
Considerations for Outdoor Lighting in the MAG Region

A Resource Guide and Report
Developed by the MAG Dark
Sky Stakeholders Group

Maricopa Association of Governments
2011

Foreword

As the council of governments and metropolitan planning organization for the Phoenix metropolitan region, the Maricopa Association of Governments (MAG) was identified as a place for discussion by the astronomy community for possible options to be considered in managing light and light pollution. A discussion and process that started in late 2008 has taken place that has seen the development of a Pattern Outdoor Lighting Code (POLC) which is contained in this document.

As with many issues associated with growth, this discussion and effort has not been without contention. On one hand, the MAG region has experienced tremendous population growth in recent decades. However, more recently the MAG region has and continues to experience a significant economic downturn. Planning for existing and future growth, while preserving existing economic interests and positioning the region for new economic opportunities has been a challenge.

In October 2010, representatives of the private sector expressed concerns to the MAG Management Committee about the potential regional economic impact of the POLC. At that time, MAG staff was directed to work with private sector representatives to address their issues with the POLC. From November 2010 to May 2011, private sector representatives have participated in five MAG Dark Sky Stakeholders meetings in addition to a number of side conversations with MAG staff. Discussion was often spirited at these meetings and limited compromise was found between the astronomy community and private sector representatives regarding the POLC.

This resource guide and report includes a Pattern Outdoor Lighting Code to interested MAG member agencies who may or may not adopt the provisions in whole or in part as necessary for their jurisdiction. MAG is not an enforcement agency, as such, the POLC is not for implementation by MAG.

The Maricopa Association of Governments (MAG) would like to thank all involved in the development of this resource guide and report, including but not limited to: MAG Dark Sky Stakeholders Group participants, MAG member agency representatives, the Arizona astronomy community, private sector representatives, and citizens.

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Frequently Asked Questions (FAQ)

What is MAG?

The Maricopa Association of Governments (MAG) is a Council of Governments (COG) that serves as the regional agency for the metro Phoenix area. When MAG was formed in 1967, local elected officials recognized the need for long-range planning on a regional scale. They understood that many issues such as transportation, air quality and homelessness, among others, transcend city boundaries.

MAG is the designated metropolitan planning organization (MPO) for transportation planning in the Maricopa County region. MAG has also been designated by the Governor to serve as the principal planning agency for the region in a number of other areas, including air quality, water quality and solid waste management. In addition, through a Governor's Executive Order, MAG develops population estimates and projections for the region.

What is MAG's policy structure?

The MAG Regional Council is the governing and policy-making body for the organization and is composed of elected officials appointed by each member agency. For the majority of members, the city or town mayor serves as the Regional Council member. Currently, the Governor of the Gila River Indian Community, the President of the Salt River Pima-Maricopa Indian Community, and the President of the Fort McDowell Yavapai Nation serve on the Regional Council. The county is represented by a member of the board of supervisors.

The MAG Management Committee provides a key role in the policymaking decisions at MAG. The Committee is responsible for receiving input from technical committees, analyzing technical and policy issues, and providing recommendations to the MAG Regional Council. The Management Committee consists of the chief administrators from each member agency. The director of the Arizona Department of Transportation and the executive director of the Regional Public Transportation Authority represent their respective agencies on transportation issues that are brought before the Management Committee.

Other MAG committees are established as needed to provide specific policy recommendations through the MAG committee process. MAG policy and technical committees as well as stakeholder groups, like the Dark Sky Stakeholders Group, can provide recommendations to the Management Committee.

How was the Dark Sky Stakeholders Group (DSSG) formed?

In January 2009, the MAG Management Committee recommended convening of a Dark Sky Stakeholders Working Group. The MAG Management Committee was requested to provide names of individuals in their respective jurisdictions to participate in the working group to develop a model Dark Skies ordinance.

What is the Dark Sky Stakeholders Group project background?

Date	Activity
August 2008	MAG Executive Director meets with a member of the International Dark Sky Association and authorized a presentation to the MAG Planners Stakeholders Group (PSG).
October 2008	Dr. Buell Januzzi, Past Director of the Kitt Peak Observatory, provided a report to the MAG Management Committee. He stated that outdoor light pollution creates a significant waste of energy and associated costs, and degrades the visibility of our night skies. This affects the world-class observatories located in the state.
December 2008	Dr. Januzzi gave the same presentation to the MAG Regional Council.
January 2009	MAG Management Committee approved convening a Dark Sky Stakeholders Group (DSSG). Jurisdictional managers were encouraged to send staff.
March-September 2009	DSSG collected information on outdoor light pollution, reviewed best practices in lighting codes, and developed a draft Pattern Outdoor Lighting Code (POLC).
October-November 2009	Made revisions to the draft POLC.
February 2010	MAG staff briefed Intergovernmental representatives.
July 2010	Held Dark Sky Workshop to gather comments from external stakeholders on the draft POLC.
August 2010	Evaluated all comments from external stakeholders and revised the POLC.
September and October 2010	MAG staff updated Intergovernmental representatives.
October 2010	Updated MAG Management Committee. Members of the committee encouraged working with stakeholders representing the private sector and to find a balanced recommendation for the committee.
April 2011	MAG staff advises members of the Dark Sky Stakeholders Group, private sector representatives, and interested parties that a resource guide and report of the DSSG efforts would be drafted and circulated for review. The draft POLC is to be included in the report along with private sector concerns and alternatives. Interested parties are able to submit comments and concerns to be included in the report.
June 2011	The draft resource guide and report is circulated for review.
July 2011	Anticipated DSSG meeting to review comments to the draft resource guide and report.

What is the purpose of the MAG Dark Sky Stakeholders Group?

The purpose of the Stakeholders Group is to collect information on outdoor light pollution, review best practices in lighting codes, and to develop a draft Pattern Outdoor Lighting Code that could be used by MAG member agencies for updating their respective outdoor lighting codes.

How can I find more information on the MAG Dark Sky Stakeholders Group?

All information on this topic can be found on the Dark Sky project page of the MAG website: <http://www.azmag.gov/Projects/Project.asp?CMSID=1082>

Who are the MAG Dark Sky Stakeholders Group staff contacts?

Jami Garrison, MAG Socioeconomic Research Program Manager jgarrison@azmag.gov
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MAG staff can be reached at (602) 254-6300.

Who participated in discussions of the MAG Dark Sky Stakeholders Group?

A number of MAG member agencies, citizens, interested parties and private sector representatives had varying levels of participation in discussions of the MAG Dark Sky Stakeholders Group. A list of participants is included in the appendix of this document.

Why did MAG develop a Pattern Outdoor Lighting Code?

- To assist MAG member agencies in updating existing outdoor lighting codes
- To help preserve Arizona astronomy - a \$250 million per year economic impact for Arizona.
- To help the member agencies and business save energy as well as costs by recognizing and prohibiting unshielded and excessive outdoor lighting. Luginbuhl & Lockwood (2008) estimate that up to \$30 million per year could be saved in Arizona

In the summer of 2008 the MAG Executive Director was approached by a member of the International Dark Sky Association with a request to make a presentation to all MAG member agencies on the growing outdoor light pollution in the MAG region. The International Dark Sky Association saw MAG as an efficient way to reach many jurisdictions. They offered staff from the astronomy community to help MAG form a stakeholders group and create a Pattern Outdoor Lighting Code (POLC).

Dr. Buell Januzzi, Past Director of the Kitt Peak Observatory, provided a report to the MAG Management Committee and Regional Council about issues related to outdoor light pollution in MAG region. He explained that outdoor light pollution represents a potential waste in energy and related energy costs, and degrades the visibility of our night skies. This affects the world-class observatories located in Arizona. During the presentations, the counties,

municipalities and Native American Indian communities were invited to consider revisiting the adequacy and enforcement of their respective lighting ordinances.

What is a pattern code?

The term “pattern code” means that the code is a guideline or template that can be modified to suit each community. The POLC does not intend to offer a single solution appropriate for all communities or situations. It offers instead a comprehensive guide describing issues relevant to the control of the obtrusive aspects of outdoor lighting, and a list of approaches to mitigate these aspects. The POLC is intended for use by any community of any size or locale that wishes to create a new, or update an existing, outdoor lighting code.

What is the need and purpose for an outdoor lighting code?

- To permit reasonable uses of outdoor lighting for nighttime safety, utility, security, and enjoyment while preserving the ambiance of the night.
- To conserve energy and resources to the greatest extent possible.
- To minimize glare and obtrusive light by limiting outdoor lighting that is misdirected, excessive, or unnecessary.
- To encourage optimum use of outdoor lighting for future development and growth.

What about existing lighting (grandfathering)?

MAG legal counsel advises that it is difficult in Arizona to require existing uses to comply with new code requirements, unless there is a change in the existing use. All outdoor lighting codes in Arizona, including this POLC, grandfather any installation compliant with the previous regulations. New installations and major modifications are where the new code could take effect; the POLC does not mandate the replacement of all lighting fixtures if one or a few need replacement. The value of the replacement must exceed 50% of the installation value at either one instant or through cumulative changes before the new standards apply.

What about retrofitting? Is there additional expense for existing businesses?

There are no requirements for retrofitting existing lighting or signs. Currently existing lighting and signs will not be affected by adoption of the POLC.

Does the Pattern Outdoor Lighting Code regulate street lights?

Section 3.5 of the POLC addresses public roadways and states that lighting for public roadways and pedestrian lighting must comply with the code, except the lumens cap of Section 4.2. Typically the municipality’s Street or Transportation Department sets and implements street lighting standards.

What is a *lumens cap* and how does it work?

The majority of issues associated with overlighting can be addressed effectively by an overall cap on the amount of light permitted, scaled to the area to be developed - lumens per acre caps. (Lumens are a measure of light output as seen by the human eye and can be found on every lamp package and catalog description.)

Lumens per acre is a simple calculation that does not require specialized technical training.

Newer versions of Outdoor Lighting Codes include a lumens cap. The lumens cap provides maximum flexibility for the lighting designer to work within an overall "lumen budget" in order to creatively achieve the goals presented by clients. Professional quality designs can achieve the goals and solve the problems, if any, of each lighting situation by trading off amounts of decorative and general illumination, areas to be illuminated, illumination levels and uniformities, types of luminaire optical design, and other factors to achieve quality lighting without the code specifying permitted or prohibited lighting uses, or illuminance levels for each situation.

What about holiday lighting?

Seasonal decorative lighting is usually exempt from Outdoor Lighting Codes and is exempt from the POLC during the holiday season.

What are Lighting Zones?

Lighting zones were first developed in Arizona lighting codes beginning in the 1980s, and were designed to help protect astronomical observatories from the growth of light pollution. Since then the concept has been expanded by the International Lighting Commission (CIE) and the Illuminating Engineering Society of North America (IESNA) to address other environmental concerns, such as energy conservation, glare, and light trespass. Environmental zone ratings (Lighting Zones) help ensure that the lighting goals of an environment are appropriately defined and met, but not exceeded. Simply put, the amount of light allowed in a given zone is tailored to the density of development, activity levels and sensitivity of the zone or nearby areas affected by lighting in the zone to off-site impacts of lighting (e.g. glare and sky glow). For example, a densely developed commercial district would have a higher lighting allowance than an agricultural area; areas near observatories or natural areas may have tighter limits than areas located far from such sensitive areas.

What is the impact on planning and code enforcement staff in terms of administering an outdoor lighting code?

Outdoor lighting codes have been in place in various Arizona communities since the 1970s and have not been shown to create an unusual administrative load. At a MAG DSSG meeting, the jurisdictions of Buckeye, Fountain Hills, Gilbert, Maricopa County and Mesa commented that the code would not have a significant workload impact for them.

Some jurisdictions have web-fillable or downloadable forms for the Existing Lighting Inventory and Lumen Output Calculation Sheets as well as examples of properly prepared applications.

Nonetheless, as with any code, implementation and enforcement of a lighting code will impact the planning and code enforcement staff. In addition to the time required to review materials related to lighting, and on site follow-up to verify compliance, the staff will need to develop some familiarity with lighting terms such as lumens, and how to reliably evaluate the shielding characteristic of luminaires. Further, enforcement of any code includes not only the assurance that plans and construction conform to the standards of the code when the building or lighting permit is issued and when the project is completed, but also monitoring of continuing compliance after the project is completed.

Can MAG adopt the POLC?

MAG is not an enforcement agency, as such, the POLC is not for adoption by MAG. It is anticipated that MAG member agencies may consider adoption of the POLC either in whole or in part as necessary for their jurisdiction.

Have crime, safety and Crime Prevention Through Environmental Design (CPTED) been addressed in the POLC?

The purpose of the draft POLC is to define practical and effective measures to minimize obtrusive outdoor light, while preserving safety, security, and the nighttime use and enjoyment of property. A common question is the connection between lighting and crime. Several reports and studies were analyzed and the information was provided to the DSSG by Dan Brocius, Whipple Observatory in 2009. According to the International Dark Sky Association, "the idea that more light always results in better safety and security is a myth. One needs only the right amount of light, in the right place, at the right time. More light often means wasted light and energy." The POLC adheres to CPTED lighting principles, though the approach is not identical: communities will benefit from a complementary approach using both.

Does the POLC allow for safe and sufficient lighting at ATMs?

Safe lighting can be provided at ATMs following the standards in the POLC. Calculations indicate that approximately 20,000 lm are sufficient to provide this lighting. As POLC allows, at minimum, 50,000 lm per acre, and bank sites are generally greater than one acre, it is evident that POLC permits sufficient lighting.

Why signage in a lighting code?

It is not necessary to have signage in a lighting code, but it is important that lighting and the potential light pollution aspects of signs be addressed. DSSG put it in the POLC. Many Arizona jurisdictions also include the lighting aspects of signage in a lighting code. The sign portion of the POLC can be easily removed and put into a sign code.

Why a lighting curfew for signs?

A number of jurisdictions within Arizona have had sign lighting curfews for many years, including: Cochise County, Coconino County, Cottonwood, Pima County, Sedona, Tucson, and Yavapai County.

According to the astronomy community, signs cause a substantial amount of light pollution (estimated 10 percent of the total). A curfew is only in effect for non-business hours. Any jurisdiction can adjust or eliminate curfews.

Why a sign brightness of 100 nits?

Nit is the standard unit used to measure the brightness of a surface, such as of a sign. The POLC includes a maximum brightness of 100 nits for digital (multi-color LED) billboards. This is based on the typical maximum brightness seen in current technology (floodlit) billboards. The standard in some Arizona jurisdictions is 300 nits, a limit supported by the sign industry.

Based on an unpublished survey of 565 floodlit billboards in the Phoenix, Tucson and Chicago metro areas, 1) more than 90 percent of floodlighted billboards are below 100 nits, and 2) floodlit billboards illuminated at 100 nits are easily readable.

Besides energy and light pollution issues, there is a safety concern. Brighter signs (at three times existing levels) may have an increased negative impact on driver vision and safety.

Why is sign color addressed in the code?

To help reduce light pollution it is best to stay away from white or very light-colored background signs as they pollute the most. White background signs produce twenty times as much light pollution as an opaque-background sign, and about six times as much light pollution as a strongly colored-background sign.

Is the pattern code a lighting design standard?

The POLC is not a lighting design standard, and does not require a property owner or business to meet any particular illumination levels. All standards in the POLC are intended to limit the off-site or obtrusive aspects of outdoor lighting, such as glare with associated decreased visibility, excessive energy use, and sky glow.

Will POLC lumen caps affect liability?

The lumen limits in POLC are 50,000, 100,000 and 150,000 lumens per acre. The lowest, 50,000, is the limit that has been in place in 2/3 of urban Flagstaff for over 20 years. There have been no complaints or cases where public safety was held to have been compromised by these levels, and as such there is no increase in liability or liability insurance costs.

How do the POLC and the International Energy Conservation Code (IECC) 2009 outdoor lighting allowances compare?

Summary: Roughly, IECC Lighting Zone 1 (LZ1) and Lighting Zone 2 (LZ2) are similar to POLC LZ2 and LZ3; IECC LZ3 and LZ4 allow substantially more light than the POLC.

Comparison of the amount of outdoor lighting allowed under POLC and IECC 2009 is complex, as the standards are written differently. The POLC is a simple lumens per acre standard, requiring only the site acreage to determine the allowance. IECC 2009 specifies allowances for a variety of uses, the amount determined by the area or linear dimensions of each use (such as parking lots, walkways, entryways, sales areas, sales canopies, façade lighting, etc.). In the IECC 2009 calculations below, we have assumed lighting will be used only for the parking area and building façade: in general these will be the principal lighting uses on most sites.

Site information:

site area = 1 acre

parking lot area = 0.6 acre

building perimeter = 200 feet

building height = 12 feet

façade area (perimeter x height) = 2400 ft.² fixture luminous efficacy (lumens per watt) = 60 (minimum); 75 (typical)

POLC lighting allowances

LZ 1 50,000 lm

LZ 2 100,000 lm

LZ 3 150,000 lm

IECC 2009 lighting allowances

LZ 1 93,000 lm (min); 116,000 lm (typical)

LZ 2 144,000 lm (min); 181,000 lm (typical)

LZ 3 223,000 lm (min); 279,000 lm (typical)

LZ 4 311,000 lm (min); 388,000 lm (typical)

Pattern Outdoor Lighting Code for the MAG Region

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Section 2: Conformance with Applicable Codes

Section 3: Applicability

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3.3 Nonconforming Outdoor Light Fixtures; Nonconforming Uses

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Section 14: Violation and Penalty
Section 15: Severability
Section 16: Definitions

Note: ***Bold italics*** indicate terms defined in Section 16.

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Section 1. Purpose and Intent.

It is the purpose of this Code to define practical and effective measures by which the obtrusive aspects of outdoor light usage can be minimized, while preserving safety, security, and the nighttime use and enjoyment of property. These measures are intended to curtail the degradation of the nighttime visual environment, *light trespass*, energy and resource waste, and to preserve the naturally dark skies relied upon by Arizona's world-class astronomical facilities by encouraging lighting practices that direct appropriate amounts of light where and when it is needed, increasing the use of energy-efficient sources, and decreasing wasted light from overlighting and poorly shielded or inappropriately directed lighting fixtures.

It is further recognized that naturally dark landscapes and star-filled skies are valued by many and that poor practices in outdoor lighting hamper the reasonable use and enjoyment of property and can endanger the public welfare by producing unnecessary glare.

Section 2. Conformance with Applicable Codes.

All *outdoor lighting fixtures* shall be *installed* in conformance with the provisions of this Code, the Building Code, the Electrical Code, the Sign Code and all other applicable laws and regulations of the jurisdiction.

Section 3. Applicability.

- 3.1. New Uses and Major Modifications. All outdoor lighting for new uses, developments or structures, and major modifications to outdoor lighting, for which a permit or other approval is issued or given after the effective date of this Code, shall meet the requirements of this Code. Cumulative modification or replacement of outdoor lighting constituting fifty (50) percent¹ or more of the *lumens* permitted by this Code for the parcel, regardless of the actual amount of lighting already on a non-conforming site, shall be deemed a major modification for purposes of this section.
- 3.2. Minor Additions. Alterations, additions or modifications to outdoor lighting of less than fifty (50) percent¹ in the value or *total outdoor light output*, and that require a permit, shall require the submission of a complete inventory and site plan detailing all existing and any proposed new outdoor lighting. Any new lighting on the site shall meet the requirements of this Code with regard to shielding and lamp type; the *total outdoor light output* after the modifications are complete shall not exceed that on the site before the modification, or that permitted by this Code, whichever is larger.
- 3.3. Nonconforming *Outdoor Light Fixtures*; Nonconforming Uses. If a use, building or structure loses its nonconforming status, or if *outdoor light fixtures* are modified in excess of fifty (50) percent¹ of their value, or *total outdoor light output*, whether all at once, or in

¹ The actual percentage that triggers the requirement to bring outdoor lighting fixtures into compliance with this Code may be that specified in each jurisdiction's zoning ordinance. Values of 25% and 50% have been used in Arizona lighting codes.

a series of cumulative changes, then all outdoor lighting must be brought into conformance with the requirements of this Code.

