

LIGHTING ZONES

The use of lighting zones (LZ) was originally developed by the International Commission on Illumination (CIE) and appeared first in the US in Illuminating Engineering Society (IES) Recommended Practice for Environmental Lighting, RP-33-99. The original system employed four lighting environmental zones, currently named LZ-1 through LZ-4. Recently, the CIE, IES and International Dark Sky Association (IDA) have all addressed a fifth zone of extreme environmental sensitivity (LZ-0) that is incorporated into the Joint IDA – IES Model Lighting Ordinance (IDA IES MLO 2011).

The National Park Service National Night Skies Team proposes two additional restrictive zones throughout National Park Service units: LZ-00, to articulate where lighting is generally not desired but may be allowed for specific targeted needs, and a Naturally Dark Zone (NDZ), a zone where no permanent lighting is allowed (National Park Service National Night Skies Team {NPS NST}, Interim Guidance for Outdoor Lighting Zones, 2013). Additionally, LZ-3 and LZ-4 are by definition inappropriate for all NPS units, and LZ-2 has been determined to be inappropriate for Grand Canyon National Park given the pattern of nighttime use, expectations of the public, and the sensitivity of the resource.

The primary purpose of delineating lighting zones in a national park is to protect the natural lightscape to the greatest extent practical through the definition of desired conditions (or expectations) within each zone. Higher light intensity zones should be kept as small as possible or omitted in favor of zones that are more restrictive of outdoor lighting. Delineated zones should reflect the desired conditions of the area, not necessarily the existing ambient conditions (NPS NST 2013). Lighting Zones are best implemented when correlated with existing Management Zones and/or Park Areas (IDA-IES MLO 2011).

Delineation of lighting zones also helps park users transition between zones effectively. The human eye is slow to adapt to different lighting levels, especially in darker ambient environments often found in parks. Thus, zones should be delineated with common travel routes and activities in mind. Higher intensity zones should be restricted to just those areas where needed, but should not be so fragmented into islands that a visitor or employee is constantly transitioning between different lighting zones and consequently markedly different lighting levels (NPS NST 2013).

The zoning process should also be cognizant of proximity to wilderness areas (NPS NST 2013). For example, inner canyon wilderness may not be protected from light pollution if it is adjacent to a high intensity (i.e. brighter) lighting zone, such as the Desert View Developed Area, or the Yavapai Geology Museum.

Standards for environmental protection

Light trespass at each zone boundary should be controlled. Measurement of light trespass, in units of illuminance (lux), is relatively quick and easy, and standards for maximum light trespass at each zone boundary must be met to ensure environmental protection. Table xx lists these standards in milli-lux.

The total lumens installed and operated outdoors per unit area of development will be limited to a maximum amount for each zone. Even with full shielding, a significant amount of outdoor light escapes to the environment by reflection off surfaces. Limiting installed lumens per acre or lumens per square foot will limit environmental impact from escaped artificial light. These amounts are listed in Table xx for each zone.

Surface luminance limits?

Proposed Lighting Zones at Grand Canyon National Park:

