Guidelines for Outdoor Lighting (Low-Impact Lighting™)

for

RASC Dark-Sky Protection Programs

Dark-Sky Preserves™
Nocturnal Preserves™
Urban Star Parks™

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1.0 SCOPE

The goal of the RASC Dark-Sky Protection Program (Program) is to promote the reduction in light pollution, demonstrate good ecologically sound night-time lighting practices, improve the nocturnal environment of wildlife, protect and expand dark observing sites for astronomy, and provide accessible locations for the general public to experience the naturally dark night sky.

There shall be no installed artificial light within a Preserve. However if the manager deems it necessary, artificial lighting will conform to these guidelines.

This document presents Guidelines for Outdoor Lighting (GOL) to be ued in, but not limited to, Dark-Sky Preserves™, Nocturnal Preserves™ and Urban Star Parks™ herein after referred to as Preserves, and describes the types of equipment required to satisfy these guidelines. It refers to areas classified as "Lighting Zone 0, and Zone 1" (per IESNA-IDA Model Lighting Ordinance). LZ 1 has low ambient lighting levels such as small rural residential areas. LZ 0 encompasses areas that are sensitive to artificial lighting and other environmental disruptions.

This GOL has three objectives: to limit glare and the adverse ecological impact of artificial lighting throughout the Preserve, provide technical specifications for acceptable illumination levels required for safe navigation, and it presents lighting policies that may be applied to urban areas beyond the its boundaries. These will protect the Preserve from deterioration by surrounding light pollution.

In Section 3.0 we present the rationale for the protection of the rural and urban night environments from the excessive use of artificial lighting. To support these guidelines, this document provides references to useful web sites and to general research into the effects of nocturnal lighting on humans, flora and fauna. Additional information and references are published in the peer-reviewed paper by Dick[1]:

The guidelines for outdoor lighting within Preserves are presented in Section 4.

A bibliography in Section 6 provides a set of references and useful websites. Supplementary technical information is provided in the appendices to this document.

Lighting hardware and signage are described in the Appendices to assist Park Managers in minimizing the impact of artificial lighting on the night environment while maintaining a degree of safety for visitors. These sections will also be useful to municipal officials who are tasked with reducing the ecological impact of urban infrastructure.

[1] Dick, R., Applied Scotobiology in Luminaire Design, Lighting Research and Technology, 2013; 0: 1-17, doi: 10.1177/1477153513505758

2.0 GLOSSARY

2.1 Acronyms

ALAN Artificial light at night

CARS Canadian Aviation Regulations
CFL Compact Fluorescent Lamps
CO Cut-off luminaires (>0% and <2% up-light)

FCO Full Cut-Off luminaires (0% up-light or "fully shielded", 10% maximum in glare zone) where the glare zone is defined to be from 80° and 90° from nadir. This is the minimum level of shielding.

GOL RASC Guidelines for Outdoor Lighting

HID High Intensity Discharge lamps (LPS, HPS, MH lamps)
HPS High Pressure Sodium lamps ("yellow" coloured HID lamps)

IESNA Illumination Engineering Society of North America

LEDs Light Emitting Diodes
LIL™ Low Impact Lighting™. Lighting that complies with these Guidelines
LPS Low Pressure Sodium lamps (monochromatic, single colour HID lamps)
LZ # Lighting Zone as per IESNA-IDA

MH Metal Halide lamps ("white" coloured HID lamps)

Preserve An area under single management that has been designated by the RASC as a Dark-Sky Preserve™, Nocturnal Preserve™ or Urban Star Park™

SAD Seasonal Affective Disorder
SCO Semi-Cut-off luminaires (<2% up-light)
ShCO Sharp Cut-off luminaires (<0% up-light, <1% between 80-90 degrees of nadir)

2.2 Definitions

Amber – a colour of light that does not have any emissions at wavelengths shorter than 500 nm with a peak around 590 nm. Generally has a broadband yellowish colour and has less impact on night vision and circadian rhythm than other colours.

Dark Time – a period after which scheduled outdoor activity has ended and visitors are expected to minimize their activity to permit other visitors to sleep.

Preserve Buffer Zone - the region within the Preserve under control of the Preserve Manager, surrounding the Core area. The Buffer is designed to prevent glare and light trespass from shining into the Core area.

Preserve Core - the region under control of the Preserve Manager surrounded by the Buffer Zone.

Filter – filters the spectral components <500 nm from light to produce amber illumination (ref: Roscolux Deep Straw #15)

Foot-candles (fc) - – the illuminance metric in the Imperial units of lumens/foot^2. Examples of levels are provided in Appendices A and C.

Glare Zone - sector between the horizon (90º from nadir) and 10º below the horizon.

Incandescent lamps - Lamps with tungsten filaments

Lumens - A luminance metric unit for the amount of emitted light. Typical luminance of various lamps are listed in Appendix A and C.

Lux – the illuminance metric in the SI units of lumens/m^2. Examples of levels are provided in Appendix C.

Nadir - the point directly below the luminaire (opposite to zenith)

Photobiology – the study of the effects of light on biological systems

Photopic Vision – vision based on cone cells that have evolved for daytime vision and high illumination levels. Their peak sensitivity is at 555 nm.

Scotobiology – the study of the biological need for periods of darkness

Scotopic Vision - vision based on rod cells that have evolved for night vision and low illumination levels. Their peak sensitivity is at 505 nm.

Sky Quality Meter – a light meter designed specifically to measure a value for the brightness of the night sky.

White Light - Coloured light with combined spectral components of blue, yellow and red

3.0 RATIONALE

Most people take artificial night lighting for granted. In cities it is considered to be an acceptable component of our society, and indeed many people think it is necessary for safety and security while providing an aesthetic quality to the night. Specifications and guidelines for street and roadway lighting[2] address these urban assumptions. These have lead to lighting policies that encourage the illumination of all urban areas to allow the use of human photopic (daytime) vision in virtually all populated areas (Figure 3.0.1).

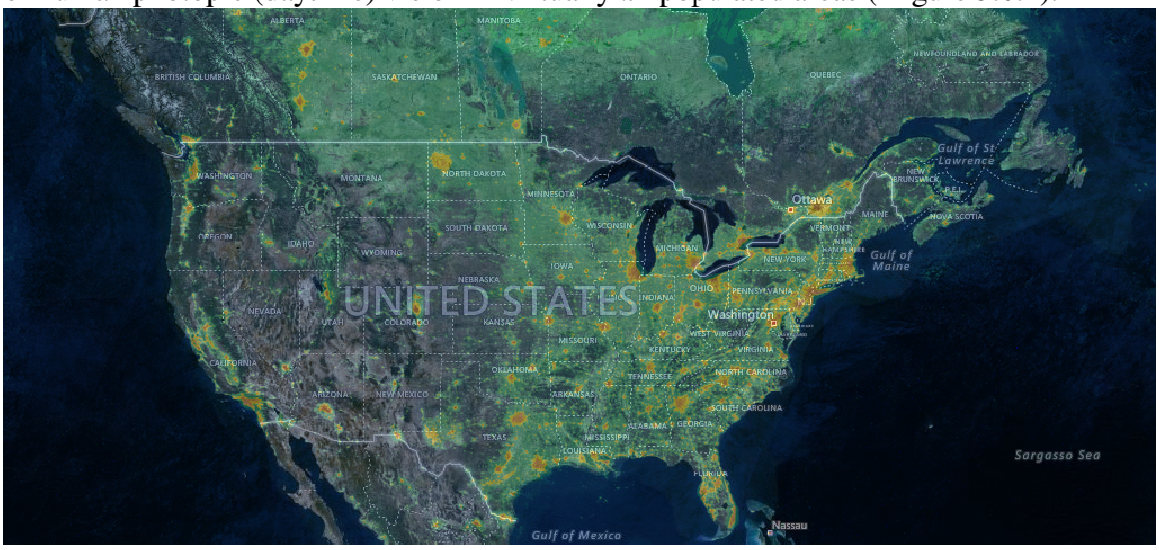


Figure 3.0.1 *Mid Latitudes at Night (http://www.lightpollutionmap.info 2018)*

The availability of electrical energy and efficient lighting fixtures have enabled the current urban lifestyle of non-stop "24-7" activity. Furthermore, the advances in lighting technology have permitted illumination levels to increase recently by about 2.2% per year[3] and over the last 50 years by over a factor 10, with the use of the same amount of electrical energy. The result is that most commercial and consumer luminaires are designed for high levels of illumination. Low intensity fixtures are primarily limited to decorative lighting such as Christmas lights.

It is now common in a city to be able to read a newspaper at night under the city's artificial sky glow. In Figure 3.0.2, the light polluted skies of Toronto are compared to good skies of Algonquin Park (upper left) that has very dark skies. Bright red corresponds to high levels of sky glow (0.010 lux) and green is an intermediate amount (0.000 4 lux).

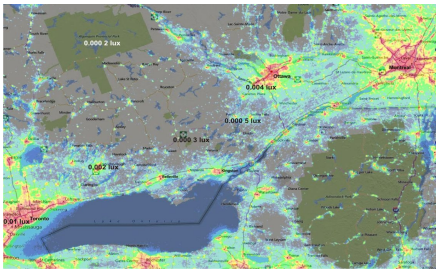


Figure 3.0.2 *Light Pollution in Southern Ontario. Illuminance (lux) values were converted from Sky Quality Meter readings made under clear skies between about 2010 and 2012. Most rural light comes from house and dusk-to-dawn lighting beside township roads and highways. (http://www.lightpollutionmap.info 2010)*

[2] Illumination Engineering Society of North American (IESNA) Handbook

[3] C. Kyba, et.al., Artificially Lit Surface of Earth at Night Increasing in Radiance and Extent Science Advances 2017;3: e1701528 November 22, 2017, http://advances.sciencemag.org/

3.1 Crime

The most prevalent reason given for light at night is to reduce crime in cities. This is generally based on the notion that more light improves visibility, and this visibility discourages criminals. Based on studies of crime statistics before and after changes in outdoor lighting, there is no clear evidence that outdoor lighting reduces crime[4]. Although there are anecdotal reports that "improved lighting" (i.e. improved visibility) reduces crime[5], there is no evidence that crime is reduced with "more or brighter lighting"[6]. In some cases crime was simply displaced, or the altered lighting was prompted or caused by a change in use of the streets by, "…strengthening informal social control and community cohesion"[7] and this may have affected the pattern of crime.

There are different types of crime. Anecdotal studies report theft and property crime is more prevalent during daytime hours. The public's belief in the prevalence of random violence (promoted by Hollywood films) is not supported by research. Further, violent crime more occurs more often in the evening and after midnight[8] between persons that know each other. Random violence is widely reported in the media but it is generally quite rare.

There was an unconfirmed report that the brightly lit City of Manila found violent crime was still more prevalent on brightly lit streets after dark but increasing the presence of police was effective at reducing crime at night. The city lights were not the deterrent to crime whereas the visible presence of the police was. A comprehensive report to Congress, by the National Institute of Justice[9] states that there is no evidence that artificial lighting deters crime. It reports that most studies are poorly designed and without controls, which undermines any conclusions to the contrary. The report states that: "We can have very little confidence that improved lighting prevents crime". Furthermore, lighting can assist criminal activity by putting the victim on display. And, the perception of safety provided by the light may have the opposite effect by encouraging unsafe behaviour.

