National Park Service

# Interim Outdoor Lighting Guidelines (DRAFT)


Developed by the
NPS Night Sky Team
Ver 1.0
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# Overview

## Purpose and Need

The US National Park Service has lacked servicewide outdoor lighting guidelines. The need for better quality lighting and guidance to parks is clear by the variable quality of lighting installations found throughout several parks and the increased concern that park facilities are causing degradation of the nighttime environment. This lighting guideline is a simplified document intended to help parks immediately address lighting concerns, guide development and compliance, and provide a best management practice template to parks and park partners. The Night Sky Team will be developing a final document with finer, more detailed guidance, in cooperation with more NPS staff, Musco Lighting Company (through a cooperative agreement via the National Park Foundation), the International Dark Sky Association, and other researchers and partners.

### *2006 Management Policies*

The 2006 NPS Management Policies (slightly modified from the 2001 version) direct the NPS to conserve natural lightscapes. Protection of natural darkness is not only a visitor resource and scenic value; it has important connection to cultural landscapes, ecological integrity, operational efficiency, and sustainability.

#### *4.10 Lightscape Management*

*The Service will preserve, to the greatest extent possible, the natural lightscapes of parks, which are natural resources and values that exist in the absence of human-caused light. The absence of light in areas such as caves and at the bottom of deep bodies of water influences biological processes and the evolution of species, such as the blind cave fish. The phosphorescence of waves on dark nights helps hatchling sea turtles orient to the ocean. The stars, planets, and earth's moon that are visible during clear nights influence humans and many other species of animals, such as birds that navigate by the stars or prey animals that reduce their activities during moonlit nights.*

*Improper outdoor lighting can impede the view and visitor enjoyment of a natural dark night sky. Recognizing the roles that light and dark periods and darkness play in natural resource processes and the evolution of species, the Service will protect natural darkness and other components of the natural lightscape in parks. To prevent the loss of dark conditions and of natural night skies, the Service will minimize light that emanates from park facilities, and also seek the cooperation of park visitors, neighbors, and local government agencies to prevent or minimize the intrusion of artificial light into the night scene of the ecosystems of parks. The Service will not use artificial lighting in areas such as sea turtle nesting locations where the presence of the artificial lighting will disrupt a park's dark-dependent natural resource components.*

*The Service will:*

- *restrict the use of artificial lighting in parks to those areas where security, basic human*
- *safety, and specific cultural resource requirements must be met;*
- *use minimal-impact lighting techniques;*
- *shield the use of artificial lighting where necessary to prevent the disruption of the night sky, natural cave processes, physiological processes of living organisms, and similar natural processes.*

*The decision about whether or not to install artificial lighting in particular circumstances is left to the discretion of the superintendent and is made through the planning process.*

### *Existing Standards and Codes*

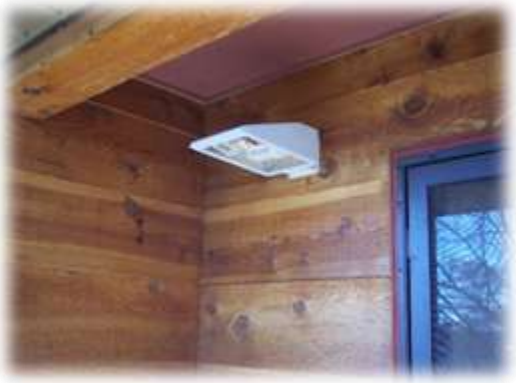
There are a variety of existing lighting standards, many of them in conflict and each focusing on variable aspects of lighting needs. Many of them are far more complex than is suitable for a small or medium sized park, seldom recognize the unique lighting needs of a national park, nor do they adequately address the recent rise in concern about light pollution. There are also other codes and standards currently being developed; these include the International Dark-sky Association (IDA) Model Lighting Ordinance, the New Buildings Institute Lighting Guidelines, and others. It should be noted that two national parks have made significant efforts on outdoor lighting— Yellowstone and Yosemite. Yellowstone has completed lighting guidelines while Yosemite has developed draft lighting guidelines that are currently undergoing additional revisions.