- 3.4. Resumption of Use after Abandonment. If a use, building or structure is abandoned (as defined in Section ____ of the Zoning Ordinance), then all outdoor lighting shall be brought into compliance with this Code before the use is resumed.
- 3.5. Public Roadways. Lighting for public roadways must comply with this Code, except the *total outdoor light output* standards of Section 4.2.
- 3.6. Alteration of Non-conforming Use. All *light fixtures* may be maintained as provided in Section ____ of the Zoning Ordinance, but shall not be re-erected, relocated, or replaced unless brought into compliance with this Code. Nothing in this Code shall affect existing property or the right to its continued use for the purpose used at the time the Code takes effect, nor to make any reasonable repairs to *light fixtures*, property, or uses for such legal existing purposes.

Section 4. Outdoor Lighting Standards.

- 4.1. Shielding Standards. All nonexempt *outdoor light fixtures* shall comply with the shielding standards provided in Table 4.1; outdoor *luminous tube* lighting does not require shielding but total output from *unshielded* lighting is subject to the limits set forth in Section 4.2. The distance from a fixture to the nearest residential property line means the distance to the nearest parcel with any kind of residential use.

Use Codes:

A = all types of fixtures allowed; *fully shielded* recommended

F = only *fully shielded fixtures* allowed

X = not allowed

Table 4.1 *LUMINAIRE* SHIELDING STANDARDS

Land Use and Lamp Output	Shielding		Notes
	Distance from Luminaire to Nearest Residential Property Line		
	< 50'	≥ 50'	
Commercial, Industrial and Multi-Family Residential			
Initial lamp output ≥ 2,000 <i>lumens</i>	F	F	
Initial lamp output < 2,000 <i>lumens</i>	F	A	1,2,3
Residential Lighting			
Initial lamp output ≥ 1,000 <i>lumens</i>	F	F	
Initial lamp output < 1,000 <i>lumens</i>	F	A	1,2,3,4

Notes to Table 4.1

See Section 16 for the definition of “residential.”

1. *Spot* and *flood lamps* must be aimed no higher than 45 degrees above straight down (half-way between straight down and straight to the side) when the lamp is visible from any off-site residential property or public roadway (Figure 4.1).

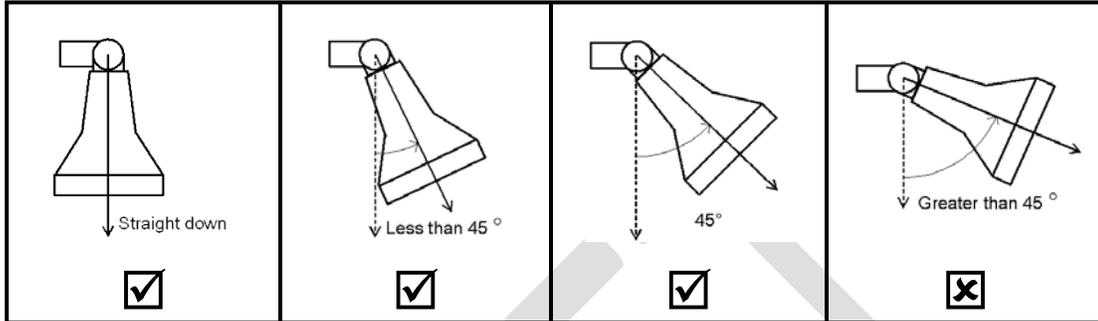


Figure 4.1. Spot light aiming

2. The maximum amount of lighting in *unshielded* fixtures is limited in Section 4.2.
3. Seasonal decorations using typical *unshielded* low-wattage lamps or LEDs shall be permitted from Thanksgiving through January 15; such lighting is not subject to the shielding or *total outdoor light output* standards of this code.
4. Examples of lamp types of 2,000 and 1,000 *lumens* and below (The acceptability of a particular light is determined by initial *lumen* output, not wattage; values listed are approximate; check manufacturer’s specifications).

Lamp Type	2000 <i>lumens</i>	1000 <i>lumens</i>
Standard incandescent and less	100 watt	60 watt
Tungsten-halogen (quartz) and less	100 watt	60 watt
Fluorescent and less	25 watt	15 watt
Compact Fluorescent and less	26 watt	13 watt
Metal Halide	40 watt	N/A
High-Pressure Sodium	N/A	N/A

- 4.2. Total Outdoor Light Output Standards. *Total outdoor light output* shall not exceed the limits set forth in Table 4.2. (The values in this table are upper limits and not design goals; design goals should be the lowest levels that meet the requirements of the task.)

Table 4.2 MAXIMUM *TOTAL OUTDOOR LIGHT OUTPUT* STANDARDS

Land Use and Fixture Shielding	Lighting Zone			Notes
	LZ 1	LZ 2	LZ 3	
Commercial, Industrial, Multi-family residential (lumens per <i>net acre</i>)				
total (<i>fully shielded</i> + <i>unshielded</i>)	50,000	100,000	150,000	
<i>unshielded</i> component	5,000	10,000	10,000	

Residential (lumens per residence)				1
total (<i>fully shielded</i> + <i>unshielded</i>)	20,000	20,000	20,000	
<i>unshielded</i> component	5,000	5,000	5,000	

Notes to Table 4.2

1. Each residential single-family detached home or duplex is allowed up to 5,500 *lumens* of *unshielded* lighting or the lighting provided in this Table based on the parcel's acreage, whichever is larger, provided Table 4.1 allows the fixture(s) to be *unshielded*. Residential spot or flood lamps are to be aimed no higher than 45 degrees above straight down (see Note 1 to Table 4.1).
- 4.3. Lamp CCT Standard. All lamps, except lamps used for *decorative lighting*, must conform to the *CCT* limits listed in Table 4.3.

Table 4.3 ALLOWED LAMP CCT

	Lighting Zone		
	LZ 1	LZ 2	LZ 3
<i>Maximum CCT</i>	3000K	3000K	4300K ²

- 4.4. Effective Shielding Standard. All light fixtures that are required to be *fully shielded* shall be *installed* and maintained in such a manner that the shielding is effective as described in the definition for *fully shielded* fixtures.
- 4.5. "House Side" Shielding Standard. Beyond the shielding requirements of Section 4.1, any privately or publicly owned *outdoor light fixture* with a lamp of initial output over 10,000 *lumens* located within 50 feet of any residential (including multi-family residential) property or public right-of-way shall utilize an internal or external "house-side" shield, with the light fixture and shield oriented to minimize *light trespass* over the adjacent property or right-of-way line (Figure 4.5). The surface of any external shield must have a black or bronze finish on the side facing the lamp to minimize reflection.

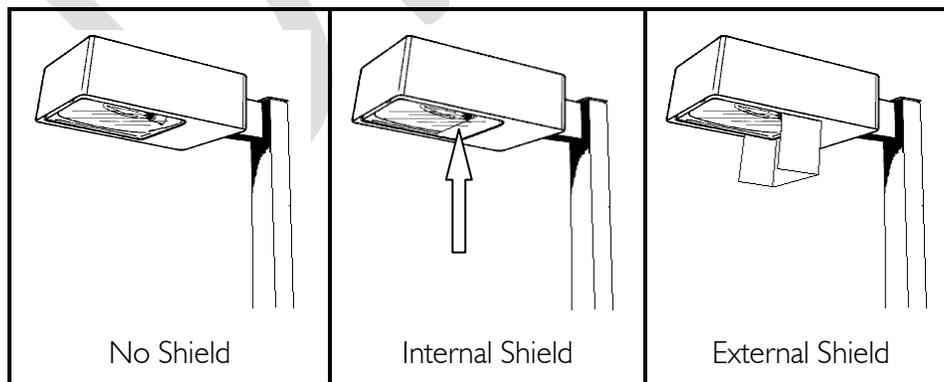


Figure 4.5. House-side shield configurations

² To decrease potential disruption of human circadian rhythms and sky glow, a CCT limit of 3000K should be considered in all Lighting Zones.

4.6. Curfews

- A. *Decorative lighting* shall be extinguished between 10:00pm, or when the business closes (whichever is later), and the time the business re-opens.
- B. *Area lighting* located 75 feet or more from the nearest building, *display area* or storage area shall be extinguished between 10:00pm, or within sixty (60) minutes of the business closing (whichever is later), and the time the business re-opens.
- C. All lighting subject to curfews in Section 4.6.A and 4.6.B shall be controlled by automatic time switches.

Section 5. Outdoor Advertising Sign Lighting Standards.³

- 5.1. Externally Illuminated Sign Lighting Standards. External lighting for signs, including *billboards*, shall conform to the provisions of this Code, including but not limited to the lamp source, shielding and *total outdoor light output* standards of Section 4 (except as provided in Section A below). All upward-directed sign lighting is prohibited.
 - A. Lighting for externally illuminated *billboards* is allowed up to a maximum of 200 initial lamp *lumens* per square foot of illuminated sign face, even when the *total outdoor light output* standards in Section 4.2 would not otherwise permit such lighting.
- 5.2. Internally Illuminated Sign, Neon Sign, Multicolor Fixed-Copy LED Sign and Single-Color LED Sign Lighting Standards.
 - A. Outdoor *internally illuminated signs* must either be constructed with an *opaque* background and translucent text and symbols, or with a colored background and generally LIGHTER text and symbols (Figure 5.2.A). Colored backgrounds shall not be white, off-white, light grey, cream, or yellow. Lamps used for internal illumination of such signs shall not be counted toward the *total outdoor light output* standards in Section 4.2.

³ Some jurisdictions include all sign standards, including those related to lighting, in a separate sign code.

Light Background <input type="checkbox"/>	Colored Background <input checked="" type="checkbox"/>	Opaque Background <input checked="" type="checkbox"/>
		
		
		

Figure 5.2.A *Internally illuminated sign styles*

B. *Neon signs, multicolor fixed-copy LED Signs and single-color LED signs* (Figure 5.2.B) shall be treated as internally illuminated signs for the purposes of this Code, and shall not have their luminous outputs counted toward the *total outdoor light output* standards in Section 4.2. Any lighting extending beyond the area considered to be the sign area (as defined in the Sign Code of this jurisdiction) shall be considered *decorative lighting*, and shall be subject to the standards applicable for such lighting, including but not limited to the lamp source, shielding and *total outdoor light output* standards of Section 4.

Neon	Multicolor Fixed-Copy LED	Single-Color LED
		

Figure 5.2.B *Neon, multicolor fixed-copy LED and single-color LED signs*

C. Other internally-illuminated panels or decorations not considered to be signage according to the sign code of this jurisdiction (such as illuminated canopy margins or building faces), shall be considered *decorative lighting*, and shall be subject to the standards applicable for such lighting, including but not limited to the lamp source, shielding and *total outdoor light output* standards of Section 4.

5.3. *Multicolor Changeable-Copy LED Sign* Lighting Standards. Lighting for *multicolor changeable-copy LED signs* must meet the following:

- A. [ALTERNATIVE A] *Multicolor changeable-copy LED signs* must include photocell technology to control and vary the intensity of lighting depending on the amount of ambient light that is present to prevent overly bright *luminance* at night: automatic controls must limit night luminance to a maximum of 100 nits when the display is set to show maximum brightness white (100% full white mode). The applicant shall provide a written certification from the sign manufacturer that the nighttime light intensity has been factory pre-set not to exceed this level, and that this setting is protected from end-user modification by password-protected software or other method as deemed appropriate by the Planning Director.

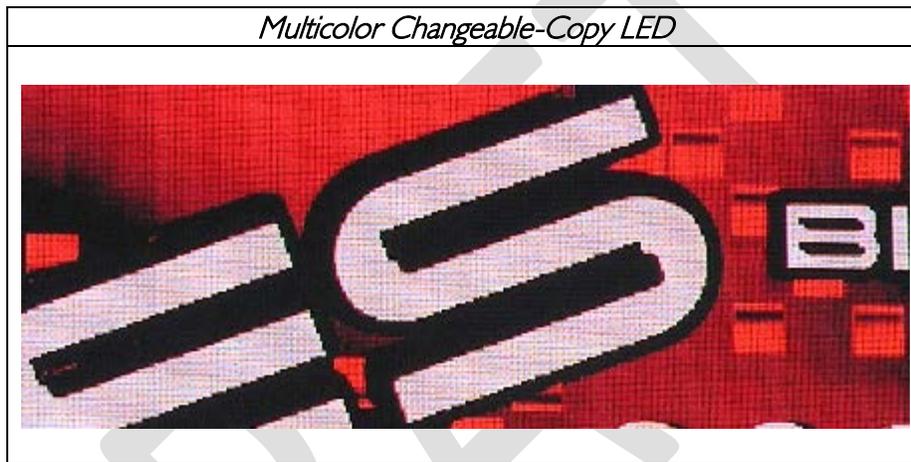


Figure 5.3.A *Multicolor changeable-copy LED sign*

[ALTERNATIVE B] *Multicolor changeable-copy LED signs* are not permitted.

- 5.4. Curfews. Illumination for all *on-site advertising signs* except *billboards*, both externally and internally illuminated, shall be turned off at the curfew times listed in Table 5.4 or when the business closes, whichever is later. Signs subject to curfews are required to have functioning and properly adjusted automatic shut-off timers. Light background (white, off-white, light gray, cream or yellow) *internally illuminated signs, installed* legally before enactment of this code [enter date], may continue to be used and illuminated but must conform to the curfews as indicated.

Table 5.4 ILLUMINATED SIGN CURFEWS

Land Use Zoning and Sign Type	Curfew
Commercial and Industrial zoning	
<i>Opaque</i> Background	10pm
Colored Background	10pm
Light Background	8pm
All residential and mixed-use zoning	
<i>Opaque</i> Background	9pm
Colored Background	9pm
Light Background	6pm

Note to Table 5.4

Land Use Zoning refers to the predominant use of land by area within 1,000 feet of the parcel on which the sign is located.

Section 6. Special Uses.

6.1. Recreational Facilities.

- A. Class of Play: Fields designed primarily for use by municipal or amateur leagues, training, recreational or social levels, shall be considered *Sports Class IV* as defined by the Illuminating Engineering Society of North America (IESNA). Fields designed primarily for college, semiprofessional, professional or national levels shall be considered *Sports Class I*, *Sports Class II* or *Sports Class III* as defined by IESNA.
- B. Lighting Amount: Lighting for outdoor athletic fields, courts or tracks shall be exempt from the *total outdoor light output* standards of Section 4.2.
- C. Shielding: *fully shielded* lighting is required for fields designed for *Sports Class III* and *Sports Class IV* levels of play. Facilities designed for *Sports Class I* and *Sports Class II* levels of play shall utilize *luminaires* with minimal upright consistent with the illumination constraints of the design. Where *fully shielded* fixtures are not utilized, acceptable *luminaires* shall include those which:
 1. Are provided with internal and/or external glare control louvers and *installed* so as to minimize upright and offsite light trespass, and;
 2. Are *installed* and maintained with aiming angles that permit no greater than five percent (5%) of the light emitted by each fixture to project above the horizontal.
- D. Illuminance: All lighting installations shall be designed to achieve no greater than the 110% of the minimal *illuminance* levels for the activity as recommended by the Illuminating Engineering Society of North America (IESNA) for the *Sports Class* as described in Section 6.1.A.

- E. Off-site spill: The installation shall also limit off-site spill (off the parcel containing the sports facility) to the maximum extent possible consistent with the illumination constraints of the design.
- F. Certification: Every such lighting system design and installation shall be certified by a registered engineer, architect or landscape architect as conforming to all applicable restrictions of this Code.
- G. Curfew: All events shall be scheduled so as to complete all activity before 11pm. Illumination of the playing field, court or track shall be permitted after the curfew only to conclude a scheduled event that did not conclude before the curfew due to unusual circumstances.

6.2. *Frontage Row of Vehicle Display Areas.*

- A. Shielding: All *frontage row vehicle display area* lighting shall utilize *fully shielded luminaires* that are *installed* in a fashion that maintains the *fully shielded* characteristics.
- B. *Lumen* Limit: *Total outdoor light output* for the *frontage row of vehicle display areas* is exempt from the standards of Section 4.2, but shall not exceed sixty (60) *lumens* per square foot.
- C. Curfew: The *frontage row of vehicle display area* lighting exceeding the *total outdoor light output* standard of Section 4.2 shall be turned off at the curfew listed in Section 6.1 or within sixty (60) minutes after closing of the business, whichever is later.

6.3. Service Station Canopies.

- A. Shielding: All *luminaires* mounted on or recessed into the lower surface of service station canopies shall be *fully shielded* and utilize flat lenses.
- B. Total Under-Canopy Output: The total light output used for illuminating service station canopies, defined as the sum of all under-canopy initial bare-lamp outputs in *lumens*, shall not exceed sixty (60) *lumens* per square foot of canopy. All lighting mounted under the canopy, including but not limited to *luminaires* mounted on the lower surface or recessed into the lower surface of the canopy and any lighting within signage or illuminated panels over the pumps, is to be included toward the total at full initial *lumen* output.
- C. The *lumen* output of lamps mounted on or within the lower surface of a canopy is included toward the standards in Section 4.2 according to the method defined for *total outdoor light output*. Other lighting located under a canopy but not mounted on or within the lower surface is included toward the standards in Section 4.2 at full initial output.

6.4. Other Lighting on Parcels with Special Uses. All lighting not directly associated with the special use areas above shall conform to the lighting standards described in this Code at all times, including but not limited to the shielding standards of Section 4.1, the *total outdoor light output* standards of Section 4.2 and the lamp CCT standards of Section 4.3. The *net acreage* for the determination of compliance with Section 4.2 shall not include the area of the athletic field or *frontage row of vehicle display area*; the area of any service station canopy shall be included in the *net acreage*.

Section 7. Submission of Plans and Evidence of Compliance with Code, Subdivision Plats.

7.1. Submission Contents. The applicant for any permit required by any provision of the laws of this jurisdiction in connection with proposed work involving *outdoor lighting fixtures* shall submit (as part of the application for permit) evidence that the proposed work will comply with this Code. Even should no other such permit be required, the installation or modification of any exterior lighting (except for routine servicing and same-type lamp replacement) shall require submission of the information described below. The submission shall contain but shall not necessarily be limited to the following, all or part of which may be part of or in addition to the information required elsewhere in the laws of this jurisdiction upon application for the required permit:

- A. plans indicating the total number and location on the premises of all *outdoor lighting fixtures*, both proposed and any already existing on the site;
- B. description of all *outdoor lighting fixtures*, both proposed and existing. The description may include, but is not limited to, catalog cuts and illustrations by manufacturers (including sections where required); lamp types, wattages and initial *lumen* outputs;

7.2. Additional Submission. The above required plans, descriptions and data shall be sufficiently complete to enable the designated official to readily determine whether compliance with the requirements of this Code will be secured. If such plans, descriptions and data are not sufficient, the applicant shall submit such additional evidence as reasonably requested by the jurisdiction, including certified reports of tests performed and certified by a recognized testing laboratory.

7.3. Subdivision Plats. If any subdivision proposes to have *installed* street or other common or public area outdoor lighting, submission of the information as described in Section 7.1 shall be required for all such lighting.

7.4. Lamp or Fixture Substitution. Should any *outdoor light fixture* or the type of light source therein be changed after the permit has been issued, a change request must be submitted to the designated official for approval, together with adequate information to assure compliance with this Code. Approval must be received prior to substitution.

7.5. Plan Approval. If the designated official determines that the proposed lighting does not comply with this Code, the permit shall not be issued or the plan approved.

- 7.6. Certification of Installation. For all projects where the *total outdoor light output* of the proposed lighting equals or exceeds 300,000 *lumens*, certification that the lighting, as *installed*, conforms to the approved plans shall be provided by a registered engineer, architect or landscape architect before the certificate of occupancy is issued.

Section 8. Approved Materials and Methods of Construction or Installation/Operation.

- 8.1. Approval of Alternatives. The provisions of this Code are not intended to prevent the use of any design, material, or method of installation or operation not specifically prescribed by this Code, provided any such alternate has been approved by the designated official. The designated official may approve any such proposed alternate providing he/she finds that it:
- A. provides at least approximate equivalence to that applicable specific requirements of this Code, and
 - B. is otherwise satisfactory and complies with the intent of this Code.

Section 9. Prohibitions.

- 9.1. Laser Source Light. The use of laser source light or any similar high intensity light for outdoor advertising or entertainment, when projected above the horizontal, is prohibited.
- 9.2. *Searchlights*. The operation of *searchlights* for advertising purposes is prohibited.
- 9.3. Mercury Vapor. Mercury vapor lights in use for outdoor lighting on the effective date of this Code shall not be used after January 1, 2011 (ARS 49-1104).