Lighting Zone	Recommended Uses or Areas	Continuity of Illumination	Zoning Considerations
NDZ	A Naturally Dark Zone (NDZ) where no permanent lighting is allowed , providing the best possible protection of natural lightscapes. Humans are provided the best opportunity for dark adaptation and enjoyment of natural lightscapes. Nocturnal wildlife habitat is afforded maximum protection.	No illumination	This is the default lighting zone for undeveloped areas in parks and should cover the majority of land area in the park, specifically wilderness areas at GRCA. Temporary small portable lighting, i.e., flashlights and headlamps, allowed only where needed for human travel or work.
LZ00	A dark ambient environment with an absolute minimal level of lighting . Permanent artificial light fixtures exist only where critical for human safety or where mandated by codes, and are for discrete tasks only. Nighttime activities in this zone are oriented to darkness at night. There is minimal impact to human dark adaptation and enjoyment of a natural lightcape. There is minimal disruption of nocturnal wildlife habitat.	No continuity of lighting . Permanent lighting is utilized only at critical safety areas, and unlit areas predominate.	Lighting restricted to specific applications (i.e. egress lighting, steps). Preference for non-white light with good glare control and minimal brightness. Light timing controls will minimize light duration. This zone is recommended for developed campgrounds, inner canyon developed areas, and other areas located adjacent to sensitive habitats, such as parking areas with limited nighttime use, low use entrance stations, outdoor amphitheaters, remote employee residences, and administrative or maintenance facilities with infrequent nighttime activity.
LZ0	A dark ambient environment with a reasonably low level of lighting for basic human safety and basic park operations . Permanent artificial light fixtures exist only where necessary for safety, where mandated by codes, or where a discrete need is identified. Activities in this zone may require artificial light. There is an expectation among visitors and staff for minimal artificial illumination.	Lighting is largely discontinuous and within the zone there are substantial unlit areas. Some high use corridors may have continuous lighting.	This is the default lighting zone for developed areas in parks . Lighting is used for a variety of safety and operational needs. Lighting is apt to be limited to certain times with restrictions on intensity and lamp color. This zone is recommended for entrance stations open at night, outdoor interpretive displays frequented at night, administrative facilities with moderate nighttime activity, most visitor centers, most residential areas, and high visitor use areas adjacent to sensitive habitats.
LZ1	To provide a modest level of lighting to meet visitor expectations, safety concerns, and park operational needs in busy park environments. Permanent artificial lighting is used for general human safety consideration and in keeping with the historic/cultural landscape; lighting is not used for convenience. There is increased emphasis on color rendition thus white light is more apt to be used in this zone. There is a moderate impact to human dark adaptation and the experiencing of natural lightscapes within this	Lighting is largely continuous along corridors and somewhat uniform, but lighting is seldom operating throughout the night.	Most lighting applications permitted, but at illumination levels below typical suburban or residential practices. Examples include transportation stations and busy staging areas, areas of high vehicle-pedestrian conflict, dense visitor lodging areas, and highly congested areas within large national parks, with the exception that this zone should not be applied adjacent to, or where light trespass could stray into a sensitive habitat or wilderness area.

	zone. Likewise there may be an impact to nocturnal wildlife habitat, so thus this zone should generally not be applied adjacent to a sensitive environment.		
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(Table adapted from National Park Service National Night Skies Team Interim Guidance for Outdoor Lighting Zones, 2013)

NDZ is strongly recommended by the National Night Skies Team specifically for use in National Parks. LZ-00 is recommended to use where environmental sensitive is very high yet there is still a clear need for artificial illumination. LZ-0 and LZ-1 zones are recommended in the Joint IDA-IES Model Lighting Ordinance for use in developed areas in parks. LZ-1 in particular allows flexibility for lighting busy park environments, including parking lots, task areas, and retail business while minimizing light pollution.

Zones with higher lighting intensity (LZ-2, LZ-3, and LZ-4) are outlined in the Joint IDA-IES Model Lighting Ordinance for use in suburban or urban areas and are not appropriate for zoning inside a national park.

LZ-1 should be applied sparingly, given the park’s high elevation, varied topography, high ground albedo (high light reflectivity of desert, dry sand, dry soil, and snow as opposed to lower light reflectivity of vegetation and wet soil at other parks), proximity to wilderness and sensitive wildlife habitat, and potential for light trespass to remote areas within and without park boundaries. Even low ambient lighting within LZ-1 can have greater negative impact than similar lighting in other environments without these multiple considerations specific to Grand Canyon (Benya Burnett Consultancy, Grand Canyon National Park South Rim Visitor Center Lighting Concept Design – Summary Report, 2013).

There may be areas in the park in which existing lighting is at a higher intensity than LZ-1. These areas will be identified in the lighting inventory database and prioritized for light retrofit implementation.