The interim lighting guidelines presented here are an amalgamation of several current and developing guidelines. They are intended to be used by most parks, although very large parks may find them not detailed enough or not addressing some unique situations. In cases where situations fall outside the realm of this document, further review and analysis, preferably through the NEPA process, is highly recommended. Thus, this document is designed to address 90% of the situations that arise in outdoor lighting.

It should be noted that the lighting recommendations contained herein produce illumination levels sometimes significantly lower than IESNA recommended practices. The trend in newer guidelines, such as ASHRAE 90.1 and the IDA MLO, is clearly toward lower illumination levels, especially in darker ambient environments. In most cases, parks have ambient light

levels much lower than what was examined when many of these guidelines were developed. Lower ambient light levels often require less light, thus the disparity between IESNA standard and recommendations in this document.

Examples of existing codes and standards include:
• NFPA Codes and Standards, but not NFPA 5000
• NESC National Electrical Safety Code
• IEEE- Standards
• Illuminating Engineers Society of North America 9th edition (IESNA)
• UL – Underwriter's Laboratory ( Product Safety)
• Americans with Disability Act (ADA)
• ASRAE/IESNA 90.1 / 1999 ( Energy Efficiency)
• LEEDS (sustainable building standards)
• EPA Energy Star
• New Buildings Institute Lighting Guidelines
• California Title 24 Building Code (Outdoor Lighting)
• International Dark-Sky Association (IDA) Pattern Lighting Code
• IDA Model Lighting Ordinance



### *Guideline Objectives*
The objectives of this lighting guideline are to provide parks a planning strategy and best management practices for outdoor lighting. An important consideration in this document was balancing the need for safety with the sensitivity of the park nocturnal environment. The guideline focuses on "off the shelf" solutions, though development of new technologies like LEDs will soon allow parks to more precisely manage outdoor lights; however, for now only mainstream technologies have been included in this document. Simplicity of understanding and implementation of these guidelines was given greater weight than the details of lighting design, visibility research, and energy efficiency.

- Curtail and reverse the degradation of the nighttime visual environment and the night sky, including casual observation, astronomy, and air quality related values.
- Minimize glare, light trespass, obtrusive light, and artificial sky glow by limiting outdoor lighting that is misdirected, excessive, or unnecessary.
- Insure "good neighbor lighting" by minimizing light trespass.
- Help minimize suspected health risks to humans from adverse exposure to light at night.
- Help protect natural ecosystems from the damaging effects of night lighting.
- Permit reasonable and rational use of outdoor lighting for nighttime safety, utility, security, and productivity.
- Help to conserve energy and resources.
- Minimize maintenance and operating costs
- Provide some flexibility for architectural and artistic lighting within the above constraints

### *Scope*
This guideline is intended to address outdoor lighting within park boundaries, including developed areas and concessions. It also may be applicable to other parklands or federal lands. It omits transportation right of ways where state and federal transportation codes may super cede park authority.

Complex facilities and lighting situations may require more guidance than is found here. In those cases, consultation with additional guidelines, lighting engineers, and the NPS Night Sky Team is encouraged.

## Outdoor Lighting in a Park Setting
Virtually all national parks will have some need for outdoor lighting. As directed by the NPS Management policies, it is important to specify the need in every case of outdoor lighting and then choose a lighting design that meets those needs. Too often, lighting does not exist where there should be some, the quality of the lighting is poor, or the brightness level is many times higher then what is required.

### *When less is better*
Lighting engineer James Benya has done a substantial amount of research in Yosemite NP on appropriate lighting levels. His findings, not widely available, indicate that levels much lower than IESNA recommended practices are adequate and quite appropriate for a national park environment, even ones as populated as Yosemite Valley. These findings, combined with field experience retrofitting outdoor lighting and emerging ethics in the lighting engineering community have lead to lighting design that finds a balance between the positive and negative attributes of light using higher performance designs at much lower illumination levels.