Section 10. Temporary Exemption.

- 10.1. Request; Renewal; Information Required. Any person may submit, on a form prepared by the jurisdiction, to the designated official, a temporary exemption request. The request shall contain the following information:
- A. specific Code exemption(s) requested;
 - B. purpose of proposed lighting;
 - C. duration of requested exemption(s);
 - D. information for each luminaire and lamp combination as required in section 7.1;
 - E. proposed location on premises of the proposed outdoor light fixture(s);
 - F. previous temporary exemptions, if any, and addresses of premises hereunder;
 - G. such other data and information as may be required by the designated official.

10.2. Approval; Duration. The designated official shall, within five (5) business days from the date of submission of the request for temporary exemption, approve or delay the request in writing. If approved, the exemption shall be valid for not more than thirty (30) days from the date of issuance of the approval. The approval shall be renewable upon further written request, at the discretion of the designated official, for a maximum of one (1) additional thirty (30) day period. The designated official is not authorized to grant more than one (1) temporary permit and one (1) renewal for a thirty (30) day period for the same property within one (1) calendar year.

10.3. Disapproval; Appeal. If the request for temporary exemption or its extension is disapproved, the applicant may appeal as provided in Section 12.

Section 11. Other Exemptions.

11.1. Nonconformance. All *outdoor light fixtures* lawfully *installed* prior to and operable on the effective date of this Code are exempt from all requirements of this Code. There shall be no change in use or lamp type, or any replacement (except for same-type and same-output lamp replacement) or structural alteration or fixture relocation made, without conforming to all applicable requirements of this Code. If the property is *abandoned*, or if there is a change in use of the property, the provisions of this Code will apply when the abandonment ceases or the new use commences.

11.2. State and Federal Facilities. Compliance with the intent of this Code at all State and Federal facilities is encouraged.

11.3. Emergency Lighting. Emergency lighting, used by police, firefighting, or medical personnel, or at their direction, is exempt from the requirements of this Code, for as long as the emergency exists.

11.4. Swimming Pool and Fountain Lighting. Underwater lighting used for the illumination of swimming pools and fountains is exempt from the lamp type and shielding standards of Section 4.1, though it must conform to all other provisions of this code.

Section 12. Appeals.

Any person substantially aggrieved by any decision of the designated official made in administration of the Code may appeal that decision to the Advisory/Appeals Board of this jurisdiction.

Section 13. Law Governing Conflicts.

Where any provision of federal, state, county, township or city statutes, codes, or laws conflicts with any provision of this Code, the most restrictive shall govern unless otherwise regulated by law.

Section 14. Violation and Penalty.

It shall be a civil infraction for any person to violate any of the provisions of this Code. Each and every day or night during which the violation continues shall constitute a separate offense. A fine shall be imposed of not less than fifty dollars nor more than seven hundred dollars for any individual or not less than 100 nor more than ten thousand dollars for any corporation, association, or other legal entity for each offense. The imposition of a fine under this Code shall not be suspended.

Section 15. Severability.

If any of the provisions of this Code or the application thereof is held invalid, such invalidity shall not affect other provisions or applications of this Code which can be given effect, and to this end, the provisions of this Code are declared to be severable.

Section 16. Definitions.

As used in this Code, unless the context clearly indicates otherwise, certain words and phrases shall mean the following:

- 16.1. ***Abandoned.*** Abandonment shall be determined as provided in Section _____ of the City/Town's Zoning Ordinance.
- 16.2. ***Area Lighting.*** All outdoor lighting used for, but not limited to, illumination for walkways, roadways, equipment yards, parking lots, outdoor security, outdoor sales or eating areas, assembly or repair areas, advertising and other signs, and recreational facilities where GENERAL ILLUMINATION for utility, safety or security of the grounds is the primary concern.
- 16.3. ***Billboard.*** Any sign designed for use with changeable advertising copy and which is normally used for the advertisement of goods produced or services rendered at locations other than the premises on which the sign is located.
- 16.4. ***CCT.*** See *Correlated Color Temperature.*
- 16.5. ***Correlated Color Temperature.*** (of a light source) The temperature (in Kelvins, abbreviated K) of a black-body radiator (e.g. the tungsten filament in an incandescent lamp) that radiates light of comparable hue to that light source. Higher CCT sources appear bluer or "cooler," lower CCT sources appear yellower or "warmer."
- 16.6. ***Decorative Lighting.*** Any outdoor lighting used for, but not limited to, architectural illumination, flag and monument lighting, and illumination of trees, bushes, etc.

- 16.7. **Development Project.** Any residential, commercial, industrial or mixed use subdivision plan or development plan which is submitted to the City for approval.
- 16.8. **Direct Illumination. Illumination** resulting from light emitted directly from a lamp or **luminaire**, not light diffused through translucent signs or reflected from other surfaces such as the ground or building faces.
- 16.9. **Directly Visible.** Allowing a direct line-of-sight to the light source or lamp.
- 16.10. **Display Area.** Outdoor areas where active nighttime sales activity occurs AND where accurate color perception of merchandise by customers is required. Recognized **display area** uses include automobile and recreational vehicle sales, boat sales, tractor sales, building supply sales, gardening or nursery sales, swap meets. Uses not listed here must be approved as display lot uses by the Planning Director.
- 16.11. **Frontage Row of Vehicle Display Area.** That portion of a **display area** used for vehicles located adjacent to the parcel frontage. Includes only the front row of vehicles adjacent to the parcel frontage; does not include the driving area located behind the parked vehicles or the remainder of the **display area** not adjacent to the frontage. (Figure 16.11)

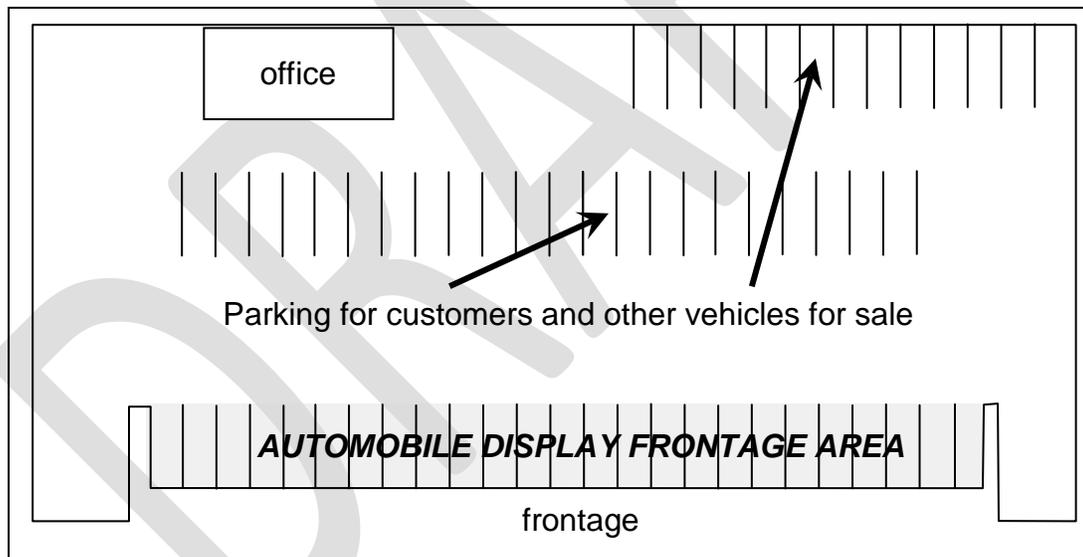


Figure 16.11. **Frontage Row of Vehicle Display Area**

- 16.12. **Flood Lamp.** See **Spot Lamp**.
- 16.13. **Footcandle.** The standard imperial unit used to measure **illuminance**, or the amount of light falling onto a surface, such as a roadway or athletic field. One **footcandle** equals one **lumen** per square foot. One **footcandle** equals approximately 10 **lux**.
- 16.14. **Fully Shielded (Light Fixture).** A **light fixture** constructed in such a manner that all light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the **luminaire**, is projected below the horizontal.

Any structural part of the light fixture providing this shielding must be permanently affixed and part of the fixture, not part of any surrounding building or architectural elements.

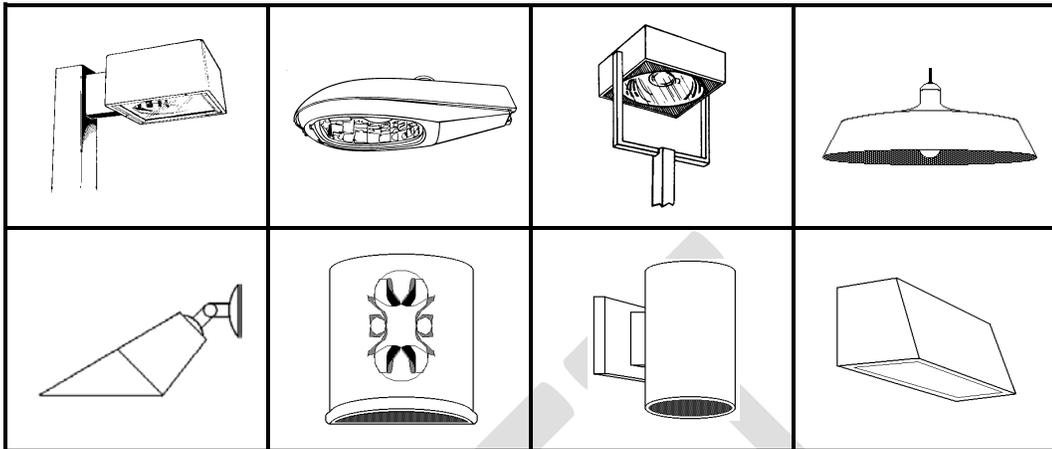


Figure 16.14a. Examples of fully shielded fixtures.

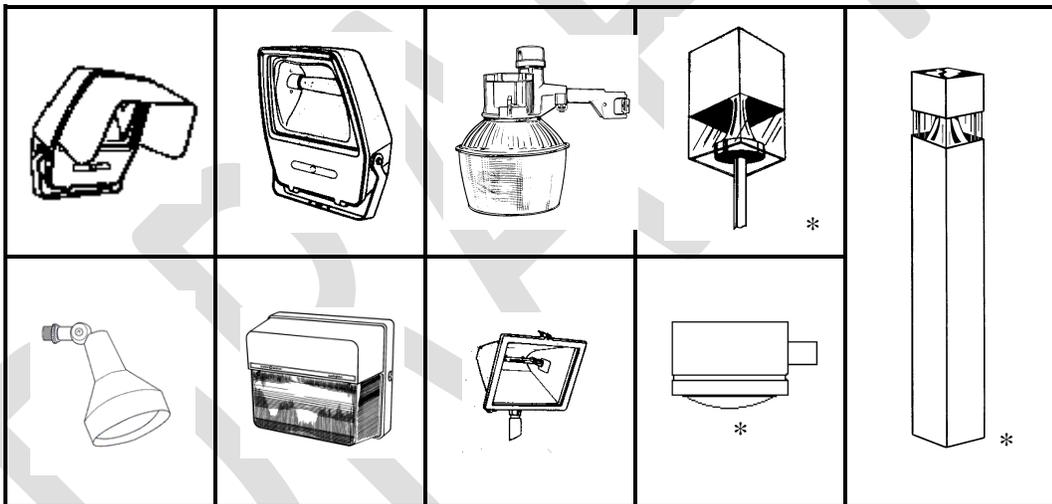


Figure 16.14b. Examples of fixtures that are NOT *fully shielded* (*even though the lamp in these fixtures is shielded from direct view when viewed from the side or above, reflective surfaces and/or lens covers are directly visible from the side).

16.15. **Illuminance.** The amount of light falling onto a unit area of surface (luminous flux per unit area) - measured in *footcandles* or *lux*.

16.16. **Installed.** The attachment, or assembly fixed in place, whether or not connected to a power source, of any *outdoor light fixture*.

16.17. **LED.** Light emitting diode.

16.18. **Light Fixture.** See *Luminaire*.

- 16.19. *Light Trespass*. Light falling across property boundaries, on property not containing the originating light source.
- 16.20. *Lighting Zones*. The three *lighting zones* are defined on the Lighting Zone Map, by this reference made a part of this Code. Guidelines used to guide the delineation of the *lighting zones* are:
- A. *Lighting Zone LZ 1*. This Zone includes rural areas, undeveloped or primarily residential, with typically small commercial centers surrounded by low density residential uses or open space.
 - B. *Lighting Zone LZ 2*. This Zone includes predominantly suburban residential areas, including neighborhood commercial or industrial areas mostly surrounded by residential areas.
 - C. *Lighting Zone LZ 3*. This Zone includes urban areas with primary land uses for commercial, business and industrial activity, including multi-family residential areas mostly surrounded by commercial areas.
- 16.21. *Lumen*. Unit of luminous flux; used to measure the amount of light emitted by lamps.
- 16.22. *Luminaire*. A complete lighting assembly (including the lamp, housing, reflectors, lenses and shields), less the support assembly (pole or mounting bracket); a *light fixture*. Includes *luminous tubes*, lamps or similar devices, permanently *installed* or portable, used for illumination, decoration, or advertisement. Such devices shall include, but are not limited to lights used for:
- A. parking lot or *parking garage* lighting;
 - B. roadway and driveway lighting;
 - C. pedestrian or walkway lighting;
 - D. entryway lighting;
 - E. buildings and structures;
 - F. recreational areas;
 - G. landscape lighting;
 - H. *billboards* and other signs (advertising or other);
 - I. product *display area* lighting;
 - J. building or structure decoration;
 - K. building overhangs and open canopies.

For purposes of determining *total outdoor light output* from a *luminaire* (see Table 4.1), lighting assemblies which include multiple lamps within a single *luminaire* or on a single pole or standard shall be considered as a single unit (Figure 16.22).

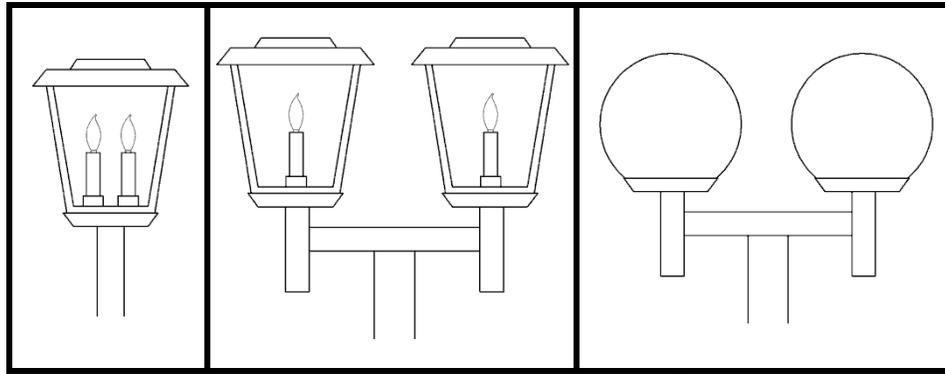


Figure 16.22. *Light fixtures* with multiple lamps in a single fixture (left) and on a single pole (center, right)

- 16.23. *Luminance*. The intensity of light reflected or emitted from a unit area of surface, such as a sign face - measured in *nits*.
- 16.24. *Luminous Tube*. A glass tube filled with a gas or gas mixture (including neon, argon, mercury or other gasses), usually of small diameter (10-15 millimeters), caused to emit light by the passage of an electric current, and commonly bent into various forms for use as decoration or signs. A "neon" tube. Does not include common fluorescent tubes.
- 16.25. *Lux*. The standard metric unit used to measure *illuminance*, or the amount of light falling onto a surface, such as a roadway or athletic field. One *lux* equals one *lumen* per square meter. One *lux* equals approximately 0.1 *footcandles*.
- 16.26. *Neon Tube*. See *Luminous Tube*.
- 16.27. *Net Acreage*. The remaining area after deleting all portions for proposed and existing streets and any *Frontage Row of Vehicle Display Area(s)* within a parcel, subdivision, or multiple contiguous parcels proposed for development.
- 16.28. *Nit*. The standard unit used to measure the brightness of a surface, such as of a sign. Equivalent to candela per square meter.
- 16.29. *Opaque*. *Opaque* means that a material does not transmit light from an internal illumination source. Applied to sign backgrounds, it means that the area surrounding any letters or symbols on the sign allows no light from any internal source to shine through it.
- 16.30. *Outdoor Light Fixture*. See *Luminaire*.
- 16.31. *Outdoor Light Output, Total*. The initial total amount of light, measured in *lumens*, from all lamps used in *outdoor light fixtures*. Includes all lights and *luminous tubes* used for *area* and *decorative lighting*, and lights used for external illumination of signs, but does not include lights used to illuminate *internally illuminated signs*, *luminous tubes* used in neon signs, or seasonal lighting from typical low-output lamps permitted between Thanksgiving and January 15th. For lamp types that vary in their output as they age (such as high

pressure sodium, fluorescent and metal halide), the initial lamp output, as defined by the manufacturer, is the value to be considered. For determining compliance with Section 4.2 [*Total Outdoor Light Output*] of this Code, the light emitted from lamps and *luminous tubes* is to be included in the total output as follows:

A. *outdoor light fixtures* and *luminous tubes installed* on poles (such as parking lot *luminaires*) and light fixtures *installed* on the sides of buildings or other structures, when not shielded from above by the structure itself as defined in parts B, C or D below, are to be included in the *total outdoor light output* by simply adding the initial *lumen* outputs of the lamps and tubes;

B. *outdoor light fixtures* and *luminous tubes installed* under canopies, buildings (including *parking garage* decks), overhangs or roof eaves where all parts of the lamp, tube or *luminaire* are located at least five (5) feet but less than ten (10) feet from the nearest edge of the canopy, building edge or overhang are to be included in the *total outdoor light output* as though they produced only one-quarter (0.25) of the lamp's or tube's rated initial *lumen* output;

C. *outdoor light fixtures* and *luminous tubes installed* under canopies, buildings (including *parking garage* decks), overhangs or roof eaves where all parts of the lamp, tube or *luminaire* are located at least ten (10) feet but less than thirty (30) feet from the nearest edge of the canopy, building edge or overhang are to be included in the *total outdoor light output* as though they produced only one-tenth (0.10) of the lamp's or tube's rated initial *lumen* output.

D. *outdoor light fixtures installed* under canopies, buildings (including *parking garage* decks), overhangs or roof eaves where all parts of the lamp, tube or *luminaire* are located thirty (30) or more feet from the nearest edge of the canopy, building edge or overhang are not to be included in the *total outdoor light output*. Such lamps must however conform to the lamp source and shielding requirements of Section 4.

- 16.32. ***Parking Garage.*** A multi-level or covered structure for parking that is open to the outside air. Includes parking facilities under buildings when the area is open to the outside at more locations than just the automobile entries and exits.
- 16.33. ***Person.*** Any individual, tenant, lessee, owner, or any commercial entity including but not limited to firm, business, partnership, joint venture, or corporation.
- 16.34. ***Residential.*** All single-family residential land uses, including all densities and types of housing such as single-family detached and duplexes, but excluding multi-family housing.
- 16.35. ***Searchlight.*** A lighting assembly designed to direct the output of a contained lamp in a specific tightly focused direction (a beam) with a reflector located external to the lamp, and with a swiveled or gimballed mount to allow the assembly to be easily redirected. Such lights are used commonly to sweep the sky for advertisement purposes.

- 16.36. *Sign, Externally Illuminated.* A sign illuminated by light sources from the outside.
- 16.37. *Sign, Internally Illuminated.* A sign illuminated by light sources enclosed entirely within the sign cabinet and not directly visible from outside the sign.
- 16.38. *Sign, Multicolor Changeable-Copy LED.* A sign composed of *LEDs* of more than one color and programmable to allow changing displays.
- 16.39. *Sign, Multicolor Fixed-Copy LED.* A sign composed of *LEDs* of more than one color with a fixed (not changeable or programmable) copy display.
- 16.40. *Sign, Neon.* A sign including *luminous tubes* formed into text, symbols or decorative elements and directly visible from outside the sign cabinet.
- 16.41. *Sign, On-Site Advertising.* A sign used primarily to advertise goods or services offered on the same parcel on which the sign is located. Such a sign may include incidental non-advertising information (for example time and temperature; does not include publicly owned signs providing general interest information exclusively (such as road names or highway conditions).
- 16.42. *Sign, Single-Color LED.* A sign composed of single-color *LEDs*, including signs with fixed and changeable copy.
- 16.43. *Sports Class I / II / III / IV.* Level of sports play as defined by the Illuminating Engineering Society of North America. This level is primarily determined by the number and distance of spectators; the higher recommended illumination levels facilitate the spectator's ability to view the action. *Sports Class IV* is the most common level, and is typical of municipal and amateur league and social level sports, with minimal accommodations for spectators, typically including bleachers located close to the field. *Sports Class III* includes increased accommodation for spectators. *Sports Class II* and *Sports Class I* apply to large sports facilities where thousands of spectators may be located hundreds of feet from the field, and television broadcasting may be a consideration.
- 16.44. *Spot Lamp.* A specific form of lamp designed to direct its output in a specific direction (a beam) with a reflector formed from the glass envelope of the lamp itself. Such lamps are so designated by the manufacturers and are often used in residential outdoor area lighting (Figure 16.44).