Figure 1: Full Map of Grand Canyon National Park: General Location and Lighting Zones

[To come]

Figure 2: Lighting Zones in South Rim Village Developed Area

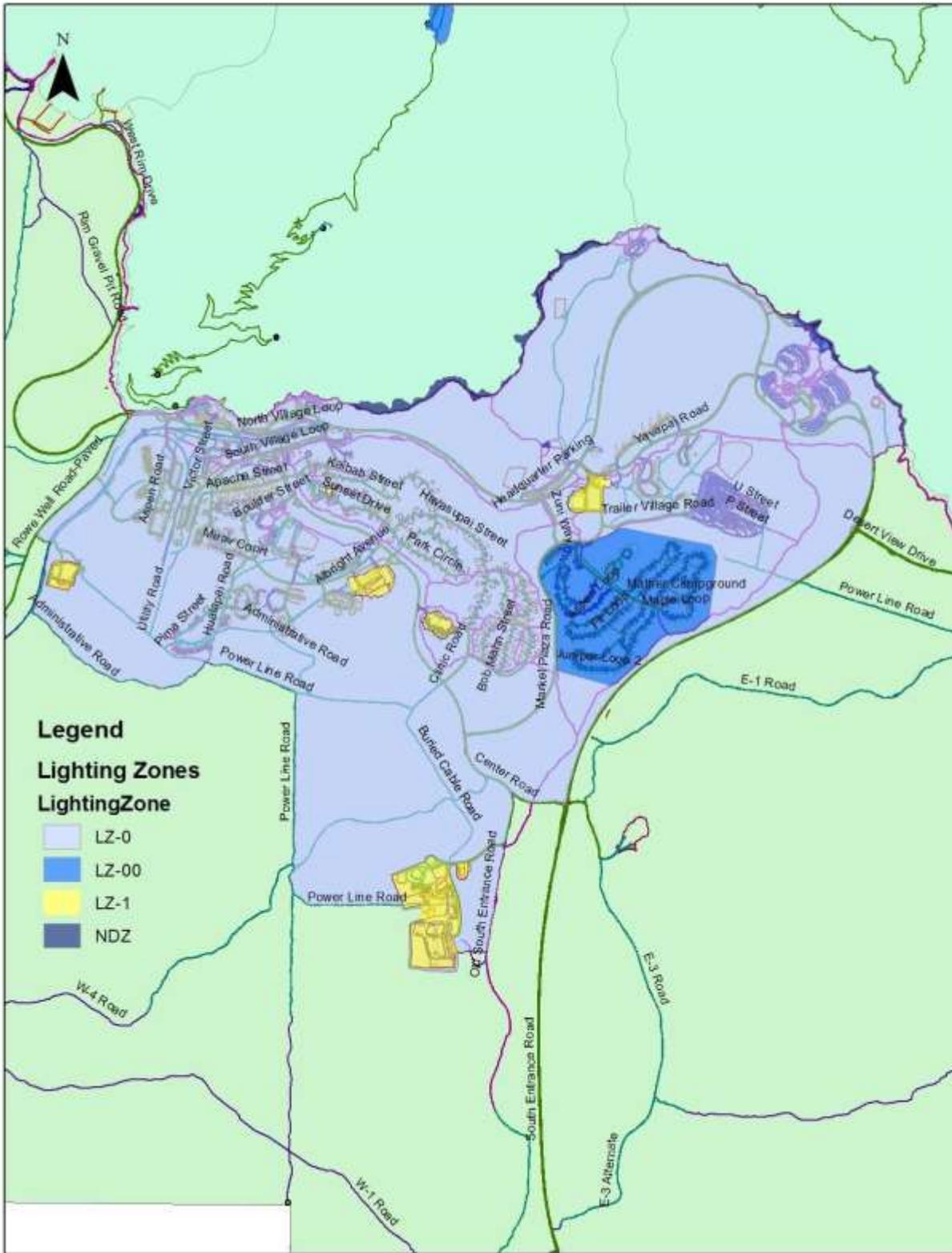


Figure 3: Lighting Zones