### *Human needs*

Lighting serves both objective and subjective human needs. Objectively, light is used to provide adequate visual perception in low light. Although a healthy human eye is capable of adequate visual perception in very low light levels, full dark adaptation can take several minutes. Additionally, the eye cannot easily transition from a bright environment (such as indoors) to a dark environment (such as outdoors at night). Thus outdoor lighting is needed to provide a minimal illumination level and ease high contrast transitions. The more detailed the visual task, the more light is typically needed. It is important to note here that human eyes function by reference to contrast, not absolute illumination. At night, one can perceive that 10 footcandles (a common measure of illumination) is twice as bright at 5 footcandles, but it has not built in ability to quantify light amount. If those same lights were gradually dimmed to 5 fc and 2.5 fc respectively, the eye may not be able to distinguish any change. Thus, the setting that a light fixture is in— the ambient light level, the lighting uniformity, the glare, and the transition a human experiences in that space are more important than an absolute illumination level. The thoughtless adherence to engineering standards without consideration of the setting is ill advised. Ultimately, visual performance in an artificial lighting environment is more closely tied to lighting *quality* than lighting *quantity* (Lighting for Exterior Environments, RP-33-99).

Safety can be defined as *freedom from danger*, an objective requirement of lighting. Security can be defined as *freedom from worry*, a subjective aspect of lighting. Generally, lighting provides both, but gauging what type, amount, and quality of light is necessary for an adequate level of security is difficult (Lighting for Exterior Environments, RP-33-99). "Too often, people associate more light or brighter light with *safer* surroundings. It can be easily demonstrated that too much light or poorly directed light, causes a loss of visibility. For example, if a light is too bright, it prevents a person from discerning important detail because of the *high brightness contrast* or glare which causes a silhouette effect." Quality park outdoor lighting may not appear to some visitors to meet their security needs at first glance, especially if they have come to associate a glary environment with security, but they should soon discover that such quality lighting has several advantages.

### *Transitions*

Unlike an urban environment where one transitions from one lit area to another lit area, a park typically has a few isolated lit areas surrounded by naturally dark spaces. The ambient light level is much lower, expectations of amenities are different, there is a emphasis on self reliance (for example, they may be carrying a flashlight), and transitions from one area to another are more important. The low ambient light level allows *less* light to be used to provide visibility and security, provided glare is properly controlled. Additionally, some areas should not be lit, either by the desire of the park management, the visitor, or both.

### *Accessibility Standards*

It is a requirement to provide accessible routes which meet standards set by the Americans with Disabilities Act (ADA). However, the ADA does not give guidelines on appropriate lighting levels for accessible routes. Lighting on accessible routes should follow the general guidelines stated here. In order to accommodate people with impaired vision, lighting should maintain a continuous illumination, minimize glare, and not create a spotty effect.

## Problems with Light

Light is not innocuous. It is an alteration of our environment like so many other human construction, but it has received little attention as a significant environment change until recently. As seen from the many images of the Earth from space, outdoor lights have sprung up throughout most of the globe. The simple fact that light is visible from space, directly overhead, shows how easily this human tool leaks out into the natural environment.

### *Light Pollution*

The upward spill of light is often called light pollution. "Dust, water vapor and other particles will scatter and reflect light that is emitted into the atmosphere creating sky glow. Light that escapes directly upward into the night sky is a major contributor to the loss of the dark night sky. Even light from a few fixtures can create an unnatural glow over a wide area" (Yellowstone Lighting Guidelines 2005). Light from cities has been documented by the NPS as being visible from over 200 miles away. Even a long streetlight in the countryside can be seen for tens of miles. Most of the upward flux if from light escaping the fixture horizontally or upward. A small fraction of light pollution, perhaps 15%, is caused by reflection off the ground and other surfaces. Direct uplight is controlled by using *full cut-off* (sometimes called shielded) fixtures. This is thought to reduce the direct uplight component to less than 25% of its former value. The reflected light component is controlled by using the minimal illumination level necessary.

Minimizing this sky glow is essential in maintaining a natural nocturnal lightscape, and sets an important example for park visitors and neighboring communities.