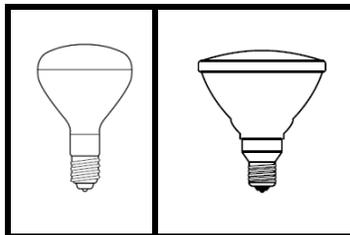


Figure 16.44. *Spot lamps*

16.45. *Temporary Lighting*. Lighting which does not conform to the provisions of this Code and which will not be used for more than one thirty (30) day period within a calendar year, with one thirty (30) day extension. *Temporary lighting* is intended for uses which by their nature are of limited duration; for example holiday decorations, civic events, or construction projects.

16.46. *Unshielded (Light Fixture)*. A *light fixture* constructed in such a manner that a fraction of the light emitted by the fixture, either directly from the lamp or a diffusing element, or indirectly by reflection or refraction from any part of the luminaire, is projected above the horizontal (see Figure 16.14b).

DRAFT

Technical Basis and Background

The purpose of the POLC is to establish a balance between outdoor lighting needs of commercial, industrial and residential lighting users and the need to limit unintended or obtrusive effects of outdoor lighting use such as light trespass, glare, excessive energy use, and sky glow. Poorly shielded lighting that shines directly from high intensity light fixtures into people's eyes, causing glare, always decreases visibility. Lighting levels above those needed for safety, utility and security consume more energy than needed, and produce more sky glow. Sky glow interferes not only with astronomical research in the state of Arizona, but also affects the environment and quality of life for all residents in the state. Reasonable amounts of lighting mean reasonable amounts of energy use, lower energy bills, and a more sustainable environment. Well shielded lighting means less glare, less trespass, and to most people a more attractive nighttime community.

The POLC codifies standards, including total lumen allowances, that are compatible with quality lighting design. The total lumen allowances are designed to accommodate basic lighting needs (such as lighting for safety, utility, security and commerce) in amounts recognized by the lighting industry (IESNA). The allowances are general and not use-specific, however, allowing lighting users to make their own choices, using the available lighting allowances according to their needs and priorities. In primarily residential or rural areas, the allowances are designed to provide some restrictions for less essential uses such as ornamental lighting, though the purpose is to effectively limit total lighting amounts, energy use, and light pollution, not to disallow nonessential uses. When alternative effective lighting practices are available with differing impacts on the night sky, preference is for standards compatible with the practices that have the smaller obtrusive impacts. As an example, lighting building façades can be done from flush in-ground lighting directed upward or from building-mounted light directed downward: preference is given to the latter because the impacts on the sky are dramatically decreased, even though this method or design may not be the “standard practice” for some lighting designers or some franchises.

The technical basis for figures appearing in the MAG POLC that are related to lighting technical aspects of lighting design or light pollution are described below in some detail. Non-technical figures related to administrative, legal, or other issues, are more briefly addressed.

Section 3. Applicability.

Figure: *50%*

Type: non-technical

Under Arizona law all lighting legally installed before passage of a new or updated code is entitled to legal nonconforming status in perpetuity; it need not be modified to meet the standards of the new or modified code. Reasonable maintenance such as lamp replacement is allowed without requiring conformance. However, when lighting equipment is replaced or “significantly” modified, the new lighting must conform to the codes in place when the replacement or modification occurs. All jurisdictions establish a threshold to differentiate maintenance from true additions or substantial modifications. In the POLC a threshold of *50%* of initial value is suggested to determine when significant modifications or upgrades to sites requires conformance. A *25%* threshold is used in many lighting codes. This threshold will be discussed and decided upon by each jurisdiction.

Section 4. Outdoor Lighting Standards.

Section 4.1 Shielding Standards.

Figures: *2000/1000 lumens; 50'*

Type: technical

(The impact of unshielded lighting on sky glow is discussed under Section 4.2.)

To minimize glare and light trespass into residential properties (arising at both commercial-residential and residential-residential boundaries), unshielded lights on non-residential properties may not be brighter than *2000 lumens (lm)* or located closer than *50 feet* to a residential property line. This is approximately based on the concept of limiting illuminance at the property line from an unshielded light to 0.06 footcandle (fc), or 2-3x full moonlight. (A *2000 lm* lamp is equivalent to about 100 W incandescent or 26 W compact fluorescent.)

The single largest source of complaint related to lighting in residential areas is light trespass or glare from unshielded lighting. On a residential property, the POLC allows a maximum brightness for an unshielded lamp of *1000 lm*, equivalent to about 60W incandescent or 13 W compact fluorescent. This lowers light trespass levels, again assuming *50'* distance, to about full moonlight level. (A *1000 lm* lamp is equivalent to about 60 W incandescent or 13 W compact fluorescent.)

Figure: *45-degrees*

Type: technical

Spotlights commonly used on residential properties can have a much higher intensity than an unfocused lamp. Therefore, the POLC requires that they be aimed downward to limit the off-parcel brightness. The angle used – *45-degrees* or half-way between straight down and straight sideways – is chosen to allow flexibility in light placement relative to the illuminated area (i.e. the lamp can still be used to illuminate an area located some distance away from the

lamp), to limit glare and trespass off-site, and to simplify interpretation for users and code enforcement.

Section 4.2 Total Outdoor Light Output Standards.

Figures: *50,000/100,000/150,000 lumens/acre* (total nonresidential lumen budget)

Type: technical

The majority of lighting needed on nonresidential properties is for basic area lighting, such as lighting for automobile and pedestrian areas including parking lots and walkways. Other lighting is often used for decorative purposes such as landscape lighting and building floodlighting.

For area lighting needs, basic recommendations of the lighting industry are for an illumination level of 0.2 footcandle (fc) at the dimmest point on the parking lot (IESNA, 1998). Assuming typical lighting technical parameters such as fixture efficiencies, light loss factors, and application efficiencies (see table below), between *50,000 lumens/acre (lm/ac)* and *100,000 lm/ac* are adequate to meet these needs. With typical design efficiencies, *100,000 lm/ac* allows a substantial amount of lighting for nonessential uses such as ornamental lighting, while *50,000 lm/ac* has much less room for such uses. A limit of *150,000 lm/ac* allows a substantial amount of light for nonessential uses, or for less efficient designs. *50,000 lm/ac* can also meet the basic area lighting needs but will require in many cases designs that are more efficient than average but achievable with good lighting design.

Lighting technical parameters

lm/ac	50000	50000*	100000	150000	150000*
application CU	0.5	0.7	0.5	0.5	0.7
LLF	0.65	0.65	0.65	0.65	0.65
fixture CU	0.65	0.65	0.65	0.65	0.65
parcel illuminated fraction	0.65	0.65	0.65	0.65	0.65
average illuminance (fc)	0.4	0.5	0.7	1.1	1.6
ave/min illuminance	2.1	2.9	3	3	3
minimum illuminance (fc)	0.2	0.2	0.2	0.4	0.5

* efficient design

CU= coefficient of utilization; LLF = light loss factor

Figures: *5,000/10,000 lm/ac* (total nonresidential unshielded lumen budget)

Type: technical

Research shows that unshielded lighting has a dramatically increased impact on dark skies compared to the same amount of shielded lighting. A 10,000 lumen unshielded light has a 2-10x greater impact on dark skies than a 10,000 lumen fully shielded light (Luginbuhl, Walker and Wainscoat, 2009).

Though there are no critical lighting needs, and very few lighting needs of any kind, which require unshielded lighting, in some applications unshielded lighting is commonly used (for example building façade lighting, landscape lighting, flag lighting). Despite the dramatic

increased impact on dark skies, the POLC allows as a compromise some unshielded lighting, though with tight limits on the total amount. Though there is no particular lighting design or application that dictates the figures of *5000 lm/ac* or *10,000 lm/ac*, these values have been found to be a practical compromise that provides flexibility with reasonable impacts on night skies.

Figures: *20,000 lm/residence* (total residential lumen allowance); *5,000 lm/residence* (total residential unshielded lumen allowance); *5,500 lm/residence* (total residential unshielded allowance minimum)

Type: technical

Lighting needs and desires on residential properties are highly variable and subject to individual tastes. The figures listed in the POLC are liberal, allowing as many as ten 100 W or eighteen 75 W incandescent lamps. As many as *5,000 lm/residence* may be unshielded, equivalent to about five 60 watt incandescent lamps.

Section 4.3 Lamp CCT Standard.

Figures: *4300/3000 K CCT*

Type: technical

Standards for lower correlated color temperatures (CCT) limit light emissions with wavelengths shorter (bluer) than about 500 nm (blue-green to the human eye). Light emissions below 500nm wavelength contribute very little to vision, but have larger demonstrated or potential negative impacts such as sky glow, glare and circadian rhythm and health disruption (IDA, 2010). Thus, lower CCT diminishes these negative effects with minimal impacts on efficiency, while still allowing a wide variety of available products and design approaches to outdoor lighting. The specific figures chosen (*4300 K* and *3000 K*) are selected to include the majority of LED products (*4300 K*), and to specify "warm white" or lower CCT (*3000 K*) in residential areas.

Section 4.5 "House Side" Shield Standard.

Figures: *10,000 lumens/50 feet*

Type: technical

When residential properties are located adjacent to commercial properties, the potential for the high intensity lighting commonly used on commercial properties to intrude on residential properties requires particular attention. The POLC requires that brighter lights (*10,000 lm* and greater) mounted within *50 feet* of a residential property line must have an additional shield, called a "house side shield," to limit trespass. The particular figures chosen are guided by a general principle of requiring the additional expense of special shielding only when the potential for light trespass is greatest.

Section 4.6 Curfews.

Figure: *10pm etc.*

Type: non-technical

Applying curfews to decorative and area lighting that is not directly associated with security arises from the general principle of energy conservation and the idea that the business/advertising and safety value of lighting when businesses are not open or late at night is reduced. This is a compromise where lighting is reduced when business or safety impacts are minimal, even though all night hours are of equal importance to professional astronomy - astronomy begins at sunset and ends at sunrise. The specific times chosen are suggestions only, and must be decided on a jurisdiction by jurisdiction basis following business activity and community goals.

Section 5. Outdoor Advertising Sign Lighting Standards.

Section 5.1.A Lighting for externally illuminated billboards.

Figure: *200 lumens/sf*

Type: technical

This figure is based on recommendations of the IESNA (IESNA, 2000) as well as a survey of 510 billboard faces in the Tucson metropolitan area. In the Tucson survey, 83% of the billboard faces used 200 lumens per square foot and less.

Section 5.2 Internally Illuminated Sign, Neon Sign, Multicolor Fixed-Copy LED Sign and Single-Color LED Sign Lighting Standards.

Figure: *"not white..."*

Type: technical

A study by Luginbuhl (2002) shows that the total light output of a typical light-background internally illuminated sign is about 7x that of a colored background sign, and 30x that of an opaque background sign. Further, as the light emitted from internally illuminated signs is directed sideways with 50% going upward and into the sky, the impact of such signage on dark skies is disproportionate to the amount of light used in such signs. In other words, even though signs do not account for a large amount of the light emitted by a city, because this light is unshielded its impact is much greater than would be indicated by its proportion of the total light output. In Flagstaff, where new light-background signs have been prohibited since 1989, a survey (Luginbuhl et al., 2009) estimated that the total amount of upward-directed light output due to signs was only 1.3% of the Flagstaff total; if these signs had used light backgrounds this proportion would have been about 4%, 1.5x as much uplight as produced by all hotels in the city, and almost 30x as much as produced by all roadway lighting.

Section 5.3.A Multicolor Changeable-Copy LED Sign Lighting Standards. Multicolor changeable-copy LED signs.

Figure: *100 nits*

Type: technical

Unlike previous technologies, digital LED billboards are designed to produce brightness levels that are visible during the daytime; though they are adjusted to fainter levels at night, should too large a fraction of this brightness be used at night serious consequences for driver visibility and safety are possible. Further, like any sign, the light emitted by billboards is unshielded, and thus has a disproportionate impact on dark skies. A review of the lighting professional literature (Luginbuhl et al., 2010) indicates that drivers should be subjected to brightness levels of no greater than 10 to 40 times the brightness level to which their eyes are adapted for the critical driving task. As roadway lighting and automobile headlights provide lighting levels of about one nit, this implies signage directed at drivers should appear no brighter than about 40 nits. Standard industry practice with previous technologies, based on a survey of over 70 billboards in the Phoenix, Chicago, Los Angeles and San Francisco metropolitan areas, shows such billboards are illuminated on average to less than 60 nits (Luginbuhl et al., 2010, with additional data), and rarely exceeds 100 nits. As these billboards were not limited in brightness by any regulation, it appears sensible from all perspectives to limit digital billboards to 100 nits.

Section 5.4 Curfews.

Figure: curfews

Type: non-technical

As for Section 4.7, applying curfews to sign lighting arises from the general principle of energy conservation and the idea that the business/advertising value of signage when businesses are not open or late at night is reduced. Specifically regarding signs, the issues for unshielded lighting discussed above under Section 5.2 also apply. The specific times chosen are suggestions only, and must be decided on a jurisdiction-by-jurisdiction basis following community goals.

Section 6. Special Uses.

Section 6.1.D Illuminance

Figure: [Illuminance]

Type: technical

The illuminance requirements are based on the IESNA Recommended Practice RP-6-01 (IESNA, 2001). Allowing 10% over the recommended levels allows an engineering design margin.

Section 6.2.B. Frontage Row of Vehicle Display Areas. Lumen Limit.

Figure: *60 lumens per square foot*

Type: technical

The limit of *60 lm per square foot* is based on efficient lighting design using metal halide fixtures, and allows 150% of the highest illumination level listed in the IESNA recommended practice RP-33-99 Lighting for Exterior Environments (IESNA, 1999). Lighting using white LEDs should be able to achieve approximately 200% of the RP-33-99 recommendation.

Section 6.3.B. Service Station Canopies. Total Under-Canopy Output.

Figure: *60 lumens per square foot*

Type: technical

The limit of *60 lm per square foot* is based on efficient lighting design using metal halide fixtures, and allows 150% of the highest illumination level listed in the IESNA recommended practice RP-33-99 Lighting for Exterior Environments (IESNA, 1999). Lighting using white LEDs should be able to achieve approximately 200% of the RP-33-99 recommendation.

DRAFT

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- Luginbuhl, C.B., et al., 2009, *From The Ground Up I: Light Pollution Sources in Flagstaff, Arizona, Publications of the Astronomical Society of the Pacific*, 121: 185
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Letters from Interested Parties

DRAFT



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October 11, 2010

President

Raymond Owens
Royal Sign Company, Inc.
Phoenix

To: Maricopa Association of Governments Management Committee

Subject: Proposed Draft Pattern Outdoor Lighting Code

Vice President

Tina Lockwood
All Sign Systems, Inc.
Phoenix

The Arizona Sign Association (ASA) has some concerns that we would like to bring to your attention with the proposed MAG Draft Pattern Outdoor Lighting Code. *We request that due to our concerns at this time that you not support the adoption of the current Draft Pattern Outdoor Lighting Code.* In this letter we explain each issue and provide specific recommendations.

Secretary/Treasurer

Chumita Hurd
Christy Signs
Phoenix

The ASA is an organization comprised of members of the on-premise sign industry. The ASA takes an active and leading role in the regulation of the sign industry in Arizona and, at times, proposes revisions to municipal sign codes to clarify provisions or to revise code language to reflect developments in the industry.

Directors

Proposed Sign Illumination Curfew

Jake Winklepleck
Young Electric Sign Co.
Chandler

Section 5.4 of the proposed Lighting Code includes language that requires businesses to turn off all sign illumination at the time a business closes or a range of times from 6:00 p.m. to 11:00 p.m., whichever is later. The curfew time varies based on the following criteria: an opaque and colored background is 10:00 p.m., a light background is 8:00 p.m., residential and mixed use zoning is 9:00 p.m. for opaque and colored backgrounds and 6:00 p.m. for light backgrounds.

Kent Grantham
Smithcraft
Phoenix

The Arizona Sign Association believes that the proposed curfew will be detrimental to the economic development and sustainability of the County and business community. To require that businesses to turn off all signage at the time of close, or the times indicated ranging from 6:00 p.m. to 10:00 p.m. severely limits the most affordable and cost effective method of advertising as indicated by the Small Business Administration. The Arizona Sign Association believes that the curfew proposal for all signage is not reasonable or justified.

Todd Anderson
N. Glantz & Son, LLC
Phoenix

In addition to the potential negative economic impacts on the entire County, the administration of the proposed language would not be practical due to the variety of sign types being addressed and the need for involved staff to determine what the "predominant use of the land" is within 1,000 feet of the parcel on which a sign is located. The proposed regulation is cumbersome, complicated and open to varying interpretations and enforcement challenges.

Charlie Gibson
Bootz & Duke Sign Co.
Phoenix

Further, current work by some dark sky advocates seems to support removal of the sign illumination curfew from the draft Lighting Code. The International Dark-Sky Association and the Illuminating Engineering Society are preparing a Model Lighting Ordinance ("MLO") to curtail impacts of outdoor lighting on the night sky. Although the

Chuck Finzer
Fluoresco Lighting & Signs
Phoenix

Past President

Michael Shano
Associated Sign Co., Inc.
Phoenix

Executive Director

Patricia King

groups have not adopted the final version of the MLO, the current draft, a copy of which is available through the International Dark-Sky Association's website, proposes to exempt lighting solely used for signs from the restrictions of the MLO and leave any signage lighting issues to a community's sign regulations.

Therefore, the Arizona Sign Association requests that all sign curfew requirements be eliminated from the Draft Pattern Outdoor Lighting Code.

Proposed Sign Color Designs

Section 5.2.A of the Draft Lighting Code has language that requires that internally illuminated signs "must either be constructed with an *opaque* background and translucent text and symbols, or with a colored background and generally LIGHTER text and symbols."

ASA recommends that the color of the background and text not be regulated. This will be detrimental to effective, viewable and safe design. In addition the administration of the code as proposed would be subjective and difficult due to the vast variations in color.

More importantly, it has been established by the Ninth Circuit Court of Appeals that business owners in Arizona have the right to display federally registered trademarks on their signs. The proposed language noted in the Draft Lighting Code may conflict with this right by requiring certain design requirements.

The ASA recommends that this section be eliminated from the Draft Pattern Outdoor Lighting Code.

Signage Proposed to be a Part of the Lumens Cap

Section 5.3.B requires that some signage extending beyond the "sign area" be included as a part of the lumens cap. ASA believes that this section is not clear and would be difficult to administer. Each jurisdiction has a methodology to measure sign area. Signs, due to the typically custom nature, are not easy or practical to measure lumens output. The administration of this section is not practical or feasible.

Therefore ASA recommends that any reference to lumens cap for all types of signage be eliminated.

Electronic Message Displays Nighttime Level

Section 5.3 of the Draft Lighting Code proposes that the nighttime illumination level for electronic message displays be at 100nits. It has been established and adopted or proposed by many jurisdictions (including Phoenix and Maricopa County) to utilize 300 nits as a reasonable and effective illumination level for electronic message displays. The ASA believes that the proposed level of 100 nits will be a detriment to the business community as the displays will not be safely viewed and will not function as intended.

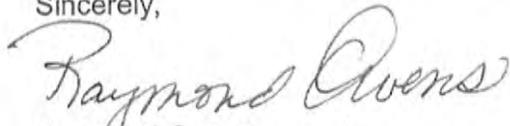
MAG Management Committee Letter
Page Three

Therefore, ASA recommends that nighttime illumination level for electronic message displays be set at 300 nits.