in Desert View Developed Area

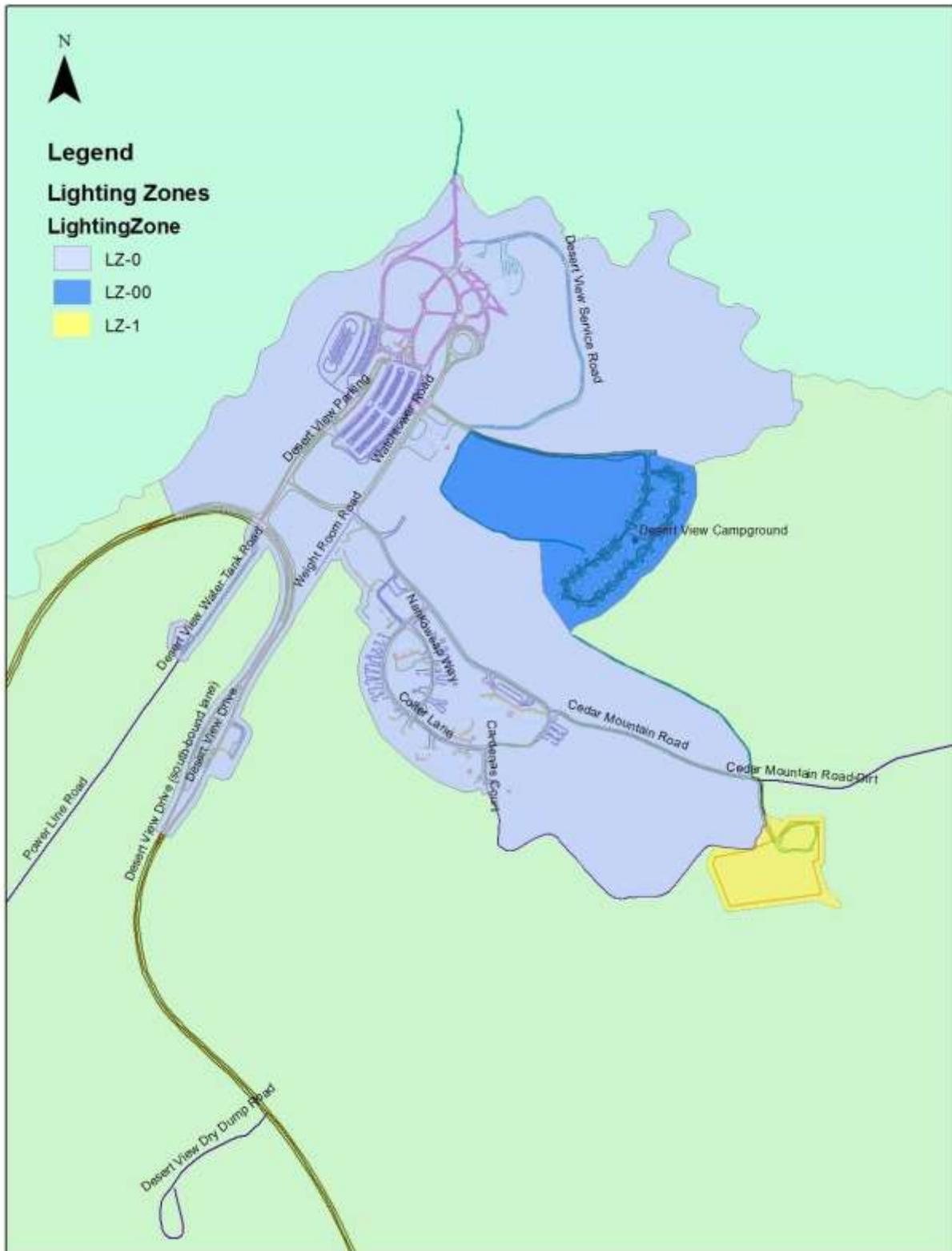
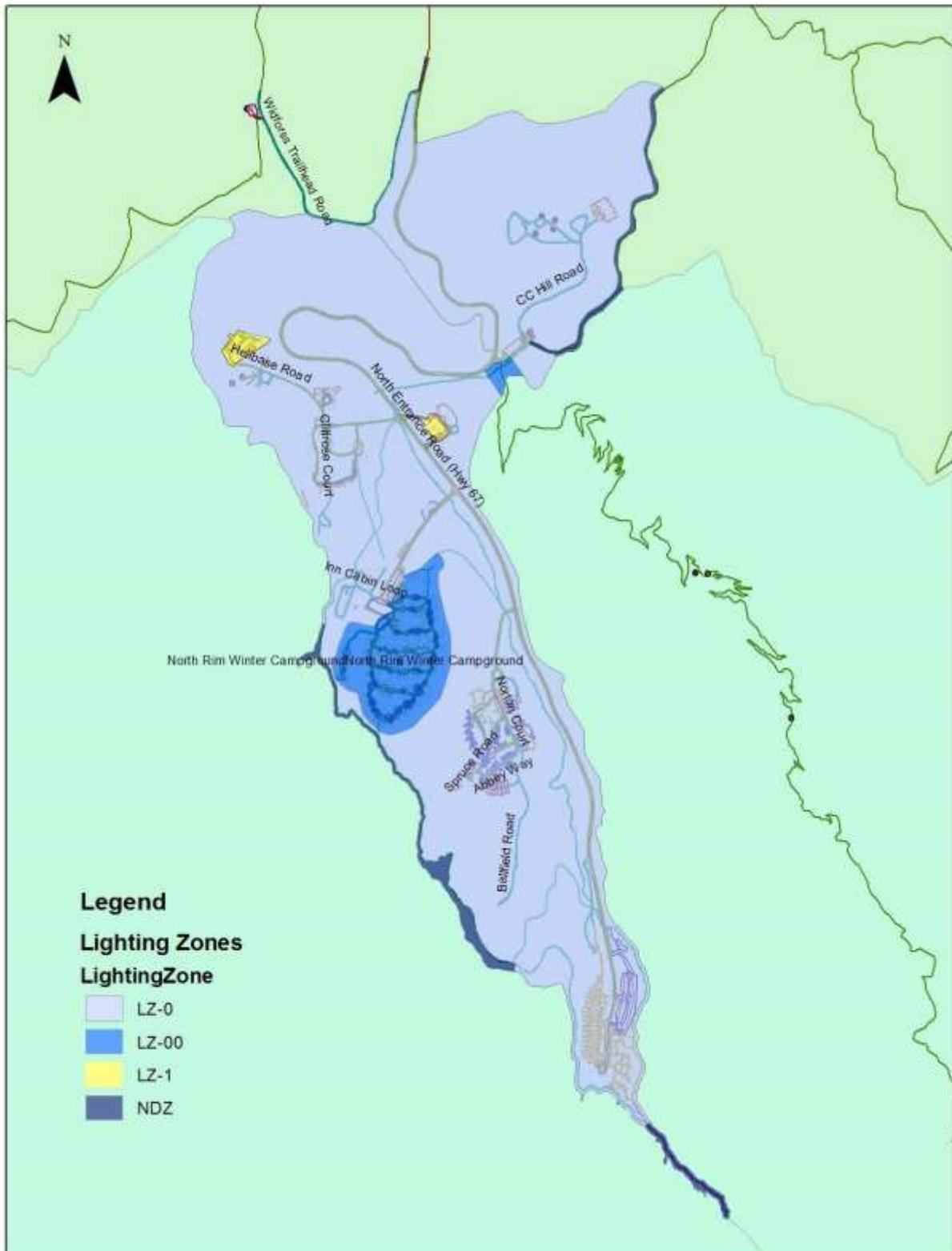