Vandalism is an example where security lighting has the opposite effect of what is generally believed. Studies conclude that lit areas are subject to more vandalism and graffiti. Anecdotal evidence[10] and more focused studies[11] support the policy of turning

[4] The Influence of Street Lighting on Crime and Fear of Crime, Prevention Unit Paper No. 28, Stephen Atkins, Sohail Husain and Angele Storey, 1991, ISBN 0 86252 668 X
[5] Effects of Improved Street Lighting on Crime: A Systematic Review, Home Office Research Study 251, by David P. Farrington and Brandon C. Welsh, August 2002
[6] The Indiana Council on Outdoor Lighting Education (ICOLE), P.O. Box 17351, Indianapolis, IN 46217
[7] ibid, page 2.
[8] www.bpap.org/bpap/research/DCA_briefing_dtd.pdf
[9] National Institute of Justice Grant Number 96MUMU0019 (www.ncjrs.gov/works/)
[10] "Darkened Streetlights Fail to Raise Crime Rate", DesMoines Register, T. Alex and T. Paluch, May 6, 2004 www.dmregister.com
[11] Effects of improved street lighting on crime: a systematic review, Home Office Research Study 251, August 2002

lights off when security staff is not around. Apparently, vandals want to see the results of the damage and for others to see it.

3.2 Lighting for Human Activities

Humans are a daytime species. Although we can see at night, our vision is significantly reduced compared to the daytime. In the past, starlight provided sufficient levels of illumination for most "pedestrian" activities. However our modern fast-paced and mechanized activity requires better visual acuity for driving cars, riding bicycles and for avoiding urban hazards.

The human reaction time to a stimulus is a function of the illumination level[12]. For our photopic vision it is less than 0.2 seconds whereas with our scotopic (night) vision it is about 0.5 seconds, which is sufficient for a walking pace. However in the presence of illuminated roadside distractions, actual reaction times are from 1 to 3 seconds[13]. Illumination levels play only a small part in reducing driver reactions but significantly increase the visibility of distractions.

Some level of artificial lighting is required for activities at night. But this lighting must be designed to increase visibility. Paradoxically, more light can reduce visibility by creating glare, especially for persons over 40 years of age[14].

Sensitivity to glare increases with age, as does our chances of developing cataracts. In the face of a bright light, our iris closes down letting light into the eye only through the centre of our lens. Since cataracts begin in the centre of the lens, the vision of senior citizens can be severely degraded by glare even without fully developed cataracts. With the aging of our population, it is becoming more important to reduce glare in urban environments.

3.3 Human Health

The proliferation of outdoor lighting has a significant impact on the health and behaviour of humans[15]. “Biological clocks control our sleep patterns, alertness, mood, physical strength, blood pressure, and other aspects of our physiology”[16]. The dominant mechanism for synchronizing this biological clock to our activity (the circadian rhythm) is the day-night contrast and the timely release of the hormone melatonin. This hormone regulates the ebb and flow of other hormones in our bodies that repair the daily damage our bodies suffer each day. Without the timely release of these hormones, healing takes longer and our bodies are less able to fend off disease[17].

[12] A.L. Robert - Simple Time Reaction as a Function of Luminance for Various Wavelengths, Perception & Psychophysics, 1971, Vol.10(6)
[13] T. Triggs, W. Harris, Reaction Time of Drivers to Road Stimuli, Human Factors Report No. HFR-12, ISBN 0 86746 147 0, Monash University, Victoria Australia, June 1982
[14] Work, Aging, and Vision: Report of a Conference, ISBN-10: 0-309-07793-1
[15] Light Research Organization, Electric Power Research Institute, (www.epri.com/LRO/index.html)
[16] WebMD, March 06, 2007, www.webmd.com/cancer/news/20040908/ light-at-night-may-be-linked-to-cancer
[17] “Light at night and cancer risk”, Schernhammer E, et.al., Photochem Photobiol. 2004 Apr;79(4):316-8.

The timing or phase of the circadian rhythm also affects our behaviour. For example, Seasonal Affective Disorder (SAD) is an emotional condition experienced by travellers and others. The symptoms of SAD can be reduced with exposure to bright light[18] in the morning as it shifts (or entrains) and resets our biological clock. However if this entrainment occurs during the late evening or at night due to artificial outdoor lighting, the biochemistry that controls our physiological well-being will also be shifted away from the optimum period.

3.4 Environmental Health

Although many people are familiar with the activity of the natural world during the day (i.e. photobiology), few people are as familiar with similar activity at night. Humans are not the only species whose biological clock is controlled by day-night contrasts and the release of melatonin. Similar biological clocks are found in plants and animals wherein darkness plays a similar role[19]. Wildlife depends on the darkness of the night and the study of this dependence is called "scotobiology".

Research into the nocturnal environment is relatively recent compared to research into the daytime environment. This situation is changing with a growing body of literature documenting the sensitivity of the general ecology at night to artificial lighting. This mounting scientific evidence is documenting the profound impact of artificial light on the ecology of the night[20].

Plants are affected by the colour and duration of lighting. Whether the effects are considered beneficial or not depends whether the outcome is desired or not. Generally, artificial lighting will change the natural growth patterns and may affect the resistance of plants to infestations and disease. Many plants respond to the length of the night and normally recognize it as an indication of the season. Extending light past the evening may slow or prevent the ability of the plant's biochemistry to prepare for winter. The various affects of light colour and duration, and type of plant, etc. makes sweeping conclusions impossible, however they indicate that changing the lighting environment will change the natural ecology of the area.

3.5 Animal Behaviour

Artificial sky glow extends well beyond the city boundaries. Therefore in considering urban outdoor lighting, city officials must also consider its impact on the rural areas in the region. As with air and water pollution, light pollution is not contained by political boundaries.

Exposure to short periods of bright illumination (less than a minute) does not seem to affect the biological rhythm in animals[21]. However, longer exposures to light can shift (or

[18] "Shutting Off the Night", H. Marano, Psychology Today, Sep/Oct 2002
[19] "Lighting for the Human Circadian Clock", S. M. Pauley, Medical Hypotheses (2004) 63,588–596
[20] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 405
[21] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 24

entrain) their circadian rhythm and can modify their behavioural patterns. Minimizing the duration of exposure to artificial light is necessary to limit its impact.

Seasonal variations will shift the time of sunset by over four hours at mid-latitudes from roughly 16:30 in winter to 21:00 in summer. During the peak of summer activities in public parks, the time of sunset can vary by over two hours (see Appendix D). In addition to this, dusk can extend the daylight by as much as an hour. The "behavioural plasticity" of animals has presumably evolved to accommodate these variations.

Natural lighting changes the behaviour of species at night[22]. Nocturnal mammals adapt their behaviour over the lunar month in sympathy to moonlight to avoid predators. This behaviour includes, in part, limiting the foraging area and carrying food back to their shelters instead of eating in the field - limiting how much they can eat[23]. They compensate for this during the dark time of the month.

Predator and prey behaviour depends on the darkness of the night[24]. Illumination levels that significantly affect our biology and that of wildlife is believed to be at the level of the full Moon, although the effect begins to be evident at lower light levels[25]. To put this in context, it is generally recommended by the IESNA that an urban parking lot be lighted to more than 100X the brightness of the full Moon (see Appendix A), and the distant illumination by the sky glow from a nearby city can exceed full Moon levels.

An illuminated road may separate animals from their normal foraging grounds. When headlights from passing cars temporarily blind them, their natural instinct is to wait until they can see where they are going. This can leave them in the open and vulnerable to predation. They may eventually abandon their established foraging areas for new ones, which will impact the indigenous species as they compete for resources[26].

It is well documented that some insects are drawn towards light sources. This interrupts their normal mating and foraging activities and it concentrates them within a small area thus enhancing predation[27]. They may also swarm the light fixture until they are exhausted. In a public park, the resulting pile of insects had to be cleaned up in the morning[28]. The blue-light components of typical white light are the main light attractors for insects. Using white light essentially attracts the insects to the people causing a

[22] The Urban Wildlands Group (www.urbanwildlands.org/abstracts.html)
[23] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Pg. 28
[24] ibid., Chapter 2
[25] ibid., Chapter 11
[26] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006
[27] ibid., Chapter 13
[28] Anecdotal reports from Parks Canada, 2011

nuisance and, since insects are vectors for disease, the white light enhances the health risk of outdoor activity[29].

3.6 Shorelines

Waterways have been used for transportation and recreation. However, they are also important ecosystems that support wildlife in the water and on the lands adjacent to the shoreline. Shoreline property is valued by our society and this is causing human developments along rivers and around lakes. An increasing number of properties have shoreline lighting that illuminates the waterway.

From the human stand point; bright lights along the shoreline make it very difficult to navigate the channel. Glare from unshielded shoreline lighting prevents boater's eyes from becoming adapted to the darkness. At night, a boater will only be able to see the points of light along the shore rendering the channel markers and floating hazards very difficult to see. Clearly, glare along the shoreline results in a safety hazard that should be corrected.

Illuminated shorelines also impact fish and aquatic plants[30]. Some fish are attracted to the light from their natural feeding depths. The increase in the concentration of small fish increases the hunting efficiency of predators. Although the behaviour of the nocturnal predator may not be compromised by artificial light, the ability of its prey to recognize the danger and to escape will affect their survival. This alters the ecological balance leading to unforeseen consequences.

3.7 Cultural Impact

There is a cultural imperative to protect the darkness of the night sky. Throughout recorded history (about 6,000 years) astronomy has been a focus of stories and mythologies. Those who have seen a dark sky are impressed by the serene majesty of the celestial sphere. It comes as no surprise that all civilizations have the constellations and asterisms woven into their culture.

After stepping outside from a lit room and under a dark rural sky, our initial count of a few stars with our photopic vision increases a hundred fold after only 10 minutes. This may increase by another order of magnitude after less than an hour as our eyes become fully dark-adapted. However, urban sky glow overwhelms the faint stars, and the glare from discrete light fixtures prevents our eyes from becoming dark-adapted. These limit the number of stars we can see from many thousands to only a few hundred. The consequence is that most people do not look up - because the view is only darkness. Our

[29] A. Barghini, B. de Medeiros, Artificial Lighting as a Vector Attractant and Cause of Disease Diffusion, doi: 10.128/ehp.1002115, August 2010, National Institute of Environmental Health Sciences, US Dept. of Health and Human Services

[30] Ecological Consequences of Artificial Night Lighting, C. Rich, T. Longcore, Island Press, 2006, Part V

current generation is the first for whom much less than half the population has seen a star-filled night sky. Most children have never seen the Milky Way.

3.8 Spectrum of Artificial Light at Night

As discussed earlier and specified in Section 4 and summarized in Appendix L, only non-white light sources are permitted in Preserves. However conversion to compliant lighting can be relatively easy (see Appendix K).

Most lamps are based on incandescent, HPS, florescent and LED bulbs. Incandescent bulbs emit a broadband "warm" white light with a correlated colour temperature (CCT) of about 2700K. HPS lamps have a "spiky" amber spectrum. Although the colour "looks" yellow, it contains 10% blue light (<500 nm).