### *Light Trespass and Glare*
Light that shines sideways (horizontally) from a fixture is not only a significant source of light pollution, but it is more apt to trespass into areas where light is not wanted. This low angle light is also the principle source of glare. This glare light strikes the eye directly, and carries no visual information, unlike the reflected light from illuminated surfaces which caries information of depth perceptions, texture, detail, color, shape, etc. Glare can cause minor discomfort, or it can completely disable the eye's ability to see properly. Even when present in low levels, it will cause the pupil to constrict down, diminishing the remaining light in the visual field. Glare should be minimized in all circumstances to both improve the lighting quality and to minimize light trespass. Solutions for this include using full cut-off or partial cut-off fixtures, aiming lights away from typical observation angles, aiming lights downward, increasing lighting uniformity, and reducing brightness levels of lights.

It is important to note that interior lights may shine outside the structure (especially common in clear-story windows in restrooms) causing the same effect as a poor quality outdoor light.

### *Ecological and Health Impacts*
"Every year there is more research suggesting that artificial light is affecting the natural environment and the biological rhythms of both plants and animals that are critical to native habitat and natural evolution. Effects of artificial light on wildlife can cause avoidance or attraction behavior with diverse and significant consequences that not only affect the species themselves but those on which they prey and those that prey on them. Research to date has concentrated on the affects of artificial light on birds and insects, but there is evidence that light affects larger animals. Mammals that travel long distances to find food or mates, such as mountain lions, may avoid links between natural areas if the areas emit artificial light" (Yellowstone Lighting Guideline 2005).

Because the scientific literature is relatively sparse on this topic, there is frequently no species specific information available. However, there are some generalities that are useful guides. Nocturnal predators are particularly affected by artificial light, either positively or negatively, which can have resultant impacts on their prey species. Birds, many of which migrate at night, are particularly prone to disorientation by artificial lights. Certain biomes are believed to be more sensitive. These include wetland and ponds, shorelines, alpine areas, and open country such as deserts and prairie. The NPS is currently working with researcher to provide lighting guidance as it relates to wildlife and these will be incorporated in the finalized document.

Finally, humans are animals too, and there is a solid body of research linking artificial light at night (as well as decreased light exposure during the day) to a myriad of health problems.

## Sustainability
Outdoor lighting is the last appliance that has received so little energy efficiency scrutiny. Though the different types of lamps are well studied (for example a 4x energy savings is realized by replacing a traditional light bulb with a compact fluorescent), the question of what type of fixture, how much light, and if an area should be lit at all has not seen much discourse. It is estimated that the portion of light that shines upward and creates light pollution represents $2 to $5 Billion annually in the US. Thus, saving our night skies can have tremendous economic and energy benefits.

### *Designing for efficiency*
The basic tenants of efficiency are to use light only when and where it is needed, and if needed, use the most efficient light source that meets the task requirement. Lamp technology has evolved much, and efficiencies can be improved 2x-5x by using modern lamp types. Reducing light levels are a viable solution if illumination can be reduced while still meeting the task, yielding similar efficiency gains. Full cut-off shielding reflects all that light that would go into space downward, further improving efficiency. And finally smart technologies, from the very basic timer or motion sensor, to elaborate computer controlled lighting and LED lamps can further improve efficiencies.

### *Maintenance Cost*
What is energy efficient is almost always cost efficient. But another aspect of cost reduction is maintainability. Lighting design should include workload estimates related to upkeep. Capital cost should be compared with energy efficiency and maintenance intervals to get a true picture of the cost of lighting. All too often, lighting choices are made based only on fixture cost. A $40 "yardblaster" light can be purchased at a hardware outlet, compared to a high end fixture (or luminaire as they are often called) costing $400. However, if the "yardblaster" is 175 watts and the full cut-off luminaire is 18 watts, the capital cost will be offset by energy savings in 4 years. Over a 20-year fixture lifetime, the difference becomes $1200.

A similar comparison can be made with lamp lifetimes. A typical incandescent lamp will last about 1500 hours, compared to 10,000 hours for a compact fluorescent lamp(CFL). The old fashioned light bulb will be changed 6 or 7 times before the CFL burns out, more than making up for its higher initial cost.

## Design

Lighting is an important element in architecture and landscapes. It can emphasize spaces, highlight the landscape, and serve purposes beyond the basic need for visibility. Just as the NPS has graphic identity guidelines and a park may have certain sign design standards, the lighting too may be part of such a design vision. Design issues can include pole height and pole spacing, fixture appearance, illumination pattern, light level, or light color to name a few. Lighting is often an important architectural element, however, architectural and artistic lighting may not be appropriate in parks. Washes of light on building, lit statues, dramatically lit boulders or waves are often not appropriate and cannot be justified under the current management policies when the purpose is merely vanity.