Figure 4: Lighting Zones in North Rim Developed Area



Residential Areas

All residences within park boundaries will be included in light fixture retrofit plans as appropriate in regards to the lighting zone. Enforcement of residential lighting compliance (i.e., light fixtures installed by residents, lights left on all night) will be primarily complaint driven. As with noise complaints that are based on a local noise ordinances, light complaints can be addressed based on a resident's lack of compliance with park lighting guidelines.

Interior lighting

These guidelines are intended to address primarily exterior lighting. However, interior lighting that is unshielded by blinds or other methods can create significant light pollution. One example on the South Rim is the El Tovar hotel room lights—curtains or blinds are provided but are not always used by guests. Another example is restrooms in campground areas, where bright interior light spills out of doors when opened. Large windows intended for viewing during the day (i.e., at the North Rim Lodge) can become huge lit reflectors at night creating light trespass into sensitive resource areas. This is often made worse by the fact that they are also locations for large chandeliers and other decorative lights. Lights in stairwells and on landings intended for egress safety may be over lit and remain on all night.

Choosing interior lighting fixtures will not be addressed in these guidelines. However, other mitigation options for minimizing light pollution from interior lighting are included in these guidelines, where appropriate.

Lighting Zone boundaries are shown in Figures 1 through 4. Descriptions of the areas included in each zone are as follows:

Naturally Dark Zone (NDZ)

All wilderness areas and minimally developed remote areas adjacent to wilderness areas, particularly along the canyon rim. Specifically (in addition to wilderness areas): Corridor Trails (i.e., North and South Kaibab, Bright Angel, and Hermit Trails), Desert View (East Rim) Drive (not including South Kaibab Trailhead and Desert View Developed Area), Shoshone Point, canyon rim trails on both South and North rims, Hermit Rest Road (not including Hermit's Rest area), Cape Royal and Point Imperial Roads and overlooks.

Lighting Zone 00 (LZ-00)

All campgrounds, including Corridor Management Zone campgrounds and Developed Area campgrounds, developed inner canyon areas adjacent to wilderness, and canyon rim areas with minimal nighttime use and/or use intended to allow for night sky appreciation (i.e., outdoor amphitheaters and some trailheads). Specifically: Roaring Springs, Tuweep, Hermit's Rest, Indian Garden, Phantom Ranch, Bright Angel Campground, Cottonwood Campground, Mather Campground, North Rim Campground, Desert View Campground, North Rim outdoor amphitheater (near the Campground), McKee Amphitheater, Mather Amphitheater, Mather Point, North Kaibab Trailhead, South Kaibab Trailheads.

Lighting Zone 0 (LZ-0)

This is the default zone for the developed areas in the park, including the Desert View, North and South Entrance Stations, and most of the North Rim, Desert View, and South Rim Developed Areas, including the Grand Canyon Visitor Center, and Yavapai Geology Museum.

Lighting Zone 1 (LZ-1)

High visitor use areas that are not adjacent to the Naturally Dark Zone, and maintenance operations requiring task lighting. Specifically: South Rim Village new Maintenance area, Helibase, Shuttle Bus Maintenance area, North Rim and South Rim Wastewater Treatment Plants, Trail Ops, Jail, Xanterra Fire and Security, Clinic/EMS buildings and parking lots, South Rim General Store/Bank/Post Office area, Yavapai Lodge main building, Concessions/GCA Warehouse and Receiving area.

LIGHTING GUIDELINES

How to Use These Guidelines

This chapter presents a step-by-step process for park electricians, planners, managers and architects to review existing and/or proposed lighting within the park. The guidelines emphasize multi-mitigation strategies to best achieve fully sustainable solutions. Adopting only one approach, such as shielding, is seldom adequate. The following mitigations must be reviewed sequentially and used in concert with one another. Specific targets (i.e., a specific light level or light color) will vary per zone, but all mitigations strategies should be evaluated in all zones where artificial lighting is permitted, according to the specific targets of each zone. They are, in order:

- I. Light only WHERE needed
- II. Light only WHEN needed
- III. SHIELD lights and direct them downward
- IV. Use the MINIMUM AMOUNT of light necessary
- V. Select lamps with WARMER COLORS
- VI. Select the most ENERGY EFFICIENT lamps and fixtures

(National Park Service National Night Skies Team {NPS NST}. Interim Guidance for Outdoor Lighting in National Parks, Version 0.6. DRAFT. Undated.)