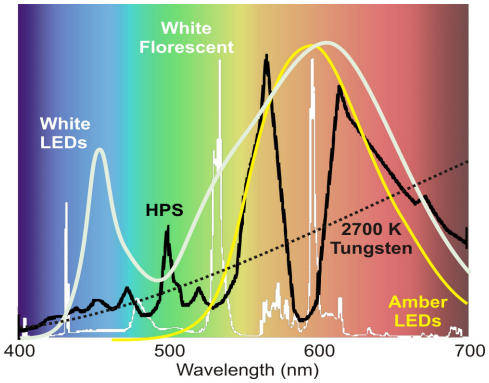


Figure 3.8 *Spectra of Common Lamps*
The light spectrum emitted but lamps depend on the physics of light emission. Incandescent lamps (~2700K tungsten filament) have a smooth spectrum that illuminates all coloured surface very well. All other sources only illuminate certain colours, which reduces the colour rendering. Although amber LEDs do not cover the range of colours as HPS lamps, it provides better colour rendering.

LEDs are available in a range of colours but they can be classified as white or amber. White-light LED luminaires are available with correlated colour temperatures (CCT) from 2700K to 5000K LEDs. However the amount of blue in these lamps can vary considerably between CCT and between companies from less than 10% to almost 40% . The amber LEDs (CCT ~1900K) emit virtually no blue light.

White light is not permitted in Preserves because of its impact on wildlife, vision and its high scattering properties in smoke and fog. Also, blue light affects the circadian rhythm of plants and animals - artificially altering their biology, and it provides subconscious lighting cues that may lead to inappropriate behaviours. For example some plants base their preparation for winter on the length of the night, which can be artificially shortened by artificial light, leading to a delay and reduced winter survival.

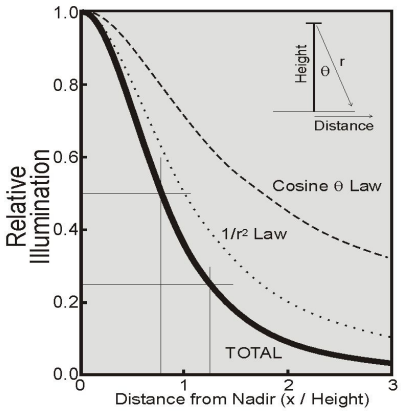
The blue spectral components attract insects to the light by approximately 50% over amber light. Apart from being a nuisance, insects can carry diseases that may be transmitted to park visitors.

The blue light components increase the impact of glare – up to 10X that of amber light. And when unshielded, white LEDs will undermine our night vision. With a compromised night vision, we are less able to see into dim areas - reducing safety by limiting our awareness of the surroundings (creating hazards) and affecting our ability to navigate at night. This lack of visibility also reduces our sense of safety and security.

3.9 Luminaire Shields

Unshielded lights are visible for "as far as the eye can see". Shielding luminaires is critical for cutting widespread glare. Shielding improves visibility and the light's impact on the environment beyond the target area.

Unshielded lights will illuminate a very large area, however the illumination level more than 2 mounting heights from nadir is, quite literally, negligible - <1/10 that at nadir and contributes little to good visibility. The useful spread of the light is only about 1.5 X mounting height from nadir. (This is due to the cosine law and the $1/r^2$ law, which are shown the accompanying figure.) So any light that shines beyond this distance primarily produces glare and wastes energy.



The light that shines within 10° below the horizon can undermine our night vision more than 100 meters away and can affect the aesthetic appearance of the night for more than a kilometre. Full cut-off fixtures (or Full-Shielded fixtures) limit the amount of light in this glare zone to <10% while Sharp Cut-Off fixtures limit it to <1%. (See Appendix G).

To expand the target area with more useful light requires appropriately designed optics to "throw light" from nadir into the periphery. However they still limit the light in this glare zone to <10%. These may be found in the more-expense luminaires.

Because of the spectral effects discussed in section 3.8, white light lamps require at least Sharp cut-off shielding for them to equal the effective of glare by amber light. Existing commercial luminaires (circ 2016) approach FCO but extra shields are required to convert them into Sharp cut-off.

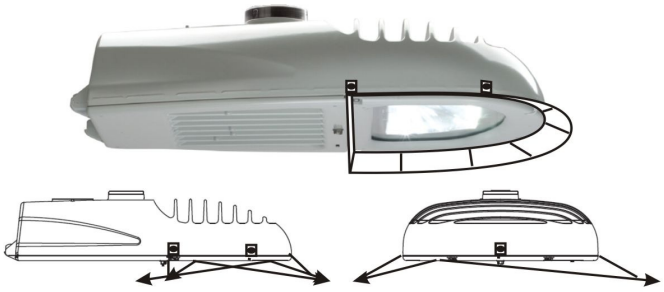


Figure 3.9 *Sketch of luminaire shield. This is a sketch of what a shield could look like. The shape is based on earlier shields that were used on non cut-off cobra lights. The front and back surfaces should be designed to limit light trespass. Similar concepts should be used for other types of luminaires.*

Mirror surfaces or bright coatings are effective at redirecting the light in the glare zone down into the target area resulting in a more effective light fixture. The removal of the offending glare significantly increases visibility across the illuminated area, and even beyond by helping to preserve our night vision. This increases our "sense of place" and "situation awareness", and thereby increasing our safety and security.

3.10 Scheduling of Light

The timing of when the illumination is used is also important. Humans are the only creatures that want light at night, so it must only be used if there is human activity in the area. However, most public parks use lights that were selected before our understanding of the impact of ALAN on the ecosystem and many of these remain turned on because there are no switches or timing circuits.

Some Preserves define a Dark Time when outdoor lighting is discouraged. It typically begins 2-hours after sunset. This is supported by the behavioural plasticity of wildlife to the changing illumination due to cloud cover and variations in nightfall over the seasons.

There are four uses for outdoor lighting.

Navigation	- assists in wayfinding
Safety	- renders hazards more visible
Security	- assists personnel to protect persons and property
Aesthetics	- illuminates a cultural display

The role of artificial light at night is to only identify hazards and wayfinding during pedestrian activities, which require relatively low illumination levels.

The norms of urban areas do not apply in a Preserve. There are usually no security personnel that make regular security sweeps of campgrounds or other areas throughout the night. Therefore, the "best practice" for urban areas should not be used in Preserves. In Preserves, the aesthetic is the natural night, which is compromised by artificial light.

3.11 Summary

Artificial lighting that is installed for human activity is altering the natural environment. Currently, this environmental degradation supported by human night culture. The cause is primarily ignorance.

It is clearly shown in published research, that artificial outdoor lighting affects the ecology by disrupting food webs, animal biology and behaviours. Although the actual mechanism for this disruption is not always clear, this does not weaken the evidence for the damaging impact of artificial light on the ecosystem and the need to minimize it.

There is growing evidence for the degradation of human health with the illumination of the night – particularly the blue components in white light and may be causing an increase in chronic diseases.

Education is the key to reducing this degradation by ALAN. Establishing Preserves is an obvious way to help inform the public about the virtues of a dark night. And, by drawing their attention to the vitality of night animals in the Preserves they will begin to understand the importance of reducing artificial light at night in their home cities.

Wildlife has no voice and cannot control their environment. We must act on their behalf. Cities must take action and advocate against change in their environment.

4.0 GUIDELINES FOR OUTDOOR LIGHTING

The need for the reduction of light pollution has been explained in Chapter 3. The information and tables in this section resent the quantitative limits to outdoor lighting in Preserves. Since the goals of the RASC Preserve Program are to promote and protect the night environment and promote astronomy, These Guidelines for Outdoor Lighting (GOL) apply to all Preserves. They give priority to the ecology, not urban lighting “best practice”.

The only difference between the RASC Dark-Sky Preserves and Urban Star Parks is the sky glow from external lighting over the site. It is understood that the establishment of an USP may not be sufficient to completely change the lighting polities of the urban area. Both DSPs and USPs should provide public outreach programs to explain and promote low-impact lighting and astronomy.

Nocturnal Preserves acknowledge that these outreach programs may not be practical due to limited staff and resources.

Before determining what type of lighting should be installed or retrofitted, it is important to ask the basic question; "Is the light necessary?" If there is no current need for artificial lighting, it should be removed rather than replaced - even with better technology. We should not assume there is a valid reason for a currently installed light.

This chapter provides guidelines that should be followed to minimize light pollution within a Preserve. It is recommended that the Preserve adopt similar equipment with low ecological impact to minimize the cost and complexity of inventory for repairs, replacements and re-purposing. Contact the RASC for assistance in selecting new compliant light fixtures, or modifying existing non-compliant luminaires.

Where necessary for basic safety and navigation:

1. Illumination should not exceed the specified levels
2. The affected area of illumination should be as small as practical,
3. The duration of the illumination should be as short as practical, and
4. Light fixtures should emit a minimum of blue spectral components (i.e. white light is not permitted).

What is “practical” depends upon the specific facilities in the area and the technology available at the time.

Illumination levels specified in this document are lower than urban areas for which most luminaires have been designed. This restricts the type of light sources that may be used. Although High Intensity Discharge (HID) and CFL lamps are very efficient, they may emit more light than is recommended in these guidelines. To address this, incandescent lights may be used for short periods of time or more advanced yellow or amber light emitting diodes (LEDs) may be installed.

These guidelines address the different types of facility and a range in pedestrian and vehicle traffic. However, the priority is given to respecting and protecting the natural environment.

Managers have the discretion to assess what levels are most appropriate for each built facility within the limits outlined in this chapter. Lighting is limited to provide only what is required for visitor navigation in built up areas. The artificial lighting is restricted to these areas and for the periods of human activity unless otherwise noted.

"Dark Time" is a term used in some parks to identify the end of significant activity within an area. This term is used herein to identify when the use of light should be discouraged. In this document, Dark Time is further defined as initiating 2-hours after sunset. Appendix D contains a reference table with the approximate times of sunset for parks in southern Canada (+50° latitude). Managers may define Dark Time that is suitable for their facility.

The following tenets have been used in developing these guidelines.

1. Buildings require illumination only when open or available to the public. After the office is closed to the public, all lighting visible from the outside should be turned off.

2. To save energy and minimize the duration and extent of light pollution, lit pathways should be illuminated only when pedestrians are in transit. All reasonable effort should be made to turn off lighting when pedestrian traffic is low or is no longer expected.

3. To minimize the impact of artificial lighting on the ecosystem, the areas covered by this guidelines should provide only enough light needed for a safe transition between lit structures and the surrounding unlit area, and to assist in navigation.

4. To minimize the ecological impact of light pollution, the extent of illumination should be strictly limited to only the area of current human activity.

5. To limit the duration of light exposure on the ecosystem and to save energy, light activated timing circuits should turn off outdoor lighting on or before the beginning of Dark Time or to the end of scheduled activity.

6. Where vehicle and pedestrian traffic is at a low speed or infrequent, retro-reflective signage should be used instead of installed lighting fixtures.

The IESNA BUG Designation System (Back-light, Up-light and Glare) that defines luminaire shielding is in Table 4.0. BUG lighting zone definitions are in Appendix F.

Table 4.0 BUG System Designation for Preserve Compliant Luminaires

BVH	<1%	**FVH**	<2%	**UH, UL**	0%
BH, BM, BL	<10%, or as required	**FH, FM, FL**	As required		

In addition to these guidelines, compliant luminaires described using the "abbreviated" BUG designation should be B=0, U=0 and G=0.

This chapter identifies six types of structures that may require illumination within a Preserve. In all cases, full cut-off (FCO) or sharp cut-off (ShCO) luminaires should be used to prevent light scattering beyond the immediate area of the light fixture. Further, the colour of this light should be amber with minimal blue (short wavelength) content. This can be achieved with amber LED luminaires, amber "bug light" lamps or with amber filters (Roscolux Deep Straw #15). Lighting curfews should apply (See Section 3.10).