### *Lamp Color*

One element that receives much attention is the color of the light. Different lamp technologies, such as High Pressure Sodium (HPS) or Low Pressure Sodium (LPS) produce yellow light. This monochromatic or color biased light cannot render colors properly (these are often described as having a low color rending index). Many feel that this light has an industrial character. Research indicates that less light is needed (and therefore less energy) for the human eye to see efficiently with a white (blue/green) light source than with a more yellow light source. However, HPS and LPS lights are more efficient than white light sources such as Metal Halide (MH), Mercury Vapor (MV), or even Compact Fluorescent Lamps (CFL), producing more lumens per watt. They are also believed to be less impacting to nocturnal wildlife. For example, LPS is often used on turtle nesting beaches with good success. Additionally, the yellow lights scatter much less in the atmosphere and are 2.5x (HPS) to 5x (LPS) less interfering with human night vision than white light. This is an important factor in maintaining dark night skies. The color rending abilities and improved visibility of white lights are at odds with their lower energy efficiency, wildlife impact, and night sky impact, causing frequent professional disagreement. The bias of this guideline is to use yellow lights sources as a default when available unless the need for better color rendition is demonstrated.

### *Historic Integrity*

Historic structure and cultural landscapes have particular lighting needs that may not be addressed in this document. Both the light fixtures themselves and the character of the light they produce are of concern. Often there is too much emphasis on selecting fixtures that look of the appropriate period, while the nighttime scene is neglected but just as important to the historic integrity.

# Lighting Guidelines

## Approaches

There are several ways to define lighting. They can be divided into two categories— *prescriptive* where the type, size, lamp, etc of the light is defined, or *performance* where the resultant illumination levels are defined. The latter is more accurate, but requires computer modeling and photometric data on each light fixture. Because so many of the fixtures used in parks are low cost ones without photometric or custom designs, and lighting expertise to run computer models is rare, a prescriptive approach is taken here.

There are several aspects of lighting design that can be controlled and defined. The ones chosen to be prescribed in this guideline are limited for simplicity and bolded.

| **Prescriptive Parameters** | **Performance Parameters** |
|---|---|
| Lumens | Illumination (minimum, avg, max) |
| Watts | Glare or Glare Ratio |
| Power density | Uniformity (average:minimum) |
| Lumen density | Uplight and light distribution |
| Pole spacing | Spill light/light trespass |
| Pole height | Transition |
| Fixture shielding and aiming | |

## Zones

Two zones should be established in a park. One zone should be a zone where permanent lighting fixtures are not permitted. The second zone should be where permanent outdoor lighting is allowed within the guidelines.

| **Typical Lighting Zones** | **Description** |
|---|---|
| No Outdoor Lighting | All wildland areas and viewpoints |
| Lighting Allowed | Developed facilities area |

## Planning and Compliance

Lighting has been considered a routine maintenance practice and has therefore escaped much of the planning and compliance process. This has lead to the current situation where light pollution in parks is not only the result of lights in distant cities, but is caused by the park itself. The 2006 Management Policies clearly indicate lighting should be part of the planning and compliance process. This interim guideline was intended to ease this process and provide more autonomy to facility and concession managers when working within the guideline.

### *Cumulative Effect*

Though cumulative effect has not been directly addressed in the guideline, it is recommended that parks not only consider the specifications of an individual light, but what the total impact of a new or expanded light project would produce. Though these guidelines mitigate negative impacts to the maximum practical extent, dramatic increases in installed lights will have a noticeable impact. Fortunately, for many parks with an installed base of mixed quality lights, offsetting impacts from new projects is fairly easily done by retrofitting additional poor quality lights.

## Lighting Applicability

Where there is an expectation by the visitor or employee of darkness and people are generally prepared for darkness (either through dark adaptation or carrying their own flashlight), lights should not be installed.