The Arizona Sign Association requests that *you not support the adoption of the proposed Draft Pattern Outdoor Lighting Code*. The ASA feels that if these concerns are not adequately addressed the Draft Pattern Outdoor Lighting Code may have some harmful impacts on the business community and economic sustainability for Maricopa County.

Thank you for your consideration of our requests. If you have any questions about these issues or would like to discuss them further, do not hesitate to contact me.

Sincerely,


Raymond Owens
President (pa)



Arizona Retailers Association

Maricopa Association of Governments
Management Committee
302 North 1st Avenue
Phoenix, Arizona 85003

VIA FACSIMILE

October 12, 2010

Dear Management Committee Members,

I am writing on behalf of the members of the Arizona Retailers Association (ARA) in regards to the proposed model lighting ordinance. ARA became aware of this proposal through a stakeholder but the retail community was not invited to be a stakeholder in this process. Therefore I am writing this letter to express our concerns about the following impacts of this proposal:

- ❖ Parking lot safety for our customers and our employees
- ❖ Costs of implementation for lighting changes
- ❖ Lost marketing opportunities
- ❖ Opportunity for fully vetting this proposal to the impacted business community

ARA works very closely with the law enforcement community through our Loss Prevention Committee as well as through ARA's involvement in the Organized Retail Crime Alliance. A standard element in the prevention of crime is lighting. Not only does bright light deter crime but lower lighting can impact the resolution of security cameras. This can hinder law enforcement's ability to identify criminals or vehicles used in a crime.

The safety of customers is a high priority for retailers and property owners. Retailers have invested in security cameras, technology and trained personnel to meet the specific needs of each neighborhood store. This proposal does not allow for modifications to be made to increase lighting when necessary. Therefore, we ask that ordinances that negatively impact safety provide some level of liability protection for the retailer.

Retrofitting parking lot lights can be very costly. Some retailers have implemented more advanced lighting while others are investing their capital resources in other areas. However in this current economic environment, most retailers have ceased all capital investment. This proposal would require some retailers to make those capital investments and retrofit their lighting. An ARA retail member reported that the costs to

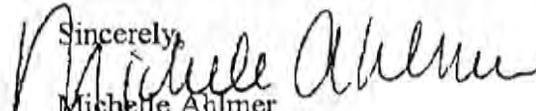
comply with this proposal for all of its store sites in Maricopa County would be in excess of *2 million dollars*. That cost in any economic climate would be excessive, however the timing alone of this proposal is simply not reasonable for sustaining the business environment, to say nothing of expanding and/or attracting new business.

Signage is extremely important to the success of any business and especially to the highly competitive retail market. Therefore a sign curfew would negatively impact a retailer's most consistent, most visible and most affordable form of advertising.

In order to fully understand the impact of this proposal on the business community a far more inclusive process should be undertaken. Retailers and developers are just two business industries that would be very negatively impacted by this proposal and two industries that were not included in the stakeholder meetings.

Each city in the State of Arizona is heavily dependent on sales tax revenues. The success of the retail industry in Arizona should be of utmost importance to Maricopa Association of Governments and every city in the State. Retail sales have not rebounded as anticipated, therefore any additional burden on this industry at this time will impact the retailer's ability to generate sales tax revenue; sales taxes that pave the roads, pay for infrastructure etc.

The members of the Arizona Retailers Association respectfully request that the Management Committee reject the model lighting ordinance due to the impacts upon the safety and security of our customers and employees as well as the economic impact on retail operations.

Sincerely,

Michelle Ahlmer
Executive Director



Arizona Retailers Association

December 14, 2010

Ms. Heidi Bickart
Regional Planner III
Maricopa Association of Governments
302 North 1st Avenue, Suite 300
Phoenix, Arizona 85003

Dear Ms. Bickart,

As a member of the Coalition for Safe and Responsible Lighting, our organization is writing to express our concerns regarding the Outdoor Lighting Code proposed to MAG. Despite the troubled economic times our businesses have endured, we are still in operation here in Maricopa County. Our effort to reduce energy consumption and cut operating costs has resulted in the installation of more efficient lighting options. But we have not done so at the expense of the safety of our employees, customers, or the public at large. While safety and efficiency have been the factors that drive our lighting decisions with our businesses in Maricopa County that does not appear to be the principles upon which the proposed Lighting Code is based. As a result, we believe the proposed Code will have adverse impacts on our industry as well as the economy and safety of the people of Maricopa County.

The retail industry in Arizona generated over \$4.3 Billion during the Arizona fiscal year of 09-10 – at the 5% collection rate. Each city in the State of Arizona is heavily dependent on those sales tax revenues. The success of the retail industry in Arizona should be of utmost importance to Maricopa Association of Governments and every city in the State. Retail sales are just beginning to rebound therefore any additional burden on this industry at this time will impact the retailer's ability to generate sales tax revenue; sales taxes that provide for police, fire, pave the roads, pay for infrastructure etc.

The members of the Arizona Retailers Association (ARA) have the following specific concerns about the proposed model lighting ordinance:

- ❖ Parking lot safety for our customers and our employees
- ❖ Costs of implementation for lighting changes
- ❖ Lost marketing opportunities

ARA works very closely with the law enforcement community through our Loss Prevention Committee as well as through ARA's involvement in the Organized Retail Crime Alliance. A standard element in the prevention of crime is lighting. Not only does bright light deter crime but also lower lighting can impact the resolution of security cameras. This can hinder law enforcement's ability to identify criminals or vehicles used in a crime.

The safety of customers is a high priority for retailers and property owners. Retailers have invested in security cameras, technology and trained personnel to meet the specific needs of each neighborhood store. This proposal does not allow for modifications to be made to increase lighting when necessary. Additionally, some retail employees work after the close of business

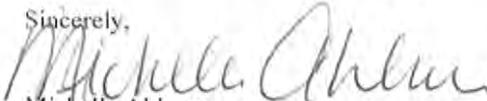
restocking shelves or doing price adjustments. Reduced parking lot lighting could negatively impact the safety of those employees as they arrive and depart during odd hours of the night. Therefore, we ask that ordinances that negatively impact safety provide some level of liability protection for the retailer.

Most city ordinances require upgrades when any expansion or remodeling is done and therefore the likelihood is quite high that retrofitting parking lot lights would be required. Retrofitting parking lot lights, security cameras to compensate for lower lighting and new requirements for sign changes can be very costly. In the current economic environment, most retailers have ceased all capital investment. However, when the economy turns around and retailers begin to explore the possibility of capital investment this proposal would work against property improvements. Any onerous regulations or ordinances will most likely delay any capital investment and other areas in Arizona or other states would take precedent to remodeling in Maricopa County. For example, an ARA retail member reported that the costs to comply with this proposal for all of its store sites in Maricopa County would be in excess of *2 million dollars*. That cost in any economic climate would be excessive, however the timing alone of this proposal is simply not reasonable for expanding and/or attracting new business.

Signage is extremely important to the success of any business and especially to the highly competitive retail market. Therefore a sign curfew would negatively impact a retailer's most consistent, most visible and most affordable form of advertising. It would also send a negative message to the citizens that the locations were not leased and therefore that the area was not recovering.

The members of the Arizona Retailers Association respectfully request that this model lighting ordinance be rejected due to the impacts upon the safety and security of our customers and employees as well as the economic impact on retail operations.

Sincerely,



Michelle Ahlmer
Executive Director

cc membership of Maricopa Association of Governments



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January 17, 2011

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Chuck Finzer
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Michael Shano
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Executive Director

Patricia King

To: Maricopa Association of Governments Dark Sky Group

The Arizona Sign Association (ASA) has some major issues with the proposed MAG Draft Pattern Outdoor Lighting Code. Due to our *concerns with the Draft Pattern Outdoor Lighting Code we recommend that this proposed code not be forwarded to the Management Committee for review.*

Our recommendations are also strongly supported by the *Coalition for Safe and Responsible Lighting*. The Coalition consists of the following: Valley Partnership, Arizona Retailers Association, Phoenix Chamber of Commerce, East Valley Chamber of Commerce, Arizona Bankers Association, International Council of Shopping Centers, Arizona Automobile Dealers Association, Safeway, Arizona Food Marketing Alliance, International Sign Association and the Arizona Sign Association.

The ASA is an organization comprised primarily of members of the *on-premise* sign industry. The ASA takes an active and leading role in the regulation of the sign industry in Arizona and, at times, proposes revisions to municipal sign codes to clarify provisions or to revise code language to reflect developments in the industry. It is also important to note that the ASA does not represent the billboard industry.

Lack of Metrics

The proposed Draft Pattern Outdoor Lighting Code has not quantified the issue and how the proposed code will address these issues. A clear identification of the problem in relation *to signs* has not been stated. The proposed code does not have any measurable outcomes. The stated purpose "practical and effective measures by which the obtrusive aspects of outdoor light usage can be minimized, while preserving safety, security, and the nighttime," is without quantifiable goals.

Non-conforming Uses

Sections 3.2 to 3.6 of the proposed Outdoor Lighting Code deal with non-conforming issues. The proposed section does not follow the typical language for non-conforming uses utilized by jurisdictions. Jurisdictions in Arizona typically use 50% as the threshold that requires a non-conforming use to comply with the code. The proposed language requires that any alterations, modifications, or

change in value of the intensity to the sign that exceeds 25% requires that the sign meet the requirements of the Outdoor Lighting Code. We believe that it is not a reasonable approach to be more restrictive with lighting than other non-conforming uses.

Regulation of Off-Premise (Billboards) and On-Premise

The proposed code includes the regulation of off-premise and on-premise signs together. The regulations for billboards and on-premise signs need to be segregated since they are each distinct types of uses. Billboards advertise off-premise information, and on-premise signs are for businesses that are part of a development where the sign is located.

Proposed Sign Illumination Curfew

Section 5.4 of the proposed lighting code includes language that requires businesses to turn off all sign illumination at the time a business closes or a range of times from 6:00 pm to 11:00 pm, whichever is later. The curfew time varies based on the following criteria: an opaque and colored background is 10:00 pm, a light background is 8:00 pm, residential and mixed use zoning is 9:00 pm for opaque and colored backgrounds and 6:00 pm for light backgrounds.

The Arizona Sign Association believes that the proposed curfew will be detrimental to the economic development and sustainability of the county and business community. To require that businesses to turn off all signage at the time of close, or the times indicated ranging from 6:00 pm to 10:00 pm, severely limits the most affordable and cost effective method of advertising as indicated by the Small Business Administration. The Arizona Sign Association believes that the curfew proposal for all signage is not reasonable or justified.

In addition to the potential negative economic impacts on the entire county, the administration of the proposed language would not be practical due to the variety of sign types being addressed and the need for involved staff to determine what the "predominant use of the land" is within 1,000 feet of the parcel on which a sign is located. The proposed regulation is cumbersome, complicated and open to varying interpretations and enforcement challenges.

Further, current work by some dark sky advocates seems to support removal of the sign illumination curfew from the draft lighting code. The International Dark-Sky Association and the Illuminating Engineering Society are preparing a Model Lighting Ordinance ("MLO") to curtail impacts of outdoor lighting on the night sky. Although the groups have not adopted the final version of the MLO, the current draft, a copy of which is available through the International Dark-Sky Association's website, proposes to exempt lighting solely used for signs from the restrictions of the MLO and leave any signage lighting issues to a community's sign regulations.

Proposed Sign Color Designs

Section 5.2.A of the draft lighting code has language which requires internally illuminated signs "must either be constructed with an *opaque* background and translucent text and symbols, or with a colored background and generally LIGHTER text and symbols."

Page Three

ASA recommends that the color of the background and text not be regulated. This will be detrimental to effective, viewable and safe design. In addition, the administration of the code as proposed would be subjective and difficult due to the vast variations in color.

More importantly, it has been established by the Ninth Circuit Court of Appeals that business owners in Arizona have a right to display federally registered trademarks on their signs. The proposed language noted in the draft lighting code may conflict with this First Amendment right by requiring certain design requirements.

Signage Proposed to be a Part of the Lumens Cap

Section 5.3.B requires that some signage extending beyond the "sign area" be included as a part of the lumens cap. ASA believes that this section is not clear and would be difficult to administer. Each jurisdiction has a methodology to measure sign area. It is not easy or practical to measure lumens output for signs due to their typically custom nature. The administration of this section is not practical or feasible.

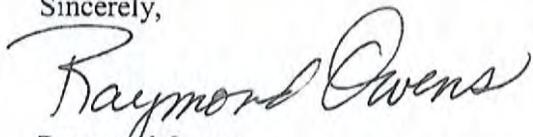
Electronic Message Displays Nighttime Level

Section 5.3. of the draft lighting code proposes that the nighttime illumination level for electronic message displays be at 100 nits. It has been established and adopted or proposed by many jurisdictions (including Phoenix and Maricopa County) to utilize 300 nits as a reasonable and effective illumination level for electronic message displays. The ASA believes that the proposed level of 100 nits will be a detriment to the business community as the displays will not be safely viewed and will not function as intended.

Due to the issues noted, the Arizona Sign Association requests that the proposed *Draft Pattern Outdoor Lighting Code* not be forwarded to the Management Committee. The ASA feels the Draft Pattern Outdoor Lighting Code may have some harmful impacts on the business community and economic sustainability for Maricopa County.

Thank you for your consideration of our request. If you have any questions about these issues or would like to discuss them further, do not hesitate to contact us.

Sincerely,



Raymond Owens
President



James Carpentier, AICP
Legislative Consultant



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Jay Kramer
General Counsel, Fenimore Craig

January 17, 2011

Heidi Brickart
Maricopa Association of Governments
302 North 1st Street, Suite 300
Phoenix, AZ 85003

Re: MAG Dark Skies Initiative

Dear Heidi,

On behalf of Valley Partnership, a nonprofit organization comprised of over 1400 private and public sector members engaged in the commercial real estate industry in Maricopa County, this is to provide the Maricopa Association of Governments our input on the Dark Skies Initiative. The Board of Directors of Valley Partnership has directed me to participate in the Businesses for Safe and Responsible Lighting and support the group's position on the proposed ordinance.

Despite the troubled economic times our businesses have endured, we are still in operation here in Maricopa County. Our effort to reduce energy consumption and cut operating costs has resulted in the instillation of more efficient lighting options. But we have not done so at the expense of the safety of our employees, customers, or the public at large. While safety and efficiency have been the factors that drive our lighting decisions with our businesses in Maricopa County, that does not appear to be the principles upon which the proposed Lighting Code is based. As a result, we believe the proposed Code will have adverse impacts on our industry as well as the economy and safety of the people of Maricopa County.

Specifically, the curfew provisions and other operation restrictions on signs attached to buildings is of great concern to Valley Partnership commercial building owners and operators, not only from a safety standpoint, but also from a business operation/economic development perspective. It is our intention to discuss these provisions as the Dark Skies Initiative proceeds.

Thank you,

Richard R. Hubbard CEO/President
Valley Partnership

5110 North 44th Street
SUITE L-200
PHOENIX ARIZONA 85016

Phone: 602-296-7844
Fax: 602-343-1406
info@valleypartnership.org



ARIZONA BANKERS
ASSOCIATION

January 18, 2011

Maricopa Association of Governments
301 North 1st Avenue, Suite 300
Phoenix, AZ 85003

RE: Outdoor Lighting Code, Proposed

Members of the Maricopa Association of Governments Management Committee:

As a member of Coalition for Safe and Responsible Lighting, the Arizona Bankers Association is writing to express our concerns regarding the Outdoor Lighting Code proposed to MAG. Despite the troubled economic times our businesses have endured, we are still in operation here in Maricopa County. Our effort to reduce energy consumption and cut operating costs has resulted in the instillation of more efficient lighting options. But we have not done so at the expense of the safety of our employees, customers, or the public at large. While safety and efficiency have been the factors that drive our lighting decisions with our businesses in Maricopa County, that does not appear to be the principles upon which the proposed Lighting Code is based. As a result, we believe the proposed Code will have adverse impacts on our industry as well as the economy and safety of the people of Maricopa County.

The Arizona Bankers Association represents the collective interests of Arizona's banking industry and counts 60 banks statewide as members, which operate over 1,000 branches in Arizona. I am writing to express our concern with the curfew for sign illumination in the proposed Outdoor Lighting Code.

Specifically, we are concerned how a curfew will apply to signage associated with banking services that are available to customers after the bank's normal business hours, including ATM and night drop services. Associated lighted signage includes drive up lane indicators, on-premise advertising signage indicating the ATM is available for customer usage, and signage that is directly on or near the ATM serving a dual purpose of advertising and illuminating the area for customer security.

The proposed curfew provisions do not clearly define when a business is considered closed or explicitly exempt signage for business services available after normal business hours. Advertising signage away from the body of the ATM or night drop is critical for customer communication that the service is available 24 hours or after normal banking hours. Requiring that these signs be subject to curfew prohibits the communication of information necessary for reasonable conduct of commerce.

The Arizona Bankers Association feels that imposing a sign curfew presents a significant security risk for customers accessing after hours services and additionally inhibits businesses ability to provide the communication necessary for the conduct of commerce. Thank you for considering our concerns.

Sincerely,
Stacey J. Langford
Vice President, Member Services



ARIZONA FOOD MARKETING ALLIANCE

January 18, 2011

Ms. Heidi Bickart
Regional Planner III
Maricopa Association of Governments
302 N 1st. Ave Suite 300
Phoenix, AZ 85003

Dear Ms. Bickart,

As a member of the Coalition for Safe and Responsible Lighting, our organization, The Arizona Food Marketing Alliance, is writing to express our concerns regarding the outdoor lighting code proposed by MAG.

Our stores constantly look for ways to reduce energy consumption and be more efficient by using the most updated lighting systems available.

Our priority is the safety of our employees, customers and public in general. We feel this proposal does not consider these issues and could create an adverse impact on our industry as well as the economy and safety for the people of Maricopa County.

The Arizona Food Marketing Alliance represents \$28 billion in sales revenue, 1300 members and 5600 outlets along with 100,000 employees in the State of Arizona.

This includes supermarkets, independents, convenience stores and all their suppliers.

The main reasons of concern are:

- Parking lot safety for employees and customers
- Cost of implementation for changes
- Lost revenue

In today's changing environment it becomes necessary to stay open for business to accommodate our customers.

The safety of our customers and employees is our major concern.

This ordinance would have a negative impact on the safety concerns and would impact the liability of our retailers.

We strive to be good, concerned citizens in all of our communities and we feel this ordinance is a step backwards.

The members of the Arizona Food Marketing Alliance respectfully request that this lighting ordinance be rejected due to its impact on safety and security concerns of our customers and employees along with the economic impact on all our retailers.

Sincerely,

A handwritten signature in black ink that reads 'Tim McCabe'.

Tim McCabe
President
Arizona Food Marketing Alliance

Keith J. Krueger
11181 E. Peralta Canyon Dr.
Gold Canyon, AZ 85118

April 20, 2011

Ms. Jami Garrison
302 North 1st Ave, Ste 300
Phoenix, AZ 85003

Re: April 19, 2011 Dark Sky Stakeholders Group meeting

Dear Ms. Garrison,

As you suggested that the participants of yesterday's Dark Sky Stakeholders Group meeting could submit further written comments, I am availing myself of that opportunity. Please forgive the fact that I am not a good observer of names.

It was disappointing to see yesterday's presenters show up so unprepared to engage the issues to be discussed. Throughout his speech, the representative from the Arizona Sign Association showed us example after example of what he said were effective signs. In example after example it was pointed out to him that these signs would be legal under the proposed Pattern Lighting Code. He did not want to engage in that discussion. He only wanted to move to his conclusion that he opposed any regulation of sign lighting, regardless of facts, or regardless of what is the code. Indeed this was the attitude expressed over and over again by all of presenters at yesterday's meeting.

The lawyer representing the presenters yesterday stated in his concluding remarks that the astronomical community had not demonstrated the effectiveness of lighting codes to curb sky glow. This was right after the presenter of the "Shopping Center Case Study" cited information indicating that shopping centers in Flagstaff contribute very little to sky glow. It was pointed out that Flagstaff is far ahead of the rest of the state in adopting effective lighting strategies, which is the reason that shopping centers there contribute so little to sky glow. Obviously the lawyer's statement was contradicted by data brought forward by one of his own people.