4.1 Buildings

Illumination levels and luminaire types for various buildings are listed in Table 4.1. Building signage is discussed in Section 4.8.

This guideline identifies five building classifications.

4.1.1 Administration Buildings

Administration buildings are defined as those with private offices and will generally be closed after dark. Illumination of the main doorway and especially any steps leading to the main door may be required after sunset in the late autumn, winter and early spring.

After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside. Light activated (sunset) or timing circuits should turn off all outdoor lighting within 30 minutes of the office being closed. Manual reset switches or motion detectors may be used to extend this period for late-working staff by a pre-programmed duration of typically less than 1-hour.

4.1.2 Public Buildings

Public buildings are defined as those open to the public during business hours and may also contain private offices. Due to the public nature of these buildings with potentially high pedestrian traffic, exterior illumination may be higher than for park administration buildings.

After hours, either all interior lighting should be turned off, or window and door blinds should be used to prevent interior light from shining outside. All outdoor lighting should be turned off within 30 minutes of the building being closed. Exterior lighting should be limited to the main door area and steps. Light activated (sunset) or timing circuits should turn the lighting on after sunset and off after a period of time specified by the Manager and subject to the building use.

4.1.3 Retail Outlets

It is assumed retail stores will have higher pedestrian traffic than most other areas and illumination may be required while they remain open for business after dark.

Window coverings should be used so that interior lighting will not shine outside 30 minutes after sunset. Exterior light is permitted, and restricted to, FCO or ShCO fixtures illuminating the ground around the door. Exterior lighting should be turned off within 30 min. after business hours.

4.1.4 Vending Machines

Vending machines should be located in an enclosed space and their lights should not shine directly outside through doorways or windows. Where practical, these machines should be enclosed in existing public buildings. Figure 4.1.4 shows an example of a dedicated vending machine enclosure. Only FCO or ShCO fixtures should be used to illuminate the area outside the entrances. The extent of this outside illuminated ground area is restricted to less than 5 metres from the entrance.

Lamps for vending machines are fluorescent tubes behind the translucent display and may emit significant amounts of white and blue light. This light undermines our night vision. Unless dimmed or filtered, the illumination levels outside these enclosures may be higher than for other buildings to allow the transition for visitors from the bright interior to the dark surroundings.

Doorway lighting should be turned off or dimmed within two hours of sunset. Interior lighting may remain on at the owner's discretion.

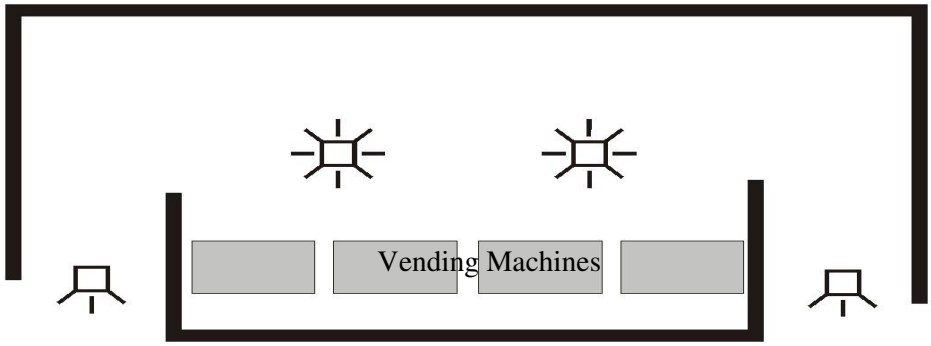


Figure 4.1.4 – Sample Vending Machine Enclosure

Table 4.1 Building Illumination Guidelines (Maximum Values)

4.1 Area	Type	Light*	Level (lux)**	Height	Curfew
4.1.1 Admin. Bldgs.	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.2 Public Bldgs.	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.3 Retail Stores	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.4 Vending Machine	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.5 Toilet, Washroom, Shower Facilities	Marker (FCO)	Amber Incandescent, CFL or LED, Filtered	~2 lux	2 m	No

* Wattages for individual lamp types are not specified due to differences in efficacy.
** 2 lux = illumination by clear sky about 20 minutes after sunset

Managers should consult Appendix C and J for guidance in meeting the recommended illumination level in all tables in Section 4.

4.1.5 Washroom and Shower Facilities

If toilet, washroom and shower facilities are available throughout the night, FCO or ShCO fixtures should be used to illuminate the entrance and any steps leading to the doorway. The illuminated door may be used as the "marker light".

Interior lighting in these facilities must also be considered. Excessive interior lighting levels can produce serious glare through the windows that impairs exterior visibility. After sunset, interior lighting should use amber (bug lights) or red lamps, or amber filters whenever possible and lighting levels, measured horizontally at the floor, should not exceed 10 lux.

4.2 Parking Lots

Generally, parking lots have less traffic at night than during the day. Parking lots may require lighting due to scheduled after-dusk activities. This lighting may be necessary until gate closure or Dark Time, which ever occurs first.

Where required, pole mounted FCO or ShCO luminaires should be placed one pole-height from the extreme corners of the parking lot and distributed evenly along the perimeter with an approximate pole spacing of no less than 4-times the luminaire height. Their light distribution pattern should be “full forward” and aimed into the lot. This is symbolically shown in Figure 4.2. If necessary for larger parking lots, poles may be located within the parking lot area.

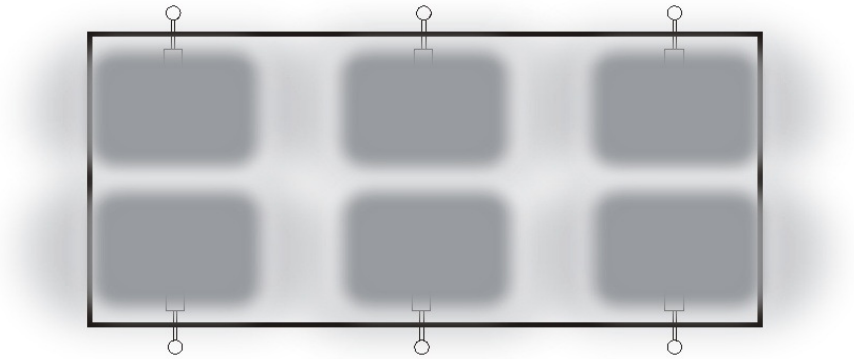


Figure 4.2 Parking Lot Lighting

4.2.1 Administration Parking Lots

Administrative personnel will generally leave when offices close. These luminaires should be turned off within 30 minutes of the office closure. A timing circuit should control the lights with a manual reset for late-working employees.

4.2.2 Visitor Parking Lots (Small)

Generally small lots (less than 10 cars) experience little traffic and should not be illuminated.

4.2.3 Visitor Parking Lots (Large)

Larger parking lots (spaces for approximately more than 10 cars) may require better visibility than smaller lots due to higher pedestrian and vehicle traffic densities. These lots may be illuminated at the discretion of the Manager. However illumination levels should not exceed the limits listed in Table 4.2.

Table 4.2 Parking Lot Illumination Guidelines (Maximum Values)

4.2 Parking Area	Type	Light	Level (lux)	Height	Curfew
4.2.1 Administration Lot	FCO ShCO	LPS, HPS or Amber CFL or LED, Filtered	~3	6 m	Yes
4.2.2 Visitor Lot < 10 cars	N/A	None	N/A	N/A	N/A
4.2.3 Visitor Lot > 10 cars	FCO ShCO	LPS, HPS or Amber CFL or LED, Filtered	~3	6 m	Yes

N/A – not applicable

4.3 Roadways

Intersections are some of the most dangerous areas for drivers and pedestrians. Drivers of high-speed vehicles require sufficient time to react when they approach an intersection (approximately 3 second reaction time before brakes are applied). Therefore, major intersections should be marked with luminaires, signage or both. Illumination of adjacent areas should be minimized to avoid distracting drivers and to limit ecological impact.

Where federal or provincial roadways run through Preserves, lighting of these roadways should be evaluated. If lighting will affect the quality of the Preserve, then the Manager should request the government to use light fixtures that will most closely comply with the these guidelines. Federal and provincial standards for roadway lighting refer to illumination levels, so FCO and ShCO shielding can and should be used. As a minimum, the Manager should form an agreement with the government so that they are asked to advise on the type of luminaires that are selected.

4.3.1 Class 1 to Class 3

Class 1 to Class 3 roadways are subject to high traffic volumes (Class 1) to medium traffic volumes (Class 3). Due to the high speed and volume of traffic, marker lighting may be required to alert drives well in advance of the intersection.

To ensure they are visible to approaching traffic, these marker lights may be semi cut-off (SCO) luminaires with a Type II distribution pattern (illumination along the major road). They should be oriented to minimize illumination beyond the side of the road. External shields may be used to prevent light from shining out of the right-of-way.

To further minimize the impact of these luminaires, the luminaire should be mounted no higher than six metres and the power should be no greater than a 35 watt High Pressure Sodium (HPS) or amber LED to minimize the blue-light exposure to the environment.

Retro-reflective signage should be used for all other intersections between the Class 1 to 3 roadways and lesser roadways. Illuminated signage should not be permitted (see Section 4.8).

Where federal and provincial highway standards take precedence, the minimum-allowable illumination in the standard should be used.

4.3.2 Class 4 to Class 6

Class 4 to Class 6 roadways have low traffic volumes with class 6 roads seeing occasional and local traffic. They provide access to large areas of the Preserve. These roads see infrequent use of after hours. These roads and intersections should use retro reflective signs instead of lighting to minimize the ecological impact.

Table 4.3 Roadway Illumination Guidelines (Maximum Values)

4.3 Roadways	Type	Light	Level (lux)	Height	Curfew
4.3.1 Class 1-3 roadways	None	N/A	N/A	N/A	N/A
4.3.2 Class 1-3 roads & intersections	SCO Marker	LPS, HPS or Amber CFL or LED, Filtered	~3	6 m	No
4.3.3 Class 4-6 Roads & intersections	Signage only	N/A	N/A	N/A	N/A

N/A – not applicable

4.4 Pathways

Pathways and sidewalks provide a relatively level surface for pedestrian traffic, and aid in site navigation. Visibility is necessary for navigation but excessive illumination will prevent pedestrians from seeing off the path for situation awareness. Although visitors might use flashlights, additional pathway lighting may be required to guide visitors to public events and facilities.

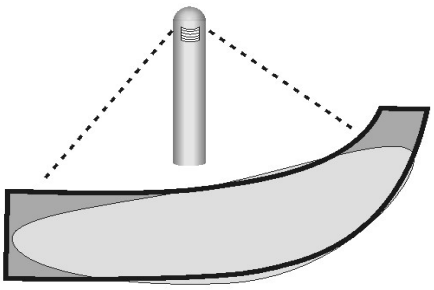
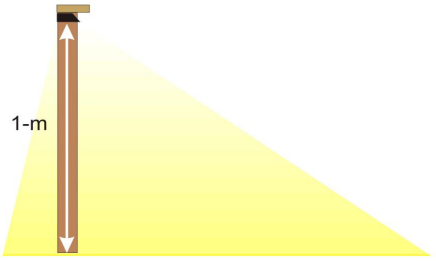
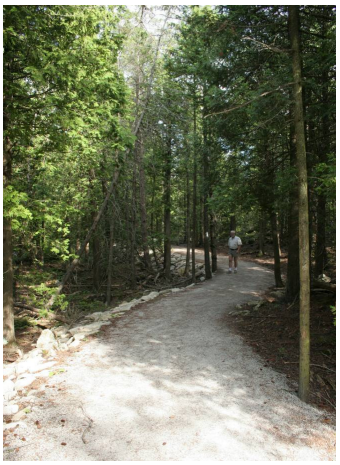


Figure 4.4.1 Bollard Luminaire

Paths are also used by wildlife. Therefore, pathway lighting should be restricted to only those paths near buildings, parking lots and campgrounds. Only those paths the Manager considers appropriate should be illuminated.