Lights should be installed as an illumination transition on commonly used building egress points, where outdoor work may be done at night, where critical information is posted, to draw nighttime visitors to important information or safety point (such as a phone booth or visitor center entrance), where there is a demonstrated need for protection of assets, where there is an identified safety hazard, or where facilities are commonly used at night (such as a laundry room in residence area).

When choosing whether to light an area, it is important to consider the cumulative effect of the action as well as if the illumination will be successful in its desired function. It is also important to consider illumination transitions; an isolated light may effectively light a small area but will render the surrounding dark area less visible.

Security lighting where no patrols exist (such as a remote storage yard) is often counterproductive, inviting crime without the opportunity to intercede.

# Requirements

## Exterior Lighting

All permanent exterior lighting shall be fully shielded and use the proper illumination level. When fixtures are articulating, such as PAR floodlamps, they should have directional shields, should be aimed within 45 degrees of downward, and should not illuminate areas outside the intended target.

## Special Use Lighting

Unshielded and partially shielded fixtures are permitted for low voltage LED pathway lights, under-canopy lights at phone booths, and other guidance lighting provided they are ≤ 7 watts each.

# Prescriptions

### *Maximum Lamp Lumens*

7000 lumens is the maximum allowable lamp output (except for emergency lighting). In most cases, 500-1500 lumens will be sufficient.

| **Pedestrian Walkways** | |
|---|---|
| **Maximum Lamp Lumens** | 1000 |
| **Recommended Light Types** | Low voltage LED guidance lighting or very low lumen fully shielded lamps. Higher illumination steps or uneven ground. |
| **Recommended Illuminated Area** | Pathway and area immediately adjacent to path. |
| **Recommended Duty Cycle** | Timer for operation during frequently used times. |

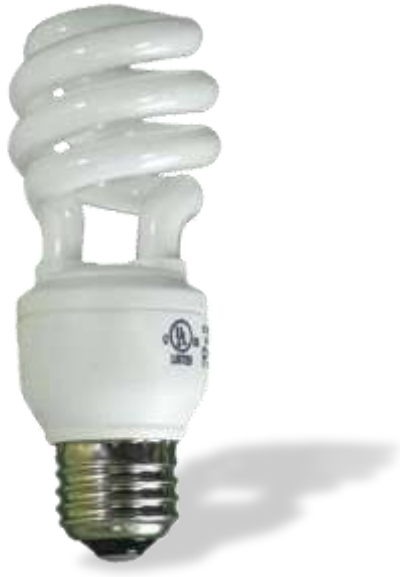
| **Residential Surrounds (Private Buildings)** | |
|---|---|
| **Maximum Lamp Lumens** | 2000 |
| **Recommended Light Types** | CFL 500-1000 lumens. |
| **Recommended Illuminated Area** | Light dispersal limited to residential boundary |
| **Recommended Duty Cycle** | Mix of switches (for occasional use), and motion sensors. |

| **Building Egress Points (Public and Staff Buildings)** | |
|---|---|
| **Maximum Lamp Lumens** | 3000 |
| **Recommended Light Types** | CFL 500-1500 lumens. Forward throw fully shielded fixture. |
| **Recommended Illuminated Area** | Egress point and surrounding approach. Transition from lit to dark area should be gradual reduction in illumination with no hard shadows. |
| **Recommended Duty Cycle** | All night operation at critical safety, frequently used, and visitor contact points. Motion sensors or user accessible switches for other tasks. |

| **Parking Lots** | |
|---|---|
| **Maximum Lamp Lumens** | 7000 |
| **Recommended Light Types** | Not generally recommended. If required, light with LPS or HPS lamps of 3500-7000 lumens (depending on pole height). |
| **Recommended Illuminated Area** | Portion of parking lot used at night. |
| **Recommended Duty Cycle** | Switched with timers to prevent all-night operation. |

| **Safety and Work Areas (Fueling Station, Generator Bay, etc)** | |
|---|---|
| **Maximum Lamp Lumens** | 7000 |
| **Recommended Light Types** | CFL of 1200-3000 lumens for most applications. Fully shielded lights. |
| **Recommended Illuminated Area** | Only immediate work area. |
| **Recommended Duty Cycle** | User controlled switches or power-interrupt sensor. |

## Lamp Selections



The standard lamp shall be a cold-start compact fluorescent lamp (CFL), ideal for its high energy efficiency and range of wattages. These should produce less disruption to the nocturnal species and human experience of the night than a 70-watt High Pressure Sodium (HPS) lamp provided the CFL lamps are 26 watts or less. Incandescent lamps may be used with motion sensor lights. Lighting requiring more than 2000 lumens should use HPS lighting.