Two thirds of the city of Flagstaff has a lumen cap limit of 50,000 lumens per acre, and yes, as I recall, Target has a store located in that zone, contrary to the assertions made by the presenter of the Shopping Case Study. In the 20 or so years that Flagstaff has had this code, no one has been sued for lack of lighting, and complaints about lighting levels are virtually nonexistent. Are businesses in Flagstaff unsafe? No one has ever made that claim. Do cameras work in Flagstaff? Yes, they do.

I believe firmly in the property rights of others, and that these rights are to be protected. At the same time, it is self evident that no one owns the sky. As expressed in the Hebrew Scriptures; “The heavens declare the glory of God, the sky shows his handiwork. Day after day they pour forth speech, night after night they show knowledge”. The sky belongs to all of us, and no one has the right to silence its speech, no matter how much money they purport to make by doing so.

There has been a lot said about the importance of astronomy in the state of Arizona. Astronomy means more to the state of Arizona than can be measured in dollars and cents alone. It is more than the discoveries that can be made here, discoveries of near earth asteroids, planets circling distant suns, perhaps even evidence of life on one of them some day. In one of Carl Sagen’s most famous speeches, “The Pale Blue Dot”, he remarked that “astronomy is a humbling and character building experience”. What is really at stake here is character. The character of our state, that character of our citizens, and the character of our future.

The recession that we are still mired in is forcing our state to grapple with questions like: “When the buildings have been built, the lights have been installed, the commissions collected, what we are left with? What will we have built? What is it that we are building towards? It has to be more than a concrete jungle under dull canopy of a grayed out sky, like you see in a science fiction movie that has a pessimistic view of the future. It need not be, we can do better. Contrary to what was presented at yesterday’s meeting, the economic costs are not onerous to prepare the state for a more engaging future, as has been demonstrated by the city of Flagstaff for many years. All it takes is a willingness to look anew at what can be, rather than be dictated by what is, and what was.

Light pollution does more than cause unattractive glare and sky glow in a community. It also increases air pollution. This is a relatively new finding, so you may not have heard of it yet. I will attach an article with this letter referencing the study that was done. What the study shows is the Nitrogen Trioxide (NO₃) helps clean the air during the night. NO₃ does not form during the daytime, because light keeps it from forming. However in light polluted areas, NO₃ also does not form at night in the amounts that it should, because artificial light also prevents it from forming, just as sunlight does. Given the urgent necessity for Maricopa County to reduce it’s air pollution levels, every avenue of doing so needs to be explored.

Thank you for your tireless efforts on behalf of Maricopa County.

Sincerely,

Keith J. Krueger
International Darksky Association

sounds like science fiction.”

Positrons (antielectrons) were sensed by Fermi’s Gamma-ray Burst Monitor (GBM) coming from “terrestrial gamma-ray flashes” that occur above thunderstorms. TGFs, discovered in 1994, are brief, upward sprays of gamma rays that typically last a thousandth of a second. An estimated 500 occur around the world each day, mostly unnoticed.

Fermi has detected 130 TGFs. In four of them, positrons also struck the satellite. Apparently, some of the upward gamma rays are sufficiently energetic to convert into electron-positron pairs, and when this happens near the border of space, the positrons flying onward become trapped along Earth’s magnetic field lines to travel in a narrow, curved stream. Occasionally a stream intersects Fermi.

The gamma rays themselves presumably originate when electrons driven by lightning are somehow accelerated to nearly the speed of light before they can strike atoms of air. Cummer pointed out that despite decades of research, scientists still don’t know exactly how lightning is produced or propagates in clouds. “This discovery has very important implications for understanding lightning itself,” he said in making the announcement. “A new result like this gives us important clues about what’s happening.”

Lights at Night Worsen Smog

Anyone who has lived in a smoggy city knows that the ugly haze is at its least in early morning and worst in late afternoon. One reason, of course, is that more cars and factories run during the daylight hours. But another factor is sunlight. During nighttime, the nitrate radical NO_3 builds up in the darkened sky and neutralizes some of the other pollutants that foul the air. The rising Sun destroys NO_3 , leading to higher levels of the bad stuff.

And so does artificial light in the night sky, according to new research presented at a December meeting of the American Geophysical Union.

Last year Harald Stark of the NOAA’s Earth System Research Laboratory conducted a series of flights over Los Angeles to measure light pollution at different



Star streams far outside the main disk of NGC 5507, probably the remnants of infalling dwarf galaxies, are recorded in this very deep image by Chambliss Award winner R. Jay GaBany, seen here with one of his scopes.

altitudes. “My original goal was simply to quantify the intensity of city lights,” Stark explains. But it also became clear that the urban glow was affecting nighttime atmospheric chemistry. When Stark and his team plugged the measured illumination into photochemical models, they found that the city lights were destroying up to 7% of the nitrate radicals that would normally be cleaning the nighttime atmosphere. This results in nitrogen-oxide levels some 5% higher than they would otherwise be, making more of these gases available for smog- and ozone-producing reactions each morning. “Ozone production during daytime could be increased by nighttime light sources,” Stark concludes.

“Many cities are close to their limits of allowable ozone levels,” says Bob Parks, executive director of the International Dark-Sky Association, “so this news is expected to have big implications for outdoor-lighting practices and should be of special interest to the Environmental Protection Agency.”

Most light pollution in the sky is unnecessary. It is the wasted light spilled from badly designed or improperly aimed fixtures that send some of their rays uselessly sideways or up, rather than down toward the area that was meant to be illuminated.

Amateur Astronomy Researcher of the Year

R. Jay GaBany of San Jose, California, is the 2011 winner of the American Astronomical Society’s Chambliss Amateur Achievement Award. The award is given each year to an amateur astronomer from North America who makes outstanding contributions to scientific research.

Using a 20-inch telescope at the remote Black Bird Observatory in New Mexico, GaBany has been one of the world’s leading amateur astrophotographers for the past decade. In recent years he has devoted hundreds of hours to working with a team led by David Martinez-Delgado (Max Planck Institute for Astronomy, Germany) to take extremely deep CCD images of galaxies — revealing faint tidal streams, rings, and arcs in the outer halos of large spirals (*S&T*: January 2009, page 92). These images are helping scientists understand how large galaxies such as the Milky Way build up through the collisions and mergers of many smaller ones. Observing under very dark skies, and using very sensitive cameras, long exposure times, and advanced imaging and processing techniques, GaBany has managed to capture details not seen in professional images. ♦

William J. Shaheen
10919 E Silver Mine Rd
Gold Canyon, AZ 85118
WJShaheen@aol.com
(480) 671-7707

April 20, 2011

Ms. Jami Garrison, GISP
302 North 1st Ave, Ste 300
Phoenix, AZ 85003

Re: Dark Skies Stakeholders Group 04/19/2011 Meeting

Dear Jami,

Again, thank you and Nathan for the opportunity to participate in yesterday's meeting. As such, I would like to submit my observations and thoughts overall.

It may be convenient to believe that proponents of the Pattern Outdoor Lighting Code are reclusive astronomers wanting to covet and hoard to themselves the night skies, at the expense of the businesses affected and at the reduction of safety. That was the picture that the uncompromising opponents of the code attempted to paint in yesterday's meeting.

From our perspective, astronomers are in effect the "canaries in the coal mine" who can't help but be the first to notice the very apparent and readily visible effects of a more fundamental underlying process: the conspicuous and gluttonous consumption of energy. Light pollution is just one by-product of an overall social-economic system in which we are consuming natural resources and polluting the environment at an unsustainable rate. Therefore, it is a community obligation of all citizens, private and corporate, to engage in efficient practices that use as much as necessary but as little as possible.

The last thing this community needs is yet another issue to polarize us. And it is unfortunate that the POLC opponents failed to see that intelligently planned lighting is both efficient and effective and consequently a win-win proposition for the community as a whole.

Now, I would like to address the specific issue of cost that was raised by the representatives from the business community. And, mind you, we are not unsympathetic, since we live, work and shop here as well.

In general, one does not get to defray cost by impinging on the rights of others. The business community does not have the right to pollute my environment so they can avoid expense, just as I, for example, do not have the right to dump my garbage in the desert just because it would be a cost to dispose of it properly. Expense is not an excuse. It's simply the cost of doing business.

I'm sure the auto industry incurred increased costs when they were required to install features we now take for granted. Few of us recall "padded dashboards" being an amenity, much less seat belts, air bags and disk brakes. A better analogy may be the catalytic converter – for those who do not recall the odor of a passing car before the converter was required, again, reluctantly by the auto industry.

Also, there were several issues identified that can be easily mitigated. For example, the issue of what to do about a sign board in a shopping mall in which all the stores don't close at the same time. There assertion that the sign casing would have to be taken off its concrete foundation and be retrofitted is a stretch to say the least. The ruling could simply be turn off the entire sign when the last store closes. And even at that, the modern sign boards really are not the issue they once were. In fact, many of the facilities they showed as having to be replaced already comply with the code, due to their recent development. Not one of the signs that were presented as effective by the Arizona Sign Association is the problem. There are, however, some newer signs that could be a problem.

It is unfortunate, but not surprising, that at the close of yesterday's meeting the business representatives chose such a staunch and uncompromising position. Hopefully, we can work with them, as well as community managers, to arrive at solutions that we can all live with, and breathe a little better about.

Sincerely,

William J. Shaheen
Superstition Mountain Astronomical League

Cc: Nathan Pryor, MPA

Jami Garrison

From: Bob Christ [bchrist@tolisgroup.com]
Sent: Monday, April 25, 2011 3:44 PM
To: Jami Garrison
Subject: Phoenix dark sky issue

Hello Heidi, I am providing the following content FYI. I am sending it to our politicians and others that may have influence to protect our night sky. Thank you.

The following message is time-gated, my apologies. Action before May 17th is requested.

Who cares about unfettered visual access to the wonders of the night's sky? Clearly anyone that simply does not care, or those individuals willing to prostitute themselves to make the almighty dollar (a much more dangerous group). In this camp the organizations of: Arizona Association of Retailers, Arizona Food Marketing Alliance, Arizona Bankers Association, Arizona Sign Association, and International Council of Shopping Centers must be included.

The sky cannot speak for itself, and we as prudent human stewards must provide the "voice."

The Maricopa Association of Governments (MAG) Dark Sky Stakeholder Group is actively engaged in discussions regarding initiatives that will have a severe impact on the ability to view the night sky. The scary part is the rationale and misstated facts of parties interested to press their agendas forward at the cost of further losing access to a dark sky. I was told one mall developer simply stated "there is no light pollution issue" and summarily dismissed the topic.

Why should we care?

Significant research has been published that proves both humans, and other animals, need darkness at nighttime to achieve optimal mental and physiological health. Want to bet some of the behaviors we are seeing with increased frequency are not environmentally induced – I will not.

Too, dark skies are needed to perform important research, including that of the early identification of asteroids that can send us into extinction should the Earth be impacted before we can react. This is a very real issue, not science fiction.

One only needs to drive eastward from California toward Phoenix on Route 10 to view the impact to our sky. Over 100 miles from Phoenix, the visible light generated by ambient and misdirected light fixtures already creates a parabolic dome that extends some 30 degrees above the horizon, totally obscuring that portion of the sky. One in the Valley needs only look outside in the late evening to see how few stars (less than 100) are visible in contrast to those that should be visible (thousands).

When we moved into the Valley some 12-years ago my family and I attended an astronomy presentation in the White Mountains. Following the presentation the lights were turned-off for telescope viewing and the Milky Way became visible like a long, cloud band in the sky. Oooohs and ahhhhs of amazement were uttered by most everyone. That same exercise today results in a delivered sky that is slight darker than Phoenix and no Milky Way is visible. The shame of it; we are losing the night sky.

The USA was once a technology leader but this cannot be said now; especially regarding astronomy. Future astronomers are not germinated because the wonder of the sky is now not part of a young person's consciousness. They have never seen a truly dark sky and there is no wonderment generated. This too is a shame.

From a purely mercenary perspective, Arizona benefits significantly from the research and attendant dollars spent to conduct astronomy-related research. Light up the Arizona sky, and the resources and dollars will flow elsewhere.

Correcting the light-pollution ills already facing us is a task that will take time and support to achieve. Such corrections are, and have been, implemented by forward-thinking cities and countries around the globe. The immediate need is to prevent further encroachment on our night skies, here, in our Phoenix backyard.

The next MAG meeting is scheduled for May 17th, and the group is looking for input prior to the session.

I ask for your support to help assure the concerns I raise as well as those supplied to you by others "in the know" are understood and brought to "good light." Otherwise, the future of access to the sky will be mortgaged for the benefit of a few in the short-term.

And this would certainly be a shame from many perspectives.

Thank you kindly,

Bob Christ

bchrist@tolisgroup.com

480.473.0966

A concerned citizen that must "remember" the beauty of the sky versus view it.

Bob Christ

TOLIS Group, Inc.

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April 26, 2011

Jami Garrison
Socioeconomic Research Program Manager
Maricopa Association of Governments
302 N 1st Ave, Ste 300
Phoenix, AZ 85003

Re: AGFD Comments for the Maricopa Association of Governments Dark Sky Stakeholders Group

Dear Ms. Garrison:

The Arizona Game and Fish Department (Department) has reviewed the Maricopa Association of Governments (MAG) Draft Pattern Outdoor Lighting Code. The Department appreciates the opportunity to work with Maricopa County and other stakeholders in developing the MAG Draft Pattern Outdoor Lighting Code (Draft), because we recognize the impacts ecological light pollution has on people, businesses, and our natural resources.

Conservation Issues

Through the last century, dramatic increases in ecological light pollution have reached the point to where wildlife has begun experiencing substantial impacts. These impacts vary greatly, but can include avian mortality from tower collisions (Gehring et al. 2010), habitat fragmentation (Beier 1995; Stone et al. 2010), disruption of natural behavior (Beier 1995; Miller 2006), and population declines (Perry and Fischer 2006). The Department believes the current Draft will help reduce ecological light pollution, but we believe there are some additions that could help further reduce artificial lighting impacts on wildlife.

The placement of lights along undeveloped wildlife habitat has been shown to alter natural behaviors (Perry and Fischer 2006; Perry et al. 2008), expose individuals to higher predation levels (Bouskila 1995), and disrupt navigational abilities (Beier 2006). We believe further restricting the permitted angle of illumination to straight down for lights bordering undeveloped wildlife habitat will help reduce/eliminate those impacts through the decline in light trespass. We recommend the following additions for placement of lights along undeveloped wildlife habitat:

- A. Spot and flood lamp fixtures located ≥ 25 feet from undeveloped wildlife habitat and/or property boundary shall follow guidelines set forth in Section 4.1 detailing Spot Light Aiming. If spot and flood lamp fixtures are < 25 feet from undeveloped wildlife habitat then their aimed angle of illumination should be straight down as explained in Section 4.1.

Ms. Garrison

4/26/11

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- B. Exterior security lights positioned ≤ 25 feet from undeveloped wildlife habitat and/or property boundary shall follow guidelines set forth in Section 4.1 detailing Spot and Flood Lamp Aiming. Security lights that use motion detector switches that keep lights off except when approached and that switch lights on for the minimum duration possible are required.

Roadway lights also further restrict movement and fragment habitat along washes, rivers, and linkages resulting in increased habitat fragmentation and isolation, and ultimately the decline and possible disappearance of local wildlife populations (Beier 1995; Stone et al. 2010). We recommend the following additions for roadway lighting, based on current research and management practices (Beier et al. 2007):

- A. Roadway lights shall not be placed within 900 feet of wildlife crossing structures, wildlife linkages, major washes, streams, and rivers.
 - Distance may be refined when driver and public safety is a concern

Lastly, illumination of skyscrapers at night is also known to cause significant impacts to migratory birds. The artificial night lighting interferes with their magnetic compass resulting in significant mortality through collision with illuminated buildings and disoriented exhaustion (Poot et al. 2008). In order to help reduce this impact, the Department recommends the following additions for illumination of skyscrapers:

- A. Interior lights of skyscrapers that result in the visible illumination of exterior windows must have blinds drawn or be extinguished by sunset.

The Department appreciates the opportunity to provide comments on the MAG Draft Pattern Outdoor Lighting Code. We look forward to continuing this collaboration with Maricopa County and other stakeholders. If you have any questions, please contact me at 928-341-4069 or tbommarito@azgfd.gov.

Sincerely,



Tab Bommarito
Habitat Specialist
Region IV, Yuma

cc: Pat Barber, Regional Supervisor, Region IV
Josh Avey, Chief, Habitat Branch
Troy Smith, Habitat Program Manager, Region IV
Leonard Ordway, Assistant Director, Field Operations

AGFD # M11-04264912

Ms. Garrison

4/26/11

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June 27, 2011

The Honorable Thomas L. Schoaf
Chair, Maricopa Association of Governments
c/o Nathan Pryor and Jami Garrison
MAG Administration
302 North 1st Avenue
Suite 300
Phoenix, AZ 85003

Dear Mayor Schoaf and Regional Council Members:

Arizona State University endorses the goal for MAG to provide a pattern outdoor lighting code to its participating governments. We therefore strongly encourage participating governments to adopt or update individual codes to reflect current conditions and local needs based on that pattern code.

We have three institutional interests in advocating community use of good outdoor lighting design:

- Protection of the shared natural resource of the dark night sky that has attracted unique investment in Arizona by astronomy, astrophysics, cosmology, and space science projects. (Combined, these projects bring in 10's of M\$ of federal funds to ASU and Arizona).
- Promotion of energy efficiency as a saving to taxpayers and stimulus to commercial activity.
- Enhancement of the ambiance and safety of the metropolitan area in which ASU plays a central role.

The ASU School of Earth and Space Exploration is rapidly gaining in international prestige, drawing positive attention to the university and the state. It attracts high caliber researchers in part because of the unique astronomical observing facilities available to them. Those facilities include the world's largest telescope, the Large Binocular Telescope, located on Mt. Graham in southeastern Arizona. ASU astronomers tell me that the light dome over the Maricopa metropolitan area has a growing impact on the western horizon at the Mount Graham site, jeopardizing the performance of these telescopes. The Maricopa metro area impacts the sky brightness throughout the State of Arizona.

A basic element of the pattern outdoor lighting code is that light fixtures should prevent light from shining in directions above the horizontal plane. That simple demand for shielding protects the night sky, as well as the investment being made in the lighting. It assures that the light ends up illuminating the street or addressing the viewers of advertising, rather than being needlessly wasted as pollution into the sky above us, thereby negatively affecting our ability to carry out our research enterprise at ASU.

For communities that have more effective outdoor lighting codes, such as Tucson and Flagstaff, the growth of wasted light in the sky has been measured to be significantly slower than the rate of population growth. We take our institutional role of protecting our astronomical sites seriously, and believe that our metropolitan area can control wasted light and energy with similar effectiveness.

A revolution is taking place in outdoor lighting with the advent of LEDs and induction lamps. They hold the promise of producing much more light per Watt of electricity purchased, compared to the current generation of lamps. We understand that many of your participating governments are considering changing to such fixtures in the near future, as are many commercial interests. ASU is very much aligned with the goal of increasing energy efficiency at the local and state level. At the same time, this new technology poses the threat of glare from over-lighting and production of excess blue light that does not aid vision. The pattern code provides a thoughtful framework for addressing the new technologies that are exploding on the scene, and that are not currently considered in existing codes.

We find that quality of life is a significant factor when we recruit top-level faculty and staff for ASU as an institution. The ability of localities to enhance the nighttime appearance and safety of public spaces is explicitly part of the pattern code. Local governments can choose to put limits on the total amount of lighting as appropriate to residential vs. commercial zoning, insist on lighting levels that are safe as opposed to dangerously over-lighted, and can have curfews to eliminate unwanted light, when no commercial activity is taking place. Attractive communities offer increased property values and enhanced business opportunity, benefiting us as an institution and as Arizona residents.

On behalf of ASU, I therefore urge you to adopt the approach of a pattern outdoor lighting code as the basis for crafting individual codes that address today's technologies. It is an approach that will enhance business and improve our communities, while protecting a valuable common resource, the dark night sky which is essential for our scientific enterprise in Arizona.

