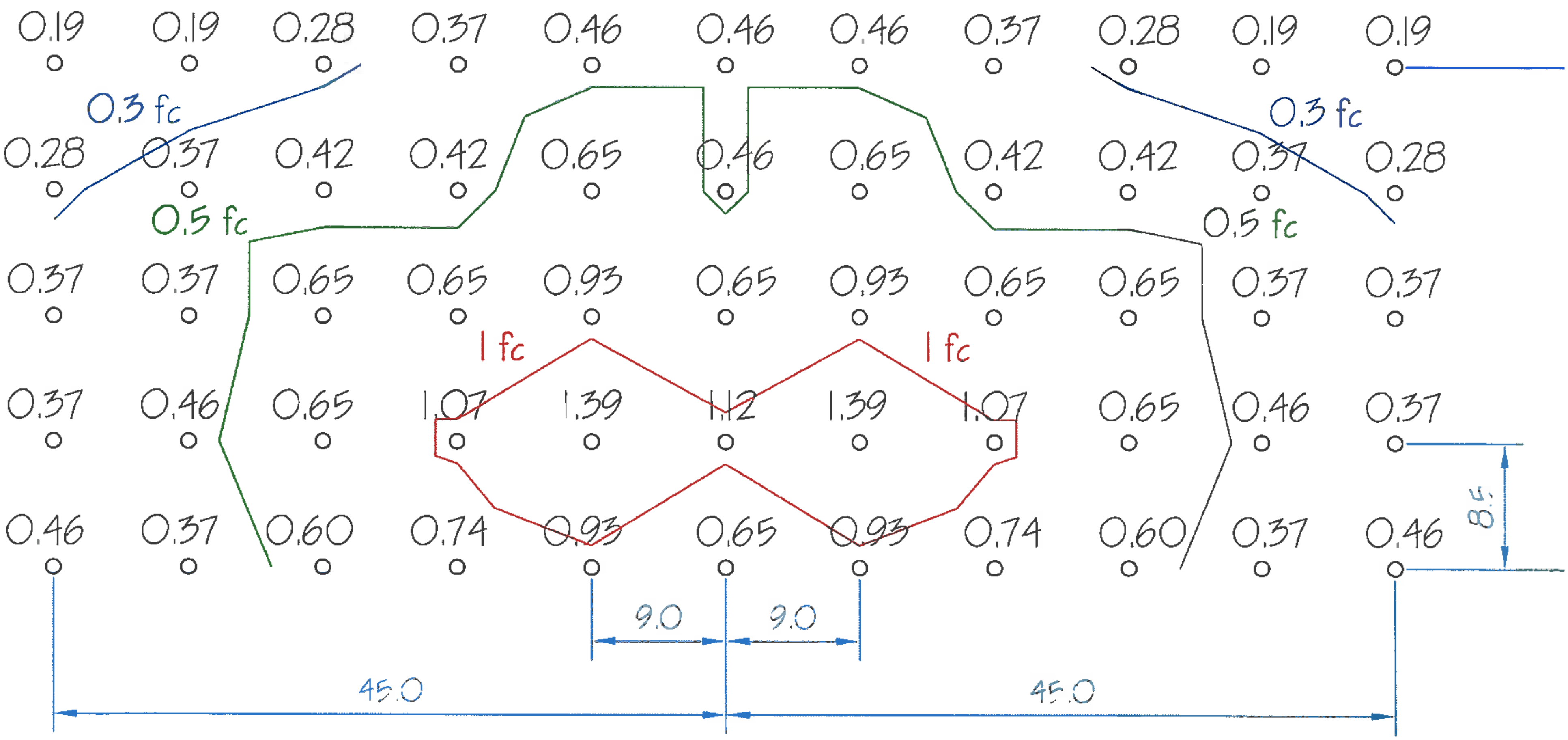


	fc
Emin	0.19
Emax	1.39
Avg	0.60

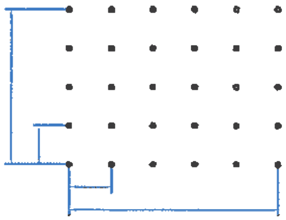
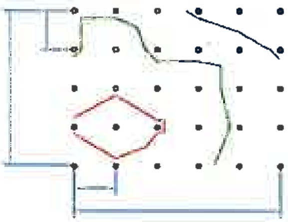
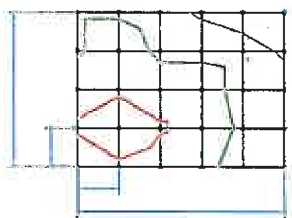
Emax/Emin	7.32
Avg/Emin	3.18

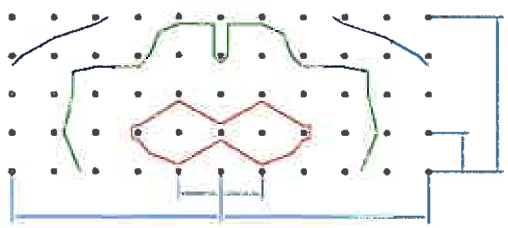


Series1
Series2
Series3
Series4
Series5
0.00
1
2
3
4
5
6
1.00-1.50
0.50-1.00
0.00-0.50



0.19 0.19 0.28 0.37 0.46 0.46 0.46 0.37 0.28 0.19 0.19
0.3 fc
0.3 fc
0.28 0.37 0.42 0.42 0.65 0.46 0.65 0.42 0.42 0.37 0.28
0.5 fc
0.5 fc
0.37 0.37 0.65 0.65 0.93 0.65 0.93 0.65 0.65 0.37 0.37
1 fc
1 fc
0.37 0.46 0.65 1.07 1.39 1.12 1.39 1.07 0.65 0.46 0.37
0.46 0.37 0.60 0.74 0.93 0.65 0.93 0.74 0.60 0.37 0.46
8.5
9.0
9.0
45.0
45.0



LED COBRA HEAD STATISTICS

- *LED Cobra Head* Statistics.xlsx

Location: 11th St./Cherry Ave. SE
Pole #/Description: A1, Steel Pole
Luminaire Description: GE Evolve LED Cobrahead 165W, mounted at 33' 11", 13' arm length
Grid Size: 50'x50', 10' between readings E-W x 10' between readings N-S
Notes: Pole located at SW corner of grid, 9' pole offset, meter settings: Fluorescent and Lux

Date of reading	Light Meter	Type of reading	Avg (fc)		Max (fc)		Min (fc)		Avg/Min		Max/Min	
			Ph	Sc	Ph	Sc	Ph	Sc	Ph	Sc	Ph	Sc
3/17/2010	GE Standard Layout	Ref. # A502831	0.66		2.19		0.16		4.03		13.40	
	GE Standard Layout	Restricted Grid	0.92		2.14		0.33		2.78		6.48	
6/10/2010	Meter	Photopic	0.87		2.60		0.09		9.40		28.00	
11/29/2010	Meter	Photopic	1.03		2.79		0.19		5.52		15.00	
11/29/2010	Rover	Photopic Scotopic	1.13	2.16	3.17	6.25	0.23	0.41	4.92	5.28	13.78	15.24
4/20/2011	Meter	Photopic	1.01		2.70		0.28		3.61		9.67	
10/25/2011	Meter	Photopic	0.95		2.60		0.28		3.42		9.33	

THE CITY OF CANTON
ENGINEERING DEPARTMENT
Daniel J. Moeglin, P.E., S.I., City Engineer

YOUR QUESTIONS