## Other Situations

### *Sign Lighting*

Internally illuminated signs should be light lettering on a dark background and should not be lit after the related facility has ceased operation for the night. Externally illuminated signs should be lit from the top downward with fully shielded or partially shielded fixtures and should use the minimum amount of light necessary. No specific guidelines are established in this interim guideline, however it is recommended that sign lighting only be employed where it is clearly necessary and that luminance be limited to approximately 1000 lumens or less per side per modest size sign, depending on viewing distance and ambient light level.

### *Flag Lighting*

The preferred practice for staffed federal facilities is to raise and lower the American flag daily at staffed federal facilities. There are only a handful of federal sites where flags are intended to fly all night, such as the Tomb of the Unknown Soldier. There is a growing misconception that flags should be up all night and should be lit. At active federal sites there is little excuse to not honor the flag daily by its raising and lowing. The Patriot Act of 1976 requires nighttime flags to be lit, but does not in any way indicate patriotic preference for leaving the flag up during darkness. Recently some top-down lighting solutions for flags have come to market. This will allow full compliance of flat lighting if there is such a need.

## Exempt lighting

1) Where OSHA states that specific lighting levels are necessary for work situations these are considered exempt from the Lighting Guidelines. However, although the lighting levels for the actual work environment must meet OSHA requirements all measures outlined in this document must be taken to exercise best energy practices and shield the light from the surrounding environment.

2) Emergency lighting is exempt from these controls provided it is not used for routine maintenance or scheduled functions. Typically, emergency lighting is used once a year or less and is necessary for human safety in emergency or unforeseen circumstances.

3) Traffic safety warning lights and speed indicators are NOT automatically exempt but should be considered on a case by case basis.

4) Holiday lighting provide they are only operation during the holiday period

*"**If the Stars** should appear one night in a thousand years, how would men believe and adore... But every night come out these envoys of beauty, and light the universe with their admonishing smile."*

*Ralph Waldo Emerson*

# Appendices

## Glossary

***Fully shielded -*** a fixture that throws light downward only and in which the lamp itself is shielded so that it can not be seen except from under the fixture.

***Full-cut-off –*** a fixture that is fully shielded and has virtually no part (or a negligible amount) of the fixture lit below the horizontal.

***Cut-off -*** is a fixture that shields upward light causing light to shine both downward and sideways only.

***Luminance*** – is the quantity of light reflected or emitted toward an observer, i.e., the light an observer sees.

***Illuminance*** – is a measure of light in either foot-candles (imperial) or lux (metric). Technically described as flux density per unit area.