Sincerely,


Michael M. Crow
President

MMC:rw
/c

Keith J. Krueger
11181 E. Peralta Canyon Dr.
Gold Canyon AZ, 85118
August 8, 2011

Ms. Jami Garrison
Socioeconomic Research Program Manager
Maricopa Association of Governments
302 N. 1st Ave, Ste 300
Phoenix, AZ 85003

Dear Ms. Garrison,

I have reviewed the Resource Guide and Report that was developed for the MAG Dark Sky Stakeholder's group and distributed last month, and I attended the Dark Sky Stakeholder's meeting that was held on July 26th, 2011.

The Arizona Sign Association asserts in their letter of October 2010 that the Model Lighting Ordinance published by the International Darksky Association, and the Illuminating Engineering Society, proposes to exempt sign lighting from curfew requirements. I am attaching a copy of the final adopted version of this MLO, so that you can confirm for yourself that there is no such exemption proposed for sign lighting. The relevant portion can be found on page 10 of the ordinance text.

During the meeting that occurred on July 26th, Tab Bommarito, of Arizona Fish and Game, made the constructive observation that perhaps our discussion has focused too much on the benefits to the astronomical community that well enforced lighting codes provide. In addition to preserving dark skies, which itself draws people to our state and increases business, dark skies also lay the foundation for a healthy habitat environment that people come to our state to enjoy in the daytime. In addition, lighting codes offer the opportunity for communities create warm, welcoming, and aesthetically pleasing night time environments by doing away with "glare bomb" lighting, that make a community look like a prison yard or junk yard at night.

Tab also made reference to the increasingly well documented negative effects that light pollution can have on human health. In support of this observation, I am attaching a research article that was done at the University of Connecticut and a letter from Dr. Steven Lockley, of the Harvard Medical School. It has long been known that women in industrialized and urbanized counties are much more likely to develop breast cancer. What was not well known until recently is the mechanism behind this correlation. The past 15 years have produced a mountain of evidence pointing toward light pollution.

The fact is that life on our planet, at least life that exists on or near the surface of the planet, including human life, is adapted for functioning in an environment that experiences both light, and darkness. This is the way the Earth was formed, and man can not improve upon it.

It is said that when Teddy Roosevelt was brought to the Grand Canyon, he gazed out over the vista and, after a long pause, said: "Leave it as it is. Just leave it as it is". "Leave it as it is" describes the prescription most suitable to the night sky as well. As trustees for those who will follow us, it is incumbent upon us to act as faithfully as did those who preserved that Grand Canyon for us, as it is.

Sincerely,

Keith J. Krueger
Section Leader
International Darksky Association

Attachments:

- 1 – Coalition Response to Resource Guide
- 2 – International Dark Sky Model Lighting Ordinance (MLO) (page 10 excerpt)
- 3 – Artificial lighting in the industrialized world: circadian disruption and breast cancer
- 4 – Dr. Steven Lockley letter on effects of street lighting

July 25, 2011

To: Dark Sky Stakeholders Group

From: The Coalition for Safe and Responsible Lighting

Re: The Proposed Resource Guide and Report

The Coalition for Safe and Responsible Lighting has some serious concerns with the Proposed Resource Guide and Report. The following is a summary of our concerns for your consideration:

- The Resource Guide and report does not take into account the costs to businesses that would be incurred to comply with the changes provided by the model code.
- The Coalition has some serious concerns with proposed sign regulations, including the proposed color limitations, sign curfews, and the restrictive night time illumination level for electronic message centers.
- The Resource Guide should be based on environmentally, safety and fiscally responsible lighting standards, not just to protect the astronomy community's interests. The approach in the Resource Guide will create an undue hardship and economic impact on the business community.
- Business stakeholders have strong concerns that the Resource Guide does not provide for the safety and security of customers.
- The Resource Guide does not address the primary cause of "light pollution" such as freeways, streetlights and ball fields.
- The Resource Guide holds businesses accountable for costly changes but does not require the municipalities to comply with these standards.
- The Pattern Outdoor Lighting section of the Resource Guide is unnecessary as cities are currently working well with local businesses to address responsible lighting practices and light pollution in their cities.

The Coalition for Safe and Responsible Lighting appreciates your consideration of our concerns.



Todd Donars
President and CEO
Greater Phoenix Chamber of
Commerce

Richard Hubbard

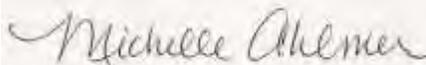
Richard Hubbard
CEO/President
Valley Partnership

Tim McCabe

Tim McCabe
President
Arizona Food Marketing



Steve Helm
Arizona State Director
International Council of
Shopping Centers



Michelle Ahlmer
Executive Director
Arizona Retailers Association



Stacey J. Langford
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Arizona Bankers Association

James Carpentier

James B. Carpentier, AICP
State & Local Government
Affairs Manager
International Sign Association



Michael Mayhew
Southern RM/CA Commercial
Regional Manager
Daktronics

Raymond Owens

Raymond Owens
President
Arizona Sign Association

III. GENERAL REQUIREMENTS (cont.) - Ordinance Text

CURFEW REQUIREMENTS - User's Guide

The intent is to reduce or eliminate lighting after a given time. Benefits include reduced environmental impact, longer hours of improved astronomy, energy savings, and improved sleeping conditions for residents. Additionally, some police departments have indicated that post-curfew light reductions make drive-by patrolling easier because it allows them to see further into and through a site.

The authority should determine the time of curfew and the amount of lighting reduction based on the character, norms and values of the community.

Typically, curfews go into effect one hour after the close of business. Restaurants, bars and major entertainment facilities such as sports stadiums, may require the curfew go into effect two hours after the close of business. The authority may elect to have no curfew for facilities with shift workers and 24 hour operations, or to extend the curfew time to meet specific needs. The MLO can be modified to address those concerns.

Areas without street lights or with very low ambient light levels should consider turning off all non-emergency lighting at curfew while commercial areas or urban areas may prefer a reduction in lighting levels. A reduction of at least 30% is recommended for most uses.

Exceptions to III.(C.) 1. Automatic lighting controls are not required for the following:

- a. Lighting under canopies.
- b. Lighting for tunnels, parking garages, garage entrances, and similar conditions.

2. Automatic Lighting Reduction Requirements
The Authority shall establish curfew time(s) after which total outdoor lighting lumens shall be reduced by at least 30% or extinguished.

Exceptions to III.(C.) 2. Lighting reductions are not required for any of the following:

- a. With the exception of landscape lighting, lighting for residential properties including multiple residential properties not having common areas.
- b. When the outdoor lighting consists of only one luminaire.
- c. Code required lighting for steps, stairs, walkways, and building entrances.
- d. When in the opinion of the Authority, lighting levels must be maintained.
- e. Motion activated lighting.
- f. Lighting governed by special use permit in which times of operation are specifically identified.
- g. Businesses that operate on a 24 hour basis.

Artificial lighting in the industrialized world: circadian disruption and breast cancer

Richard G. Stevens

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Abstract Breast cancer risk is high in industrialized societies, and increases as developing countries become more Westernized. The reasons are poorly understood. One possibility is circadian disruption from aspects of modern life, in particular the increasing use of electric power to light the night, and provide a sun-free environment during the day inside buildings. Circadian disruption could lead to alterations in melatonin production and in changing the molecular time of the circadian clock in the suprachiasmatic nuclei (SCN). There is evidence in humans that the endogenous melatonin rhythm is stronger for persons in a bright-day environment than in a dim-day environment; and the light intensity necessary to suppress melatonin at night continues to decline as new experiments are done. Melatonin suppression can increase breast tumorigenesis in experimental animals, and altering the endogenous clock mechanism may have downstream effects on cell cycle regulatory genes pertinent to breast tissue development and susceptibility. Therefore, maintenance of a solar day-aligned circadian rhythm in endogenous melatonin and in clock gene expression by exposure to a bright day and a dark night, may be a worthy goal. However, exogenous administration of melatonin in an attempt to achieve this goal may have an untoward effect given that pharmacologic dosing with melatonin has been shown to phase shift

humans depending on the time of day it's given. Exogenous melatonin may therefore contribute to circadian disruption rather than alleviate it.

Keywords Breast cancer · Circadian disruption · Melatonin · Shift work

Introduction

There is a large variation in risk of breast cancer among societies of the world, with the relatively more industrialized showing five-fold or higher risk than the least industrialized [1]. In contrast with other common cancers which also vary across societies, the reasons for the rise in breast cancer that comes with Westernization is poorly understood. For lung cancer, the reason for its variation is very clear: as societies pick up the habit of smoking, lung cancer incidence and death increase accordingly and dramatically; liver cancer is largely explained by endemic hepatitis virus infections, and aflatoxin; stomach cancer declines as societies refrigerate food; colon cancer is strongly influenced by red meat intake, sedentary lifestyle, and aspirin ingestion. In contrast, the majority of the variation in breast cancer risk among societies, and rising risk within societies, is unaccounted for by the established risk factors for breast cancer [2, 3]. There is increasing support for the idea that circadian disruption from aspects of modern life, especially electric lighting, is a factor in the population burden of breast cancer [4]. Studies of shift workers, as suggested by Stevens et al. [5], have reported elevated risk [6–10], and studies in blind women, as suggested by Hahn [11], have reported reduced risk [11–14]. The studies in blind women were conducted under the belief that blind

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women, as opposed to sighted women, do not have the opportunity for nocturnal melatonin suppression by exposure to light during the night.

‘Light-at-night’ and breast cancer

Originally, it was argued that part of the rising risk of breast cancer in industrialized societies was due to increased use of electric lighting which could suppress melatonin [15]; a suppression of melatonin was hypothesized to increase estrogen [16], and thereby increase risk. This idea was based on experiments in rodents on the effects of constant light exposures on mammary tumorigenesis [e.g., 17], and on the epidemiology of breast cancer in which risk was highest in the most industrialized, and thereby most electrified, societies. However, Shah et al. [17] found no effect of constant light on plasma estradiol levels in rats, although melatonin administration lowered estradiol. It is not clear whether melatonin or light-at-night affects estrogen production in humans, the data being limited and conflicted [18–25].

Apart from effects on estrogen production, there are several mechanisms by which melatonin might affect breast cancer that have emerged (reviewed in [26]). These include direct oncostatic effects, interference with estrogen receptor function, effects on immune function, and effects on free radical biology. In particular, an effect of light at night, including dim light, on melatonin production can have profound effects on growth and progression of both transplanted liver tumors in rats [27] and transplanted human-derived breast tumors in rats by altering linoleic acid metabolism [28].

The first study of prediagnosis melatonin level did not find a difference between women who later developed breast cancer and those who did not [29]; the authors note, however, that the early studies of estrogen and breast cancer were inconsistent, and it has required a combined analysis of many studies to show that there is in fact a strong association [30]. In addition to affects on melatonin, the potential for light to alter circadian rhythm generation in the suprachiasmatic nuclei (SCN) leads to the potential for disruption of clock gene communication with cell cycle regulation in the mammary tissue [4, 31]. Disruption of cell cycle regulation and/or apoptosis opens a large new area for investigation of light effects on cancer risk.

Light and exogenous melatonin

Suppression of the normal nocturnal surge in melatonin by exposure to light at night may increase breast cancer risk by several different mechanisms [26, 28, 32–34].

(Stress and cortisol may also play a role in circadian disruption and cancer [35, 36]) Therefore, maintenance of a strong melatonin rhythm seems desirable. However, supplementation with melatonin could result in ‘Circadian Disruption’ itself due to the emerging understanding of the impact of exogenous melatonin on the human circadian rhythm. In fact, the circadian phase shift induced in humans by a pharmacological bolus of melatonin can be comparable to that induced by a bright light stimulus. Wirz-Justice et al. [37] conducted a study in which 9 healthy young men were subjected to one of 4 conditions: 5 mg of melatonin at 20:40 in the evening, a 3 h period of 5000 lux light beginning at 21:00, both, or neither (with placebo for the melatonin tablet). All nine subjects received all four exposure conditions. Melatonin onset was then measured the day following the treatments under a constant-routine, dim-light regime (>10 lux). Under the light-only exposure, there was a 41 min phase delay; under the melatonin-only exposure, there was a 24 min phase advance. The two together tended to cancel each other: with both exposures, dim-light melatonin onset (DLMO) was not significantly different from exposure to neither.

Before Lewy et al. [38], it was speculated that the human pineal was insensitive to light. Since that seminal work, the intensity of light at night shown experimentally to be required to lower melatonin has declined to very low levels [39].

It is also becoming clear that light level during the day can affect melatonin secretion at night [40], and also sensitivity to a light exposure at night on suppression of melatonin [41]. Hebert et al. [41] conducted an experiment in which 12 young, healthy subjects (6 male and 6 female) spent 1 week in a bright-day environment (exposed to sun) and 1 week in a dim-day environment (dark goggles worn during the day). At the end of each week, the subject’s sensitivity to melatonin suppression by light in the middle of the night was assessed. On the 6th night in dim light (<15 lux), a baseline of melatonin was determined by saliva sampling every 30 min. During the next night, the subjects were exposed to 500 lux light for 3 h beginning at 1 am. Percent light suppression was significantly greater after the dim week than after the bright week. However, there was a greater amplitude of melatonin production after the bright week than after the dim week.

Light and cancer in mice and rats

Among the first experimenters to investigate the impact of constant lighting on mammary tissue susceptibility to tumorigenesis was Jöchle [42]. He reported that C3H-A mice under constant light showed accelerated development

of spontaneous tumors, whereas C3H–HeJ mice under constant light showed delayed spontaneous mammary tumor development and a longer life span. The C3H–HeJ mouse has a degenerate retina (rd) and is visually blind. However, it has now been shown that nocturnal melatonin in the C3H/He rd mice can be suppressed by light [43].

Among the first to investigate the effect of light on chemically induced mammary tumors in rats was Khaetski [44; as described in 45] who conducted experiments in which ‘outbred rats’ were exposed to constant light beginning at four months of age, and given dimethylbenzanthracene (DMBA). Compared to rats on 12:12 light–dark (LD) cycle and which also received DMBA, those on constant light had reduced mammary tumor yield. In contrast, Khaetski reported that when constant light did not start until 4 weeks after DMBA administration, tumor development was accelerated compared to rats which continued on the 12:12 LD cycle.

Within the context of the conflicting early experiments in which mammary tumors were either stimulated or reduced in rodent models, the question becomes what are the factors which influence tumor yield from constant light? In the 1980s, Shah et al. [17] conducted an elegant series of experiments in which constant light and pinealectomy were used to investigate whether melatonin might explain the effect of light. They found that constant light beginning before birth significantly increased terminal end buds of the female offspring at maturity, and increased susceptibility to DMBA-induced mammary tumors. In an attempt to replicate this finding, Anderson et al. [46] obtained weanling female rats from a supplier, placed one group on constant light and the other on 8:16 light/dark regimen, and administered DMBA when the animals were 52 days of age. In contrast to Shah et al. [17], Anderson found a significant reduction in mammary tumor burden in the constant light group. They also found, unexpectedly, that 29 of the 50 rats in the constant light group showed mature milk glands in the mammary glands at age 141 days despite being virgin, whereas none of the 50 rats on LD showed any such structures.

The reason for the different tumor response appears to be due to differences in the age of the rat at first exposure to constant light which resulted in differences in mammary tissue development. This, in turn, would alter tumor susceptibility [47]. Constant light began in utero in Shah et al. [17], but began at age 26 days in Anderson et al. [46]. After a replication of these exposure conditions, Russo et al. [48] conducted a detailed histological examination of the mammary tissues, and found that light beginning at 26 days of age (LL26) produced a very different mammary gland development than light beginning in utero (LL0); among the LL26 rats, mammary gland differentiation was dramatically accelerated compared to the LL0 rats, and

thereby at the age of 50–55 days were less susceptible to DMBA-induced tumorigenesis.

Another possibility is that light exposure of pregnant rats restricted to the period of gestation might increase mammary density and susceptibility to chemically induced mammary tumorigenesis of the female offspring later in their lives, even though after birth they were maintained on a 12:12 light–dark cycle. This is based on the idea that in utero exposures which alter hormones relevant to breast cancer might increase the lifetime risk of daughters [49, 50].

Shift work and diurnal preference

Shift work presents a quantifiable exposure that can result in circadian disruption. Time of day preference (or morning/evening preference; [51]) has been reported to predict tolerance to evening or graveyard shift work. Those workers who report a preference for morning being less tolerant to night work, and more likely to stop this work for medical reasons [52]. Melatonin profile has also been reported to be the best predictor of Horne–Östberg score for morningness/eveningness among the three circadian markers: rectal temperature, heart rate, and melatonin. Griefahn [53] conducted a controlled constant routine study in which 51 persons completed the Horne–Östberg questionnaire and were then kept under strict bedrest for 24 h under constant dim light. Among both women (17 subjects) and men (34 subjects), the peak melatonin during the night hours was about 4 h earlier in the morning types than evening types. In addition, the total melatonin production was greater in morning types. A possible implication of this is that shift-working women with a morning preference, or who have a genetic polymorphic variant associated with morning preference, may be at greater risk of breast cancer than women with an evening preference.

Schernhammer et al. [25] present interesting new data showing lower melatonin and higher estradiol in long-term shift working nurses compared to non-shift working nurses in the Harvard Nurses’ Health Study. These data are consistent with an elevated breast cancer risk, but are not consistent with an elevated risk of colon cancer in shift workers (as these authors have also reported, [54]). Both Zhang et al., [55] and Nelson et al., [56] report higher estradiol associated with *lower* risk of colon cancer. In contrast, high estrogen (and estradiol in particular) has been convincingly associated with increased risk of breast cancer [30].

Light and alcohol interaction

An emerging area of research is focusing on effects of diet and of alcohol ingestion on circadian rhythms and on

modifying the effect of light on circadian rhythmicity. It is becoming apparent that timing of meals and alcohol ingestion can alter circadian rhythms independently of light and also affect light's ability to phase shift circadian rhythms. These ideas may have relevance to risk of breast cancer in women in the industrialized world. For those women on non-day shift work schedules, the timing and composition of meals may be an important co-factor in their risk of breast cancer [28].

Change in time of day of meals in rats can uncouple the circadian rhythm of the liver from that in the SCN [57]. Changes in circadian markers occur less rapidly in other tissues such as kidney, heart, and pancreas than in the liver [58], but eventually also become uncoupled from the SCN. Baird et al. [59] reported on experiments in which rats received ethanol injections at four times during the day: 1 am, 7 am, 1 pm, and 7 pm. Ethanol shifted circadian activity and temperature rhythms depending on the time it was administered.

Earnest and colleagues have been investigating the effects of developmental exposure to ethanol in rats. They have found that ethanol during the period of rapid brain development (postnatal days four to nine) causes permanent changes in the endogenous circadian clock of the SCN [60]. In particular, rats exposed to ethanol at ages four to nine days postnatal (corresponding to third trimester in utero exposures in humans), are more sensitive to the phase shifting effects of a light pulse during the dark period of the circadian day [61]. Moderate to heavy alcohol consumption has been consistently associated with increased risk of breast cancer in women [62]. Stevens and Hiatt [63] suggested that alcohol ingestion may result in lowered melatonin levels which, in turn, may lead to elevated circulating estradiol concentration in blood [16]. Stevens and Hilakivi-Clarke [64] hypothesized that exposure of pregnant rats to ethanol would increase susceptibility to mammary tumorigenesis in their female offspring by raising estradiol. Hilakivi-Clarke et al. [65] have now investigated this possibility. Pregnant female Sprague-Dawley rats were pair-fed isocaloric diets containing either 16% alcohol of total energy (labeled as low), 25% alcohol (moderate) or no alcohol, from day seven to day 19 of pregnancy. These alcohol exposures generate blood alcohol levels of about 61 mg/dl (0.061%, stimulatory dose) and 96 mg/dl (0.096%, modestly intoxicating dose), respectively, and are much lower than those that induce fetal alcohol syndrome in rodent models (which is between 0.15% and 0.175%). Female rats exposed to alcohol in utero developed increased number of mammary tumors, consistent with increased presence of terminal end buds and epithelial density seen in these animals. The greatest tumor yield and greatest mammary density in the female offspring at their adulthood was in the moderate in utero

alcohol group. However, for estradiol, there was an increase in pregnant rats in the lower alcohol group, but not in the moderate alcohol group. This casts doubt on the presumed estradiol-mediated mechanism for an in utero alcohol effect on mammary tissue development and breast tumorigenesis, and may indicate a role for altered circadian functioning as a mechanism.