Since overhead FCO and ShCO luminaires will illuminate areas much wider than the path, low wattage bollard lighting, or railing mounted lighting, should be used such that the light is directed down and along the path. Fixtures should be shielded or lensed such that the illumination is approximately limited to the path width.



Pathways should use white or light coloured crushed stone (limestone) instead of asphalt to help reflect ambient light.

Generally, individuals walking along a pathway will have left the area after a minute or so (a distance of 30 metres) unless they remain for an activity. To minimize unnecessary light exposure, motion detectors should be used to turn on the string of lights and timing circuits to turn them off after a few minutes. Detectors may be installed at the entrances to pathways or at the limits to the illumination portion of the path.

Passive fluorescent markers may be used to mark the extent and direction of the pathway when the lights are off. These may be mounted on bollards or in the pathway surface.

The closeness of the luminaires to the ground necessitates very low intensity lights. This limits the current available products to low wattage incandescent bulbs and amber, or filtered LEDs. Low-brightness CFL Lamps are not yet available.

1. Whenever possible, pathways in the PRESERVE should not be illuminated. If deemed necessary by the Manager, specific pathways may be illuminated, or lined with white or yellow paint, or have fluorescent markers.
2. Illuminated pathways should have FCO or ShCO shielded fixtures, mounted on low-height poles, railings or bollards.
3. Pathway lighting should be turned off during the Dark Time lighting curfew. Retro-reflective markers or florescent markers on the bollards/railing may be used to assist pedestrians after Dark Time.
4. Main pathways leading to all-night facilities may be illuminated throughout the night at the discretion of the Manager but limited to Table 4.4.

Table 4.4 Pathway Illumination Guidelines (Maximum Values)

4.4 Pathways	Type	Light	Level (lux)	Height	Curfew
4.4.1 Pathways	None	None	N/A	N/A	N/A
4.4.2 Illuminated Paths	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1 m	Yes
4.4.3 Main Pathways	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1 m	No

N/A – not applicable

4.5 Shorelines

This section provides guidance to Managers for reducing the impact of lighting along a waterway. Shorelines consist of docks, jetties, lock facilities, boat launching areas, beaches, homes, cottages and undeveloped lands. Direct illumination of the shallow water

near shore alters the behaviour of aquatic species and the foraging patterns of land species and insects.

These guidelines are relatively general due to the limited authority of Managers over some of these properties.

1. Park personnel should inform the owners and users of shoreline property of the impact artificial light has on the ecology of the water and adjacent lands.
2. Property owners should be advised to shield all outdoor lighting to comply with FCO or ShCO requirements and to turn off this lighting when they go to bed.
3. Shoreline lighting should consist of amber or red light. Blue and white lights are not permitted.
4. Light fixtures should be prohibited within ten metres of a shoreline unless the Manager deems them necessary. Overhead luminaires that shine into the water are not permitted.
5. High traffic areas and areas near machinery (lock facilities) may require higher levels of illumination at the discretion of the Manager.

Table 4.5 Shoreline Illumination Guidelines (Maximum Values)

4.5 Waterways	Type	Light	Level (lux)	Height	Curfew
4.5.1 General Areas	N/A	None	N/A	N/A	N/A
4.5.2 Dock Bollards	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1m	No
4.5.3 Lock Facilities	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~3 lux	6 m	Yes

* - lowest practical wattage N/A – not applicable

4.6 Colour or Spectrum of Illumination

All outdoor illumination shall be amber. On a case-by-case basis the RASC may allow 3000K LEDs. However, no more than 1% of the total emitted light shall be emitted in the "glare zone" between 90-80 degrees from nadir (ShCO requirements). And, the illumination level must be less than 1/4 the levels specified in this chapter. This will help preserve night vision and limit the extent of the ecological impact.

4.7 Scheduling Illumination

Wayfinding requires very little light (0.1-1 lux), but unshielded fixtures undermine this because the glare prevents the visibility of trees and other landmarks. Some Preserves have a defined a Dark Time during which all unnecessary lighting should be turned off.

Dark Time typically begins 2-hours after sunset. The Manager may identify safety-critical lighting that should remain on but in a significantly dimmed level.

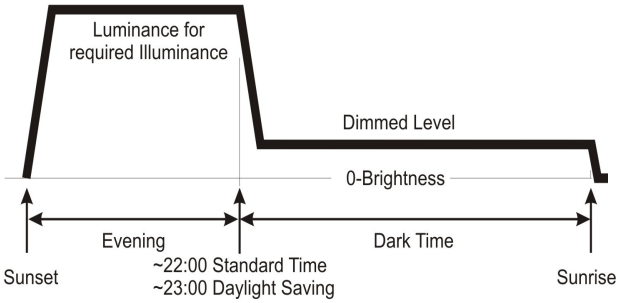


Figure 3.10 *Illumination Schedule. Light may be used during peak activity during twilight and early evening. At the beginning of dark time the outdoor artificial light should be turned off or significantly dimmed.*

Virtually all visitors to a park use flashlights. So visitors have light when necessary during Dark Time. Convenient signage compliments the use of these personal lights (See Section 4.8).

4.8 Signage

Signs within a Preserve are essential to the efficient navigation of the site. They may display three forms of information: names for sites or buildings (usually mounted in proximity to buildings or other structures), directions (located along roadways or pathways and their intersections) and those meant to convey other information (also located to the side of roadways and pathways).

Illuminated signs shall be prohibited in a Preserve. These include, but are not limited to, back illuminated signs, electronic billboards, signs illuminated from below and above the sign, and in front of the sign. To provide the visibility of signs after dark, their location, colour scheme, and material should permit reading the sign with flashlights or existing compliant pathway or roadway lighting.

When deemed necessary by the Manager, signs may be illuminated to the levels in Table 4.6.

Table 4.6 Signage Illumination Guidelines (Maximum Values)

4.6 Signage	Type	Light	Level (lux)	Height	Curfew
4.6.1 Building	Reflective, Light colour	Amber LED*, Filtered	~3 lux	1-2 m	Yes
4.6.2 Navigation	Reflective, Light colour	Amber LED*, Filtered	~3 lux	<1 m	N/A
4.6.3 Information	Retro-reflective Light colour	Amber LED*, Filtered	~3 lux	1-2 m	Yes

* Lowest wattage for about 3 lumen/ m^2 (0.3 lumen/ft^2) N/A – not applicable

Retro-reflective signage should be used to ensure signs are visible only when necessary. Signs may be mounted on or near buildings such that exterior building lighting may provide some illumination, and they should use colours consistent with retro-reflective materials and illumination with flashlights.

Pathway and information signs should be located less than one metre above the grade of the path so they may be found and read by pedestrians with flashlights after dark. All

bollards and railings should be marked with retro-reflective material so they may be visible to pedestrians after Dark Time. Roadway signs should be mounted in accordance with standard roadway practice.

4.9 Tower Navigation Avoidance Beacons

There is a proliferation of communication towers for cell phones and for wind turbine power generation. Towers that may have heights of hundreds of metres are being erected in otherwise unspoiled areas. Managers should be aware of the options available for tower navigation beacons that are regulated by Transport Canada[31] and Industry Canada. Communication towers erected on or near Preserve should not be fitted with night navigation beacons unless strictly required by Transport Canada regulations (CARS 621.19The brightness of night navigation beacons should be the minimum required by Transport Canada regulations (CARS 621.19). And, all towers requiring night navigation beacons should use red flashing lights.

There are several types of navigation avoidance beacons that may be used on towers (see Appendix E). A low impact example is a beacon with a collimated rotating beam (Appendix E CL864). In principal, its luminous intensity can be lower than other types of beacons and would emit less total light into the air, resulting in less scattered light into the environment but maintains its critical visibility to pilots. Birds are not attracted to red light as much as white light and they appear to be less able to orient themselves to the flashing beacons compared to non-flashing types[32].

Tower and wind turbine lighting may not be required unless the tower exceeds 90 meters. Consult applicable national aviation standards for the specific location. Single wind turbine towers less than 90 metres high do not have to be lighted unless specifically identified by Transport Canada as a hazard to aviation. For wind farms with several towers, the towers on the edge of the array and the central tower must be illuminated[33].

Managers may not have authority over the illumination of these towers so these guidelines are provided as a guide when discussing tower illumination with tower owners and Transport Canada. Where tower lighting contributes undue glare or illumination within the Preserve, Transport Canada may consider collimated beacons or down-shields.

4.10 “Developed” Properties

These properties include, but are limited to, private-owned and rental properties and towns within the Preserve's boundaries.

Owners of private properties within the Preserve should be informed of the impact of artificial lighting on wildlife. They should be encouraged to remove “dusk to dawn” lights, replace "yard lights” with FCO or ShCO luminaires. And they should replace

[31] Canadian Aviation Regulations (CARS) 621.19
[32] Gehring,J. Aviation Collision Study for the Michigan Public Safety Communications System (MPSCS): Summary of Spring 2005 Field Season, Central Michigan University, August 12, 2005
[33] Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 - DRAFT 9, Transport Canada

white LED, MH bulbs with either HPS, Low Pressure Sodium (LPS) fixtures or amber LED or filtered fixtures. They should be encouraged to turn off all exterior lighting when they are indoors.

All municipal lighting should be FCO or ShCO and illumination levels should be no greater than the "minimum" recommended IESNA Guidelines (RP-08). White light luminaires are not permitted, however 3000K LED luminaires may be approved by the RASC if they comply with Section 4.6.

The outdoor lighting on built facilities under the control of the Manager should use FCO or ShCO fixtures. Area lighting fixtures, such as "yard lights" and “dusk to dawn” fixtures or similar luminaires, are not permitted. White LED, Metal Halide (MH) or mercury vapour lamps are not permitted. These products produce excessive glare and light trespass and emit short wavelength light that affects wildlife and our night vision.

Use of outdoor lighting on all built facilities within Preserve should be discouraged during the Dark Time, and should be turned off when people are indoors. The RASC may approve some lighting on a case-by-case basis but this must be specifically requested in the Preserve application.

Table 4.8 Other Properties Illumination Guidelines Maximum Values)

4.8 Other Properties	Type	Light*	Level (lux)	Height	Curfew
4.8.1 Door Lights	FCO	Amber Incandescent, CFL or LED, Filtered	<3	1.5 m	Yes
4.8.2 Yard Lights	FCO	LPS, HPS, Amber CFL or LED, Filtered	<3	6 m	Yes
4.8.3 Municipal Lights	FCO	LPS, HPS, Amber CFL or LED, Filtered	≤ minimum IESNA	TBD	No

* Wattage of lamps should be based on illumination limits.