***Brightness*** – is a subjective sensation to measured luminance.

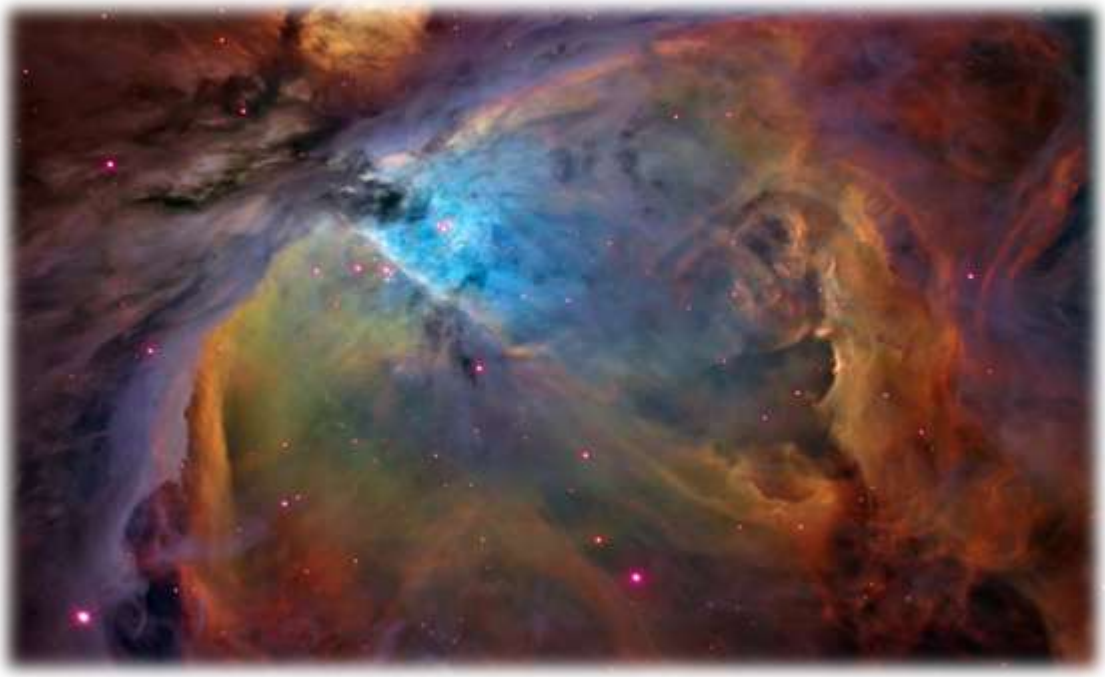
***Glare*** –

- ***Disability Glare*** (veiling luminance) – is stray light scattered within the eye reducing the contrast of the image.
- ***Discomfort Glare*** – is high contrast or non-uniform distribution of luminance in the field of view.
- ***Nuisance or annoyance glare*** – is not quantified but is basically annoying light such as "the light shining in the window".

***Visual Adaptation to Light –***

- ***Photopic Vision*** – is the eye's response at high light levels when cones are used to determine color and to focus on objects.
- ***Scotopic Vision*** – is the eye's response at low light levels such as moon-light when rods are used. Peripheral vision is strong and everything appears in shades of gray.
- ***Mesopic Vision*** – is a combination of photopic and scotopic Vision.

- *All definitions "Lighting for exterior environments" IESNA*



## Lamp Characteristics

Lamp types should be carefully chosen. Proper lumen output, efficiency, and spectral characteristics should be key elements in the decision. Other factors to consider should be lamp life, lamp available and cost, aesthetics, and appropriateness.

The following are allowed under these guidelines when specifically permitted.

**Table 6 – Typical lamp characteristics**

| Lamp | Watts | Lumens (initial output) | Lumens/watt (efficiency) | Lifetime (hours) | Color Rendering |
|---|---|---|---|---|---|
| A-Lamp Incandescent | 40 | 500 | 12 | 1000 | 100 |
| | 60 | 850 | 15 | 1000 | 100 |
| | 100 | 1600 | 16 | 1000 | 100 |
| Compact Fluorescent | 7 | 400 | 57 | 10000 | 85 |
| | 13 | 775 | 60 | 10000 | 85 |
| | 23 | 1400 | 60 | 10000 | 85 |
| | 26 | 1650 | 65 | 10000 | 85 |
| | 42 | 2800 | 65 | 10000 | 85 |
| Metal Halide | 39 | 2800 | 72 | 6000 | 85 |
| | 50 | 3700 | 75 | 6000 | 85 |
| | 100 | 7500 | 75 | 6000 | 85 |
| | 150 | 10500 | 70 | 6000 | 85 |
| High Pressure Sodium | 35 | 2200 | 50 | 24000 | 40 |
| | 50 | 3700 | 60 | 24000 | 40 |
| | 70 | 6200 | 75 | 24000 | 40 |
| | 100 | 8000 | 80 | 24000 | 40 |
| | 150 | 14500 | 85 | 24000 | 40 |
| Low Pressure Sodium | 18 | 3800 | 150 | 18000 | 0 |
| | 35 | 6800 | 150 | 18000 | 0 |
| | 90 | 15300 | 150 | 18000 | 0 |

Note- High color rendering combined with total brightness typically results in higher impact to nocturnal environment.