For breast cancer in women, and the potential for exposures of pregnant women to increase risk in their daughters later in life, the role of diet and alcohol in modifying circadian rhythms and interacting with lighting is an important area of pursuit.

Early susceptibility and lifelong risk

If cancer requires two or more mutations in a cell [66, 67] as is currently believed, then the occurrence of breast cancer at a young age does not require membership in a susceptible subgroup. There will be a distribution of cases across the age spectrum even if all women were genetically identical and had similar carcinogen exposures throughout life. However, there clearly are susceptible subgroups who are indeed diagnosed with breast cancer at a younger age such as carriers of a mutant BRCA1 allele. Mutations in genes involved in fundamental processes of cell cycle regulation and apoptosis would be expected to be more strongly associated with risk in young women because these processes begin at conception. Given the emerging realization of the central role of the clock gene apparatus in gene regulation throughout the organism, there may be specific clock gene variants which also confer early susceptibility. These may both explain part of the family history effect from germ line mutation, and confer increased individual risk from sporadic mutation. In support of this possibility, Zhu et al. [68] have reported that a polymorphic variant of the Per3 gene is associated with breast cancer in young women.

Causal associations and biological mechanisms

There are two pathways to discovering causal associations: serendipity and prediction. The vast majority of causal associations have been found by the first pathway, serendipity. This has come from the astute observation of a series of cases, from ecological studies, and from large epidemiological studies examining many exposures. For example, it became clear from epidemiology that smoking 'caused' (i.e., greatly increased risk) lung cancer long before biological mechanisms were identified. There is now consensus that the observed association of smoking and lung cancer in epidemiological studies is causal; yet

there is still not consensus on exactly what mechanism(s) is operating. Many examples of this exist including consensus that the associations of HBV and liver cancer, aspirin use and colon cancer, and alcohol and breast cancer are all causal, yet for none of these is there consensus on what is the dominant mechanism. For each, much has been learned about the pathophysiology of exposure to the agent, but it is still not clear what part of this pathophysiology is most important, or whether there are other unrecognized mechanisms which account for the observed causal association.

To obtain consensus that an observed association is causal requires more epidemiological studies to eliminate chance, and then bias, as accounting for the results. At some point, it becomes clear that the exposure ‘causes’ the disease. Factors to consider are described by Hill [69] and include strength, consistency, dose response, reversibility, coherence, temporality, and biological plausibility. Biological plausibility, or lack of it, is weak evidence for or against the causality of an association; as Hill wrote: ‘...this is a feature we cannot demand.’

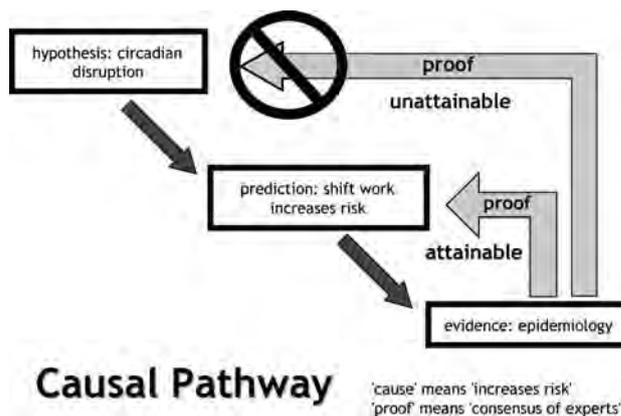
Strength of the association is only pertinent to a judgment of causality, not of importance. Once an association is judged to be causal, then even a very modest relative risk can be very important. For example, smoking accounts for more deaths from heart disease than from lung cancer despite the fact that the relative risk is over ten for lung cancer but less than two for heart disease.

The shift work association with breast cancer was found only after a biological mechanism was proposed and a prediction made (by letter to the Nurses’ Health Study in 1987, and then published in 1992; 5). Before this association can be judged to be causal, chance and bias must be eliminated as plausible explanations. The status of this association is shown below.

It is rare for a postulated biological mechanism to lead to an epidemiological observation, as was the case for shift work and breast cancer. More typically, the epidemiological observation is made and then this leads to laboratory/basic science aimed at identification of potential biological mechanisms.

Biological plausibility plays at best a minor role in judging causality, and is not required. The value in iden-

tifying possible biological mechanisms can be for the purposes of intervention, but not always. The mechanism by which smoking causes lung cancer is irrelevant to the intervention: smokers should just quit. For shift work, however, identifying possible mechanisms would be very helpful for interventions because shift work will not go away. For shift work, a flow chart of hypothesized mechanism leading to a predicted association leading to evidence for that association is shown below.



The studies can ‘prove’ the predicted association to be causal, but cannot verify the originally proposed mechanism. Proof of causality is attainable, whereas proof of the mechanism is virtually unattainable. (The word ‘proof’ in this context can only mean a consensus of experts. In reality, proof exists only in mathematics.)

Conclusion

The topic of light, circadian disruption, and risk of breast cancer has expanded in scope dramatically in the last ten years. Since the first speculation that increasing light-at-night might be raising breast cancer risk by reducing melatonin and raising estrogen [15], many more potential mechanisms for a light effect on breast cancer have emerged [26]. The epidemiology has also advanced from the original suggestion that shift workers would be at

Reason for observed association	Status of evidence	Needed
Chance	Too few studies so far conducted to eliminate chance despite ‘significance’ of some of them	More studies of different types and locations
Bias	Other factors associated with shift work may be the real cause, e.g., alcohol consumption	Co-variate adjustment on all known risk factors –studies of demographics of shift workers
Causal	If chance and bias are eliminated, then the association is causal	But this does not prove the originally proposed mechanism

increased risk. This was published in 1992 [5], although it was communicated by letter to the Nurses' Health Study researchers in 1987; it was subsequently incorporated into their 1988 questionnaire, and the question formed the basis for findings from the Nurses' Health Study of increased risks of heart attack [70], breast cancer [10], and colon cancer [54] in shift working nurses. Davis et al. [9] also reported increased risk of breast cancer associated with history of shift work in a case-control study; and before either of these reports, Hansen [8, 71] reported increased risk in shift workers in a huge case-control study in Denmark. Hahn's [11] idea that another test of the 'light-at-night' hypothesis is the prediction that blind women should be at lower risk has also yielded valuable data. And now a new generation of studies can examine dietary interactions with altered light exposures (such a shift work), and focus on polymorphic variants in clock genes for possible associations with risk and/or for interactions with other factors that may disrupt circadian rhythms.

Note added in proof A study just released has reported a significant inverse relation of melatonin and breast cancer risk in the Nurses' Health Study (Schernhammer ES, Hankinson SE (2005) Urinary melatonin levels and breast cancer risk. *JNCI* 97:1084–7).

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Leo Smith
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May 31, 2008

Dear Mr. Smith:

This letter is in response to your inquiry as to whether light levels produced by streetlights might adversely affect sleep, hormone levels and potentially health in people living in a dense urban environment.

By way of introduction, I am a faculty member in the Division of Sleep Medicine, Brigham and Women's Hospital and Harvard Medical School and I have been studying the effects of light on human circadian rhythms, including sleep, hormones, alertness and performance rhythms, for 15 years. Among other roles, I am the Chair of the Commission Internationale de l'Eclairage (CIE) Division 6 Technical Committee TC6-63 'Photobiological strategies for adjusting circadian phase to minimize the impact of shift work and jet lag' and a Member of the Light and Health Committee, Illuminating Engineering Society (IES) of North America. I am also on the Editorial Boards of the journal *Sleep* and the Sleep and Health Education Program, Harvard Medical School.

Our studies aim to understand the 'non-visual' effects of light on human physiology. About 10 years ago, a novel photoreceptor was discovered in the mammalian eye, including humans, which is anatomically and functionally different from the rod and cone photoreceptors that we use for vision. This new photoreceptor cells are located in a different part of the eye to rods and cones, in the ganglion cell layer, and these cells are 'hard-wired' to the parts of the brain that control our daily sleep and hormone rhythms, particularly the suprachiasmatic nuclei in the hypothalamus, the site of the central circadian pacemaker or 'body clock'. Light information from the environment is detected by these cells to synchronize the internal circadian clock with the external time of day and day-night changes to ensure that our physiology and behavior is properly synchronized with the external environment. The importance of this regular, daily light-dark cycle exposure is readily observed if this light-dark information is altered. For example, shift-workers who stay awake at night and try and sleep in the day, or those flying across multiple time zones, experience sleep, alertness, performance and metabolic disorders because their internal clock cannot readjust quickly enough to the change in light-dark cycle and consequently becomes desynchronized from the environment.

In addition to resetting the biological clock, light also acutely suppresses the production of the pineal hormone melatonin. Melatonin is the internal biochemical signal of darkness and night duration and its production changes in response to season and light exposure. Under a natural light environment, light would never be seen when melatonin is produced and would therefore be unaffected. With the invention of artificial light, however, light exposure now often occurs during the night, stopping the production of melatonin and increasing alertness. In animal studies, melatonin can act as an oncostatic – can slow down the growth of cancerous tumors – and suppression of melatonin speeds up some types of tumor growth. While such studies have not been repeated in humans, there is good epidemiological evidence that female shift-workers, who are often exposed to light at night when their melatonin production occurs, have higher rates of breast cancer than non-shift working women. Notably, totally blind women, who have less light exposure, have reduced rates of breast cancer. While we have yet to understand fully the environmental and health impact of being exposed to light at night, these preliminary data suggest a detrimental effect of prolonged exposure to light at night.

While early research into the effects of light on sleep and hormones suggested that bright light exposure was necessary to stimulate a response, over the past 20 years ours' and others' research has shown that the sleep and circadian systems are exquisitely sensitive to light, and that very dim light is capable of eliciting measurable effects on human physiology. There are many papers detailing the effects of light levels equivalent to that experienced indoors in artificial room light, down to light as dim as 1.5 lux. Below I will review briefly the results from several papers from our own laboratory (copies of the papers are enclosed). There are other papers which I would be happy to provide if necessary.

The first studies describe the effects of different intensities of light on the circadian pacemaker, melatonin levels, alertness and brain activity (see Zeitzer et al., *Journal of Physiology* 2000 and Cajochen et al. *Behavioral Brain Research* 2000, enclosed). Subjects were exposed to one intensity of white light ranging from 3 lux to 9100 lux for 6.5 hours during the night. During the light exposure, blood samples were drawn to measure levels of the pineal hormone melatonin, they were asked to rate their alertness levels, and electrodes were placed in their face and head to measure the rate of slow eye movements and brain activity. The circadian rhythms of melatonin were measured the day before and the day after the light exposure to assess the effects on the biological clock.

Figures 1 and 2 show the dose-response effect of light on the physiological and behavioral responses. Figure 1 shows the effect of light on circadian rhythm resetting (A, left panel) and suppression of melatonin production (B, right panel). The first thing to note is that the dose-response function is such that about 100 lux of light causes ~50% of the maximum response to very bright 10,000 lux light. Secondly, light from 20-100 lux is still capable of causing a 0.5 -1 h shift in the timing of the circadian pacemaker (A) and suppressing melatonin by up to 20% (B).

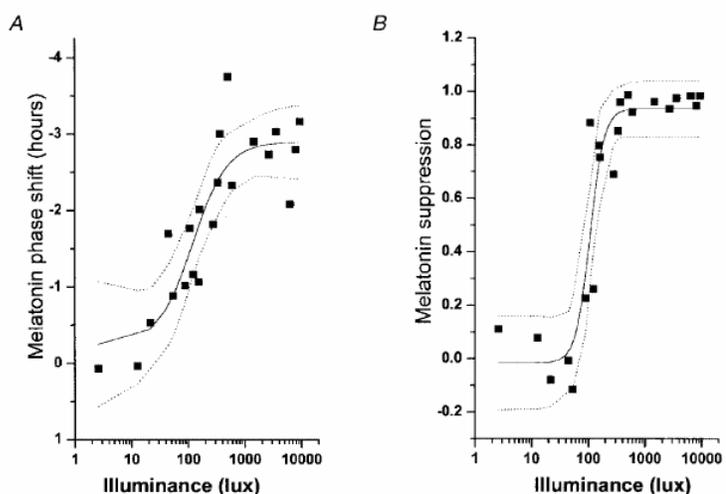


Figure 1

Figure 2 shows the results from the same study but for the dose-dependent alerting effects of light. The left panel shows subjective ratings of alertness and the middle panel shows the rate

of slow eye movements, considered a reliable objective marker of fatigue. The right panel shows the power density in the electroencephalogram (EEG) recordings in the theta-alpha range (5-9 Hz); high brain activity at these frequencies is indicative of sleepiness. As Figure 2, shows, all three measures of alertness showed a dose-dependent change with light intensity such that higher intensities caused a more alerting effect. Even a low intensities (100 lux and lower), however, light was still able to induce a measurable change in fatigue.

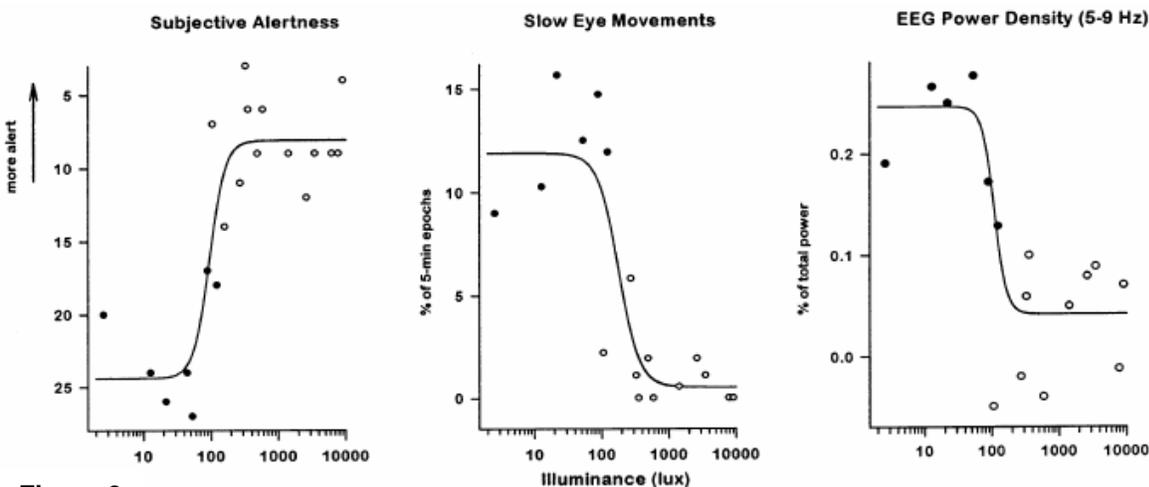


Figure 2

The final laboratory study was conducted to test the power of dim candle-light (~1.5 lux in the vertical angle of gaze) to keep the circadian system synchronized to 24 hours (Wright et al., *Proceedings of the National Academy of Sciences USA*, 2001; attached). Subjects lived in the laboratory for up to 55 days and were scheduled to live on one of three different 'day'-lengths; 23.5 h, 24.0 h and 24.6 h under dim light while awake and darkness when asleep. Although the dim light was unable to reset the circadian pacemaker enough to remain synchronized to the 23.5 h and 24.6 h days, candlelight was sufficient to keep the subjects entrained to 24 hours. Notably, most totally blind people are unable to remain synchronized to 24 hours, again highlighting the importance of even dim light on affecting human physiology and behavior.

These and other studies have shown that dim light is capable of stimulating effects on human sleep and hormonal levels. While brighter light elicits larger effects, we cannot consider dim light an inert stimulus and must keep it in mind when reviewing the appropriateness of light environments. Studies are underway to measure the actual light levels that people are exposed to while indoors and I anticipate that these levels will be significant in urban environments, and even higher when individuals live closer to intrusive street lighting. There is absolutely no need for any horizontal or vertical light to be emitted from street lamps; focusing light solely downward will provide better, more focused lighting for traffic and pedestrians and allow sufficient lighting to be produced with lower energy usage and at a reduced cost. Fixtures which permit horizontal and vertical light are not only inefficient and unnecessary but also emit light inappropriately into living spaces, particularly bedrooms. This light intrusion, even if dim, is likely to have measurable effects on sleep disruption and melatonin suppression, particularly in those whose bedrooms might be in close proximity to streetlights. Even if these effects are relatively small from night-to-night, continuous chronic sleep and hormonal disruption may possibly have longer-term health risks. For example, recent epidemiological studies have shown increased rates of obesity and cancer are associated with decreased nightly reported sleep duration. Intrusive street lighting, as well as wasting money and energy, is likely to have an adverse effect

on human health, effects which are entirely avoidable with better planning of urban lighting fixtures. Short- and long-term measures to reduce light pollution will reduce energy demands, reduce reliance on carbon-based fuels and improve the health of the urban environment.

With these consequences in mind, I applaud your efforts to have intrusive street lighting abolished and I wholeheartedly support your campaign. Please let me know if I can be of further assistance.

Yours sincerely,



Steven W. Lockley, Ph.D.

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Encl.

Zeitzer JM, Dijk DJ, Kronauer R, Brown E, Czeisler C. Sensitivity of the human circadian pacemaker to nocturnal light: melatonin phase resetting and suppression. *Journal of Physiology* 2000;526 Pt 3:695-702.

Cajochen C, Zeitzer JM, Czeisler CA, Dijk DJ. Dose-response relationship for light intensity and ocular and electroencephalographic correlates of human alertness. *Behavioral Brain Research* 2000; 115(1):75-83.

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Capitol Consulting, LLC

August 24, 2011

Ms. Jami Garrison
Maricopa Association of Governments
302 North 1st Street, Suite 300
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Re: Proposed Dark Sky Resource Guide

Dear Ms. Garrison:

On behalf of the Arizona Multihousing Association (AMA), we respectfully submit our position on the proposed outdoor lighting resource guide and report developed by the Maricopa Association of Governments Dark Sky Stakeholders Group.

The AMA is the statewide trade association for the apartment and rental housing industry. The AMA represents the owners, operators and developers of multi-family communities with over 2,000 members and 205,000 rental apartment units statewide.

At this time, the AMA is opposed to the proposed resource guide and outdoor lighting code recommendations.

The proposed resource guide or any local code that could be subsequently adopted to its standards (lighting curfews, "total outdoor light output," etc.) will undoubtedly jeopardize the safety of the employees and residents that live and work in apartment communities throughout Maricopa County.

Currently, as a means to deter crime and provide a safe living and working environment, most apartment communities have implemented minimum lighting standards as part of a protocol known as Crime Prevention Through Environmental Design (CPTED). These lighting standards are endorsed and recommended by the county's very own local law enforcement and crime prevention officers. It is generally accepted that walkways, parking lots, pedestrian corridors and any other outdoor common areas that are well illuminated with bright lights will indeed reduce crime.

Though our industry is certainly empathic to the astronomy community's interest in darker skies, we at this time will not support a potential mandate that could jeopardize the safety of our employees and residents.

We appreciate your consideration of our industry's position. If you have any questions regarding our position, please do not hesitate to contact me at (602) 343-6279 or jake@capitolconsultingaz.com.

Respectfully,

Jake A. Hinman
Capitol Consulting, LLC

On behalf of: Arizona Multihousing Association

C: Courtney LeVinus

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Internet Resources

[Dark Sky Ordinances: How to Separate the Light from the Darkness](#)  (530 Kb)

[MAG Presentation of Economic Impact on behalf of Sign Industry](#)  (81 Kb)

[The Economic Value of On-Premise Signage](#)  (5 Mb)

[Process and Methodology for Economic Value of On-Premise Signs Research](#)  (367 Kb)

[Arizona's Aerospace and Defense Commission Annual Report - See Pages 3, 10, 12, and 14](#)  (722 Kb)

[Joint IDA-IES Model Lighting Ordinance \(MLO\)](#)  (2 Mb)

[Web Links to Member Agency Lighting Ordinances](#)  (96 Kb)

[Safety Impacts of the Emerging Digital Display Technology](#)  (1 Mb)

[Impact of the Kitt Peak Ordinance on Streetlight Rates 1984](#)  (1 Mb)

[Outdoor Light Pollution Standards Presentation](#)  (4 Mb)

[IDA Outdoor Lighting Code Handbook](#)  (978 Kb)

[Outdoor Lighting Codes](#)  (3 Mb)

[MAG Draft Pattern Outdoor Lighting Code, Version Six](#)  (521 Kb)

[MAG Dark Sky Initiative Status Update](#)  (51 Kb)