4.11 Light Pollution Abatement Beyond Preserve Boundaries

As with air and water pollution, light pollution respects no boundaries. Light pollution is best reduced at the source by decreasing the light emitted. Some cities are actively promoting the replacement of luminaires that contribute to sky glow but these policies are not wide spread. Preserves may influence the producers of air and water pollution and this influence should be extended to include light pollution.

- Managers should introduce and encourage programs of light pollution abatement in neighbouring municipalities around the Preserve with the goal of reducing glare across the Preserve boundaries and sky glow visible from within the Preserve.
- Managers should approach individuals whose lights shine into the Preserve. The goal is to have those lights shielded, reduced in brightness or removed.

4.12 Historic Sites

These guidelines give priority to wildlife in the Preserve; but historic sites may be located within urban areas where light pollution is generally so bad that lighting to the above standards will have no significant improvement. The philosophy of not over-lighting the area is prudent for better visibility, which leads directly to safety, aesthetics, and it will reduce operating costs.

Outdoor lighting at historic sites should use FCO or ShCO fixtures and should illuminate the faculties to the minimum levels of standards and guidelines in the surrounding area. If “Period Lighting Fixtures” are used on the site, then the FCO or ShCO varieties should be used where possible. Historic lighting rarely included "white light, so amber light should be used because perceptually it is also more historically accurate.

4.13 Wilderness Areas

Wilderness areas are all “undeveloped” properties in their natural state. No artificial lights shall be installed in wilderness areas.

The use of personal red or amber flashlights should be encouraged but high power flashlights (> 300 lumens) should not be allowed. As with permanent lighting, amber and red light flashlights will reduce glare and help maintain dark adaptation. The use of white flashlights should be discouraged or used sparingly. Installation and extended use of portable outdoor lighting is strictly prohibited.

5.0 LIMITATIONS

No assurance is made regarding the accuracy and completeness of these data. The author and the RASC disclaim responsibility for consequential financial effects on transactions or property values, or requirements for follow-up actions and costs.

This document is based on data and information collected during work undertaken by the author and the RASC. The author and the RASC shall not be held responsible for the errors and omissions of work carried out by third parties.

This document provides a professional opinion and, therefore, no warranty is either expressed, implied, or made as to the conclusions, advice and recommendations offered in this document. This document does not provide a legal opinion regarding compliance with applicable laws. With respect to regulatory compliance issues, it should be noted that regulatory statutes and the interpretation of regulatory statutes are subject to change.

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Shutting Off the Night, H. Marano, Psychology Today, Sep/Oct 2002

Tested Strategies to Prevent Crime: A Resource for Municipal Agencies and Community Groups, National Crime Prevention Council, Copyright © 1995

Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 DRAFT 9, Transport Canada

C. Kyba, et.al., Artificially Lit Surface of Earth at Night Increasing in Radiance and Extent, Science Advances 2017;3: e1701528 November 22, 2017, http://advances.sciencemag.org/

6.2 Web Sites

Astronomy Outreach and Education Materials
www.starlight-theatre.com

Canadian Aviation Regulations (CARS) 621.19
https://www.tc.gc.ca/eng/civilaviation/regserv/cars/part6-standards-standard621-512.htm

International Dark Sky Association
www.darksky.org

Fatal Light Awareness Program
www.flap.org

Light Pollution by Pierantonio Cinzano
www.lightpollution.it/indexen.html/

Royal Astronomical Society of Canada (RASC) Light Pollution Abatement Program
http://www.rasc.ca/lpa

The Urban Wildlands Group
www.urbanwildlands.org/abstracts.html

WebMD, March 06, 2007,
www.webmd.com/cancer/news/20040908/light-at-night-may-be-linked-to-cancer

Work, Aging, and Vision: Report of a Conference, National Academy Press,
Washington, DC, 1987, ISBN-10: 0-309-07793-1,
http://books.nap.edu/openbook.php?isbn=POD252

APPENDIX A - Natural and Urban Illumination Levels

Condition	Illumination Levels* (lux)**
Clear night sky (no Moon)	0.000 05
Clear Urban Sky with Light Pollution	0.015
Twilight	0.1
Overcast Urban Sky with Light Pollution	0.15
Full Moon	0.26 max. (0.1 typical)
Urban Road Artificial Illumination	3-4***
Open Urban Parking Lot	11-22
Car Dealership Lot	200
Full Sunlight	130,000

* Clarity of the atmosphere is highly variable over hours and days. These values are presented to provide only a rough guide to approximate illumination levels.

** "lux" is a Système internationale (SI) unit of illumination equal to 1 candela/m^2 (cd/m^2) = 0.093 foot-candles (fc)

*** IESNA RP-8-00

To place these levels in context, people have reported seeing "fine" at full Moon illumination levels in the absence of glare[34].

[34] Preliminary Recommendations: Outdoor Lighting at Highlands Center, Cape Cod National Seashore, Chad Moore, March 25, 2006

APPENDIX B - Colour of Various Light Sources

This table lists six lamps that convey “colour” from bright white to deep yellow and amber. LEDs can be designed to provide a range of different colours so they have two entries.

White Light LEDs	Available in a range of CCT with 10% to >50% blue light. Blue light components impact the biology and behaviour of wildlife and plants. Undermines night vision. Should not be used in a PRESERVE due to ecological impact and vision degradation. White light gives very good colour recognition.
MH – Metal Halide	HID lamp that must be warmed up before it can reach full brightness. MH has high blue spectral content, produces a significant amount of UV and therefore its use should be avoided in all Preserves.
Incandescent bulbs	These emit a warm white light (~2700K CCT) and have very low energy efficiency. They can be turned off and on very quickly so they can be used for motion detection systems. Should be considered only if amber LED or amber CFL lamps are not available with low enough brightness.
HPS - High Pressure Sodium	These are bright yellow and allow fair colour recognition. A HPS bulb has a small light-emitting region for very good control over where the light is focused. As a HID source, they require a few minutes to heat up before they reach their design brightness.
Amber CF – Compact Fluorescent Lamps	These produce filtered light and are commercially sold as bug and party lights. They may be identified as yellow and orange but their colour and quality vary greatly. Choose darker yellow and orange whenever possible to avoid flying insect attraction. They typically do not perform as well in cold temperatures and may take several minutes to warm up in sub-zero temperatures.
LPS - Low Pressure Sodium	Deep yellow light is virtually a single colour offering very poor colour recognition. It is the most energy efficient of the above lamps. They are so efficient that even low wattages may produce too much light for use in Preserves. The light-emitting region in the lamp is quite large compared to other HID lamps.
Amber and Red Light Emitting Diodes	Amber and red LEDs have low impact on the environment. They can produce very focused illumination, which is very desirable for Preserve applications. For Preserve purposes “Amber” is defined as light in the wavelength of 500 – 700 nm and “Red” is 600 - 660nm. Most people can see "better" with amber than red LEDs.

APPENDIX C - Light Output from Typical Bulbs

Bulb Types	Lumens	Lux at 6 m	Lux at 2 m	Lux at 1 m
Incandescent*				
7 watt	60	0.13	1.2	4.8
15 watt	128	0.28	2.6	10.2
40 watt	342	0.8	6.8	27.2
60 watt	513	1.1	10.2	40.8
100 watt	855	1.9	17.0	68.0
Metal Halide (MH)				
70 watt	3,000	6.6	59.7	238.7
100 watt	5,800	12.8	115.4	461.6
High Pressure Sodium (HPS)				
35 watts	2025	4.5	40.3	161.1
50 watts	3600	8.0	71.6	286.5
70 watts	5450	12.1	108.4	433.7
100 watts	8550	18.9	170.1	680.4
Low Pressure Sodium (LPS)				
18 watts	1570	3.5	31.2	124.9
35 watts	4000	8.8	79.6	318.3
55 watts	6655	14.7	132.4	529.6
Compact Florescent (CF)				
9 watt (40 w equivalent)	550	1.2	10.9	43.8
13 watt (60 w equivalent)	850	1.9	17.9	71.6
LED**				
1 watt (amber) ***	75	2.	19	75
3 watt amber A19	90	0.5	4.0	12
3 watt amber PAR16	90	1.8	16	50
7 watt amber PAR30	200	5.5	50	200
13 watt amber PAR38	400	11	100	400

Note:
Fixture and bulb degradation before cleaning or replacement may decrease these to as low as 50%.
Fire has an approximate efficacy of 0.5 lumens/watt
* The luminous efficiency of incandescent light is approximated as 1/10 that of HPS for photopic vision
** Supplied by IDA
*** Assumes a 1 steradian illumination angle and no external optics, typical for 2011
Lumens is the total amount of light emitted in all directions (over 4π steradians)
Lux is the amount of light illuminating a surface of one metre square

$$1 \text{ lux} = 1 \text{ Lumen} / (4\pi \text{ dist}^2)$$ where distance is in metres

References:

IDA Information Sheet 4, Operating Data and Economics of Different Lamps, (08/96)
CAN/CSA-C653-94 (2000) - Performance Standard for Roadway Lighting Luminaires
Mesopic Street Lighting Demonstration, Lighting Research Centre, Jan. 31, 2008, (Rensseaer), Table 2, 5

APPENDIX D - Approximate Times of Sunset (Areas in Southern Canada - +50° Lat.)

The time of sunset depends on the time of year and the latitude for a site. The following table lists the approximate time of sunset (DST) for latitude of about +50 degrees from May to the end of September.

May 1	8:17
8	8:29
15	8:38
22	8:48
29	8:57
June 1	9:00
8	9:08
15	9:11
22	9:13
29	9:13
July 1	9:13
8	9:09
15	9:04
22	8:57
29	8:48
August 1	8:42
8	8:31
15	8:19
22	8:06
29	7:50
September 1	7:45
8	7:30
15	7:15
22	6:59
29	6:44

From the Royal Astronomical Society of Canada
Observers Handbook

APPENDIX E - Navigation Beacon Photometrics[35]

			Minimum Intensity (candelas) **(a)**				Intensity (candelas) at given elevation angles when the light is levelled **(c)**				
Light Type	Colour	Signal type	day	twilight	night	Vert. beam spread **(b)**	- 10deg **(d)**	- 1deg **(e)**	± 0deg **(e)**	+ 2.5deg	+12.5deg
CL810	red	fixed	N/A	32min	32min	10deg	-----	-----	-----	32 min	32 min
CL864	red	flashing 20-40fpm	N/A	N/A	2,000 ±25%	3 deg min	-----	50% min 75% max	100% min	-----	-----
CL865 **(f)**	white **(f)**	flashing 40fpm	20,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----
CL866	white	flashing 60fpm	20,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----
CL885 Catenary	red	flashing 60fpm	N/A	N/A	2,000 ±25%	3 deg min	-----	50% min 75% max	100% min	-----	-----
CL856	white	flashing 40fpm	270,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----
CL857 Catenary	white	flashing 60fpm	140,000 ±25%	20,000 ±25%	2,000 ±25%	3 deg min	3% max	50% min 75% max	100% min	-----	-----

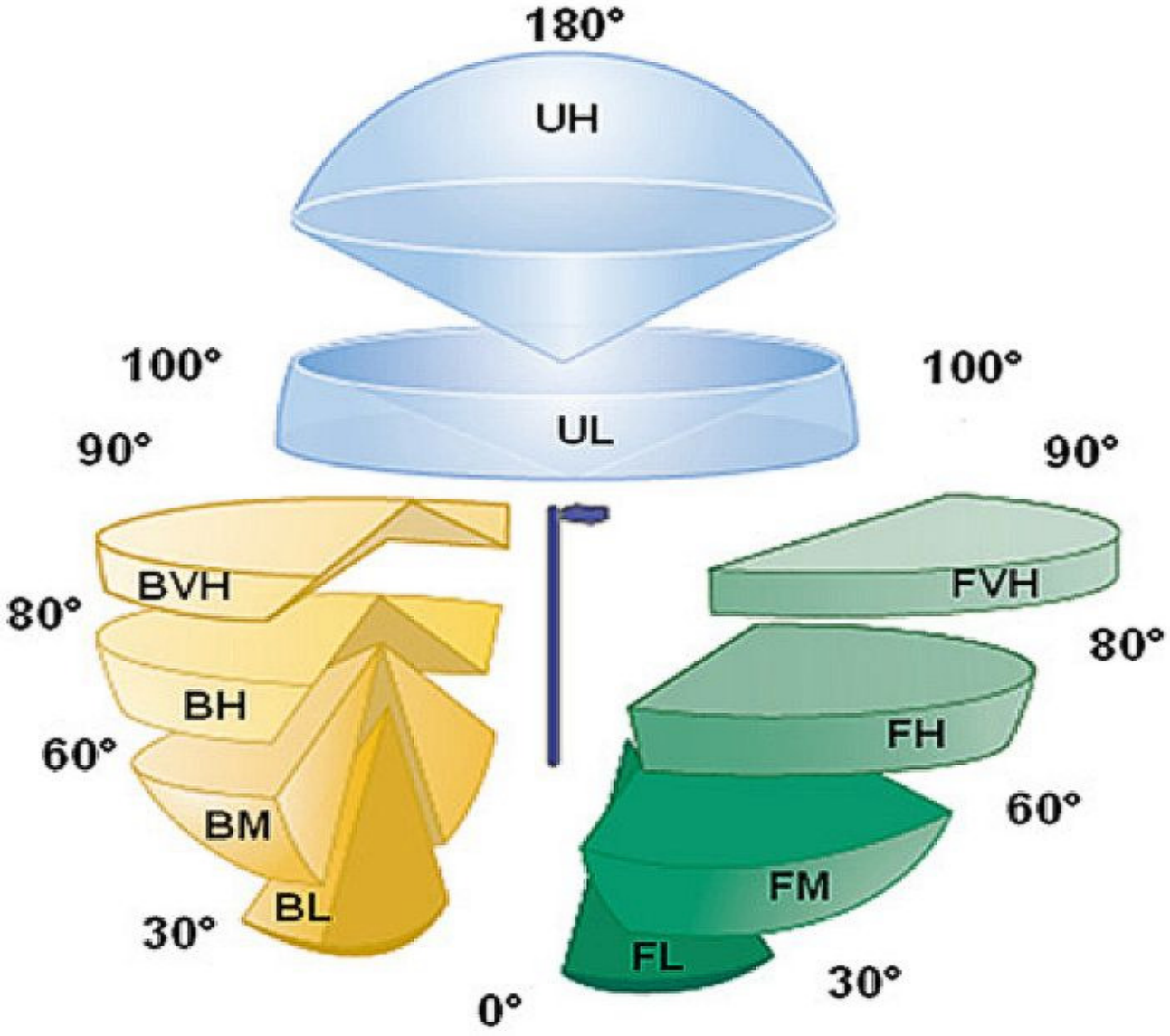
(a) Effective intensity, as determined in accordance with External Transport Canada Document
(b) Beam spread is defined as the angle between two directions in a plane for which the intensity is equal to 50% of the lower tolerance value of the intensity shown in columns 4, 5 and 6. The beam pattern is not necessarily symmetrical about the elevation angle at which the peak intensity occurs.
(c) Elevation (vertical) angles are referenced to the horizontal.
(d) Intensity at any specified horizontal radial as a percentage of the actual peak intensity at the same radial when operated at each of the intensities shown in columns 4, 5 and 6.
(e) Intensity at any specified horizontal radial as a percentage of the lower tolerance value of the intensity shown in columns 4, 5 and 6.
(f) In the case of rotating type CL865 one third of the flash display should be red in colour. e.g. WWR

[35]Wind Turbine and Windfarm Lighting, CAR621.19 Advisory Circular 1/06 - DRAFT 9, Transport Canada

APPENDIX F - IESNA BUG Designation System

The IESNA BUG System has been developed to more specifically define the illumination from a luminaire. Ten zones have been defined that affect the shielding and glare from a light fixture.

The Addendum A for IESNA TM-15-07 provides examples of this system for a given luminaire. The diagram below (IDA Specifier Bulletin for Dark Sky Applications, Vol. 2(1), 2009) visually defines the different zones.



FCO luminaire preclude any up light (UH and UL = 0% of total emitted light). To minimize glare and light trespass that increases the impact area of the illumination should have BVH and FVH as close to 0% as possible. FCO fixtures allow 10% of the total light to be emitted in the zone from 80° to 90° of nadir (Glare Zone). However the preferred Sharp Cut-off designation only permits 1% in the Glare Zone.

APPENDIX G - Summary of RASC Recommended Lighting

This summary applies to all property and structures within the Preserve.

1. No additional light fixtures should be installed.

If additional light fixtures are considered necessary by the Park Manager, and with approval by the RASC, additional fixtures may be installed. All new fixtures should conform to the requirements of Items 3-8 below.

2. Signage should not use active lighting.

Signage should use retro reflective materials. Pedestrian signs should be mounted at a height suitable for illumination with flashlights (<1 metre from the ground).

3. Only full cut-off (FCO) and Sharp cut-off (ShCO) fixtures should be used.

All existing light fixtures should be replaced with FCO or ShCO fixtures or shielded to prevent light from shining above the horizon or beyond the immediate area requiring illumination.

4. The illumination level produced by all light fixtures should be as low as practical.

Dusk and night pedestrian and vehicle traffic densities should be used in assessing the level of illumination within the limits of this Guideline. For vehicles, typically < 70-watt HPS at 6-m is sufficient (3 lux) for large parking lots and high traffic density areas where low speed limits are in effect. Major pedestrian routes may be illuminated by typically < 8-watt incandescent light or <1 watt amber LED (< 5 lux). With the use of vehicle headlights and pedestrian flashlights, lower power lamps can be used with the understanding that they are used only as marker lights. Phosphorescent markers may be used.

5. Structures and barriers should be used to confine illumination to the immediate area.

Illuminated areas should be bordered by trees and bushes, or other barriers, to prevent the light from shining and scattering beyond the area being illuminated.

6. All light sources should be turned off within 2-hours of sunset (Dark Time)

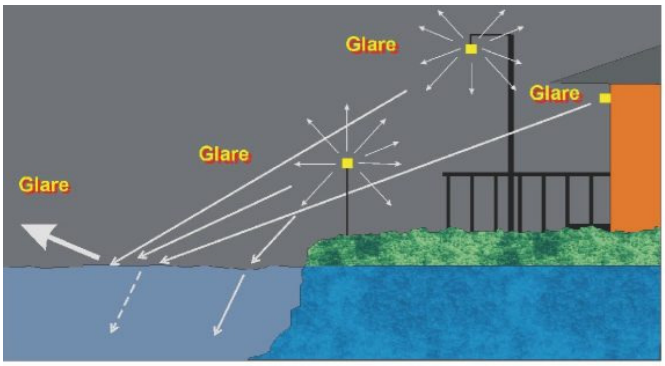
Automatic timers should be used to avoid the need for staff to turn off the lights. The timers should detect nightfall and should turn the lights off within 2-hours. If the Park Manager considers lights will occasionally be required after this time, the timer should be capable of being reset by staff.

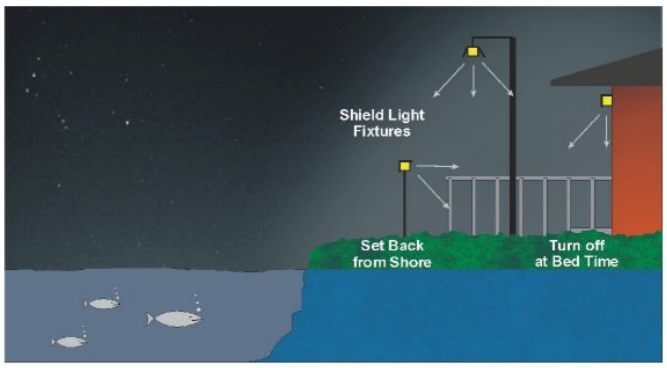
7. Indoor lighting should be prevented from shining through exterior windows.

If interior lights must be used after sunset, window curtains should be closed within 30-minutes of sunset or interior illumination levels must be reduced significantly so as not to produce glare or light trespass.

8. The colour of all light fixtures should emit <1% blue light in their spectrum.

“White” light sources such as metal halide lamps and white LEDs should not be used. High-pressure, and low-pressure sodium lamps, incandescent and CFL bulbs, and amber LEDs may be used as long as they are in FCO fixtures and they provide amber light at the required illumination levels.





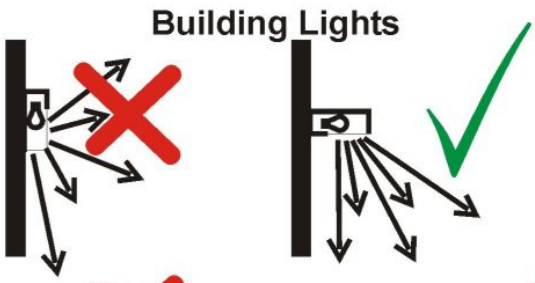
The Bad and the Good
Shoreline Lighting

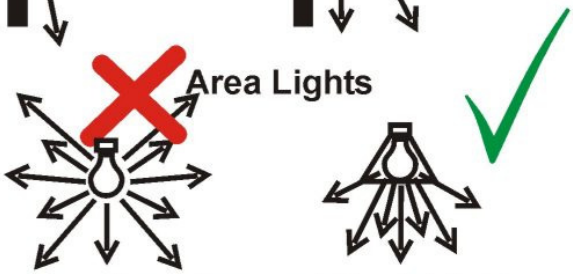
White Stone on Pathway
and Shielded Bollard

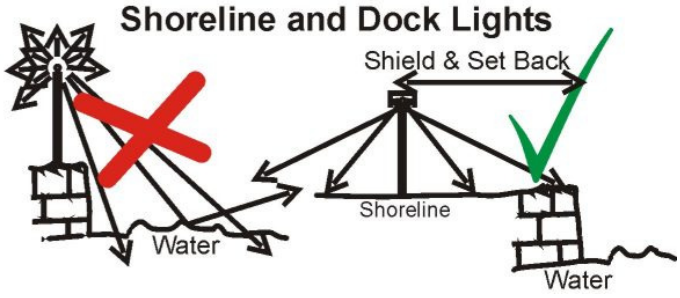
Use "Warm Light"
- not white light

Use Timers
- on at sunset
- off 2-hours later

Use Motion Sensors
- lights on only
when needed







APPENDIX H - Critical Outdoor Lighting Attributes

Colour and Spectrum

Only amber light should be used. No white light should be permitted. The energy spectrum of amber light (>500 nm) shall contain less than 2% of the total emitted light as shown in Figure G.1

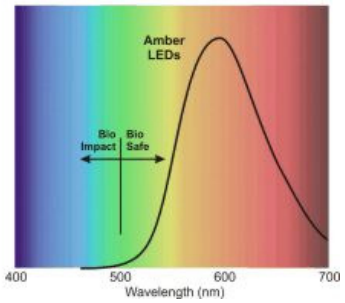


Figure G.1: *The spectrum of compliant amber light for* Preserves.

Shielding

All luminaires shall have Full Cut-Off or Sharp Cut-Off shielding or better. The industry definition of FCO shielding is for only 10% of the total light the luminaire shall be emitted within the zone between 80-degrees and 90-degrees from nadir. And, zero light shall be emitted above 90-degrees from nadir. ShCO shielding allows only 1% of the light in the glare zone. This is presented in figure G.2

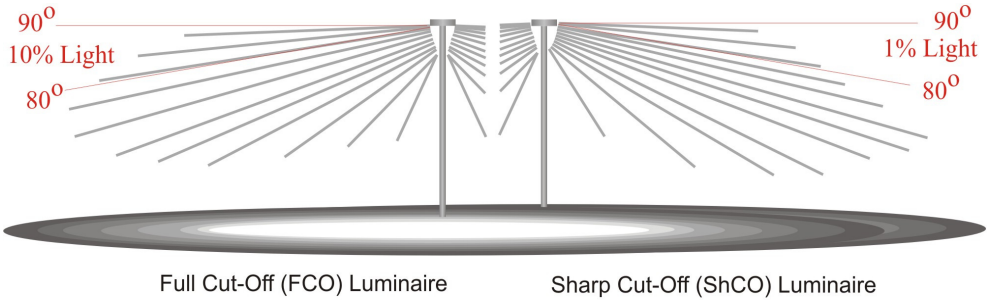


Figure G.2
Definition of Full Cut-Off shielding.

Brightness

The illumination levels (brightness) shall be limited to those tabulated in Chapter 4 and compiled in APPENDIX I. These lux values require selecting lamps with the correct wattage. We provide a guide to these wattages in the table of APPENDIX J.

It is obvious that these powers are considerably less than typical luminaires. There are two reasons for this.

1) The illumination in a Preserve is based on protecting the ecology, not maximizing visual impact.
2) By shielding to either FCO or ShCO and using non-white light, our night vision is preserved and the resulting visibility is quite good.

Tests performed with these levels provide very good visibility for visitors in a park setting.

APPENDIX I - Summary of GOL Illumination Tables

Table 4.1 Building Illumination Guidelines (Maximum Values)					
4.1 Area	Type	Light*	Level (lux)	Height	Curfew
4.1.1 Admin. Bldgs.	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.2 Public Bldgs.	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.3 Retail Stores	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.4 Vending Machine	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~2 lux	2.5 m	Yes
4.1.5 Toilet, Washroom, Shower Facilities	Marker (FCO)	Amber Incandescent, CFL or LED, Filtered	~2 lux	2 m	No

* Wattages for individual lamp types are not specified due to differences in efficacy.
Park Managers should consult Appendix C of the GOL for guidance in meeting the recommended illumination level in all tables in Section 4.
Note: 1 lux = limit for reading printed text in brochure
2 lux = illumination by clear sky about 20 minutes after sunset

Table 4.2 Parking Lot Illumination Guidelines (Maximum Values)					
4.2 Parking Area	Type	Light	Level (lux)	Height	Curfew
4.2.1 Administration Lot	FCO ShCO	LPS, HPS, Amber CFL or LED, Filtered	~3	6 m	Yes
4.2.2 Visitor Lot < 10 cars	N/A	None	N/A	N/A	N/A
4.2.3 Visitor Lot > 10 cars	FCO ShCO	LPS, HPS, Amber CFL or LED, Filtered	~3	6 m	Yes

N/A – not applicable

Table 4.3 Roadway Illumination Guidelines (Maximum Values)					
4.3 Roadways	Type	Light	Level (lux)	Height	Curfew
4.3.1 Class 1-3 roadways	None	N/A	N/A	N/A	N/A
4.3.2 Class 1-3 roads & intersections	SCO Marker	LPS, HPS, Amber CFL or LED, Filtered	~3	6 m	No
4.3.3 Class 4-6 Roads & intersections	Signage only	N/A	N/A	N/A	N/A

N/A – not applicable

Table 4.4 Pathway Illumination Guidelines (Maximum Values)					
4.4 Pathways	Type	Light	Level (lux)	Height	Curfew
4.4.1 Pathways	None	None	N/A	N/A	N/A
4.4.2 Illuminated Paths	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1 m	Yes
4.4.3 Main Pathways	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1 m	No

N/A – not applicable

Table 4.5 Shoreline Illumination Guidelines (Maximum Values)					
4.5 Waterways	Type	Light	Level (lux)	Height	Curfew
4.5.1 General Areas	N/A	None	N/A	N/A	N/A
4.5.2 Dock Bollards	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~1 lux	1m	No
4.5.3 Lock Facilities	FCO ShCO	Amber Incandescent, CFL or LED, Filtered	~3 lux	6 m	Yes

* - lowest practical wattage N/A – not applicable

Table 4.6 Signage Illumination Guidelines (Maximum Values)					
4.6 Signage	Type	Light	Level (lux)	Height	Curfew
4.6.1 Building	Reflective, Light colour	Amber LED*, Filtered	~3 lux	1-2 m	Yes
4.6.2 Navigation	Reflective, Light colour	Amber LED*, Filtered	~3 lux	<1 m	N/A
4.6.3 Information	Retro-reflective Light colour	Amber LED*, Filtered	~3 lux	1-2 m	Yes

* Lowest wattage for about 3 lumen/ m^2 (0.3 lumen/ft^2) N/A – not applicable

Table 4.8 Other Properties Illumination Guidelines Maximum Values)					
4.8 Other Properties	Type	Light*	Level (lux)	Height	Curfew
4.8.1 Door Lights	FCO	Amber Incandescent, CFL or LED, Filtered	<3	1.5 m	Yes
4.8.2 Yard Lights	FCO	LPS, HPS, Amber CFL or LED, Filtered	<3	6 m	Yes
4.8.3 Municipal Lights	FCO	LPS, HPS, Amber CFL or LED, Filtered	≤ minimum IESNA	TBD	No

* Wattage of lamps should be based on illumination limits.

APPENDIX J - Power and Lumens to Comply with GOL

The following table provides a convenient guide for the selection of luminaires that will provide illumination that is compliant to this GOL.

The power levels are based on five mounting heights that correspond to typical applications. The power levels are further given for the two levels of average illumination (1 lx and 3 lx), which also correspond to applications typical of Preserves. Other levels may be interpolated.

To use the table,
1) Identify the application (mounting height and illumination).
2) Select the corresponding column for application and row for lamp type.
3) The lamp power is printed in the shaded part of the table.

Applications										
	1m x height =	bollard or pathway light								
	2.5m height =	over-door light								
	3m height =	under-eve light								
	4m height =	over-head pathway light								
	6m height =	roadway and parking lot light								
Height	**1m**		**2.5m**		**3m**		**4m**		**6m**	
Lux (GOL)	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**3**	**1**	**3**
LED	0.1	0.2	0.4	1.2	0.6	1.7	1.0	3.1	2.3	6.9
HPS	No lamps available. Do not use.									
CFL	No lamps available. Do not use.									8.7
Incandescent	0.6	1.9	4.0	12.1	5.8	17	10	31	23	69
Lumens (ave)	6.4	19	40	120	58	174	103	309	231	694
Notes:	Pick lamp wattage closest to that in the table									
	Lumens based on average lux									
	Assumes 50% fixture efficiency and no backlight (50% of light is "lost")									
	Approx. coverage area = 1.5 x 3 mounting-heights = 4.5 x MH^2									
	Uniformity 3:1 => Max = 1.5 ave. lux and Min + 0.5 ave. lux									
Efficacy (lm/W)	LEDs - 100		HPS - 100		CFL - 80		Incandescent - 10			

These powers are only approximate and can be affected by the type of fixture, shielding, optics and degree of in-use degradation. However lamps using more than 2X these levels should not be used. Note that all lamps must only emit amber light.

APPENDIX K - Converting Non-Compliant Fixtures for GOL

Converting existing light fixtures to comply with the GOL may be done on a case-by-case basis. We will begin with an Edison screw socket. These take the standard consumer incandescent and compact fluorescent bulbs (E27 base).

The simplest way to convert from non-compliant to compliant lamps is to replace the white light incandescent, compact florescent and LED bulbs with amber bulbs - usually referred to as bug lights. The challenge with using off-the-shelf bug lights is that they tend to be too bright. Most applications in a Preserve require less than 50 lux.

25 1ncandescent	~200 lumens
13W CFL	~550 lumens
9W LED	~800 lumens

Therefore they require careful shielding to reduce the impact of the glare. Since they have very low wattage, they generate relatively little heat. Only the incandescent bulb may be too hot to touch (~55C). (Smaller incandescent bulbs are available at 8W.) This simplifies the materials that may be used for shields.

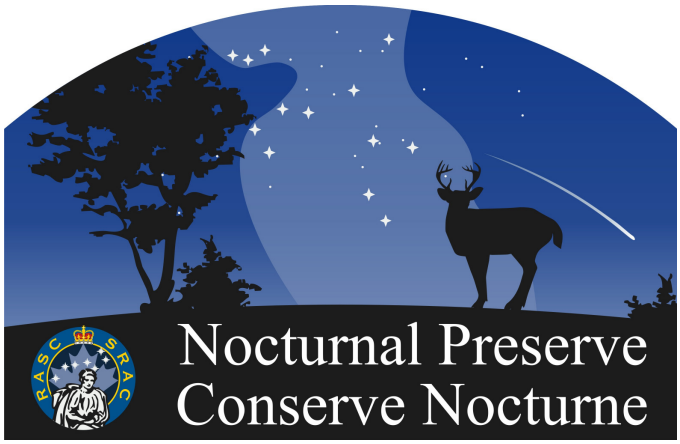
This example is made from cardboard with a coat of outdoor paint to protect it against weather. The exterior colour may be selected for it to blend in with the surroundings, the interior colour may be white to maximize the illumination, or black to reduce the brightness of the ground. If metal is used, care must be taken to prevent touching the electrical contacts at the bottom of the bulb.

Larger lamps, such as florescent tubes, may be filtered. The photographic filter material by Roscolux (Deep Straw #15) will filter out the blue light of typical white lamps. This amber coloured plastic foil can be purchased in sheets from www.bhphotovideo.com.

To assemble, line the interior of the U-shaped diffuser on a typical florescent tube fixture. To further reduce the glare and light trespass from the fixture, the interior sides of the diffusing plastic should be lines with light-blocking material (cardboard).

APPENDIX L - RASC Dark-Sky Protection Programs

Dark-Sky Preserves
Limited use of artificial light at night
Visitor facilities
Visitor access at night
Limiting artificial sky glow
Stargazing and astronomy outreach programs
Promotion of light pollution Abatement



Nocturnal Preserve
Limited use of artificial light at night
May have visitor facilities
May have visitor access at night
Limiting artificial sky glow
Promotion of nocturnal environment

Urban Star Park
Limited use of artificial light at night
Visitor facilities
Visitor access at night
Noticeable impact of artificial sky glow
Stargazing and astronomy outreach programs
Promotion of light pollution Abatement