Applicability and monitoring

- These mitigations are to be applied to all new and retrofitted lights.
- These guidelines have been written, and are expected, to conform to existing applicable codes. However, codes change and interpretations of codes occasionally vary among lighting experts. All applicable lighting and exit discharge lighting codes should be followed, including the International Building Code (IBC), the International Existing Building Code (IEBC), and the National Fire Protection Agency (NFPA) Life Safety Code and any other applicable codes or regulations specified by the NPS Denver Service Center Design Standards, available here: <http://www.nps.gov/dscw/dstandards.htm>
- An exterior lighting inventory is in progress and is expected to be completed by December 2014. This inventory will record spatial and tabular data for all lights in the park and will monitor compliance with these guidelines. A Standard Operating Procedure

(SOP) document will be finalized to document protocols for outdoor lighting inventory data collection and data management.

- Existing exterior lights will be evaluated for compliance with these mitigations based on inventory data that has been collected and evaluated. 90% of existing lights will be removed, retrofitted, or otherwise altered to be compliant with these guidelines within 5 years of approval of these guidelines. Plans will be made to subsequently bring 100% of the park's lights into compliance with this plan. These percentages and time frames are a standard requirement of achieving International Dark Sky Association (IDA) Dark Sky Park Status.
- This document is not intended to replace compliance procedures required or recommended by the Office of Planning and Compliance. All light retrofit or other changes will continue to require necessary compliance procedures, with the additional requirement that new or retrofitted exterior lighting should be compliant with these guidelines.
- Periodic monitoring of exterior lighting, using protocols established by the exterior lighting inventory, will be conducted during and after light retrofits to confirm compliance with these guidelines.
- Periodic informal monitoring of visibility of interior lights will be conducted to evaluate and prioritize management options for light pollution emitted by interior lighting.

Light only WHERE needed

First establish whether lighting is needed

Permanent outdoor lighting is a pollutant to be used judiciously for specific needs, following restrictions and guidance outlined in zoning. Other pollutants or potentially hazardous substances are similarly used minimally for human safety, such as chlorine in water treatment. Outdoor lighting generally will be restricted to “areas where security, basic human safety, and specific cultural requirements must be met” (National Park Service Management Policies, 2006, Section 4.10). Convenience, providing the feeling of increased security, and decorative lighting are insufficient reasons to warrant lighting at night in a national park.

Pursue alternatives first

Consider methods for providing safety other than permanent illumination. If the problem is lack of pathway visibility at night, determine if non-illumination solutions are adequate, such as painting curbs or steps, retroreflective markers, luminescent markers, using light colored pavement and surfaces, providing flashlights, trimming vegetation to minimize deep shadows, or smoothing out walkway tripping hazards. Signs and markers may be made visible with retro-reflective or photo-luminescent coating. When in doubt, choose the minimum impact solution to best achieve the NPS mission (NPS NST undated).

Naturally Dark Zone (NDZ)

No permanent exterior or interior light fixtures will be installed in the Naturally Dark Zone. Note that some permanent structures with windows may be installed in this zone (i.e., composting toilets), and these structures should not contain interior lighting.

Lighting Zones 00, 0 and 1 (LZ-00, LZ-0, and LZ-1)

For most human activities in the park outside the NDZ, the recommended lighting application is listed in Table 1 at the end of this section titled “Lighting Applications and Light Levels by Zone.” Other applications not addressed in this table should be weighed carefully. **Do not assume that lighting is always needed.**

Exceptions:

In addition to the guidance in Table 1 the following guidelines and exceptions will apply in all zones outside the NDZ.

RVs and trailers

RVs and trailers in employee residential areas will be subject to the same guidelines as permanent structures in the zone where they are located. This refers specifically to trailers and RVs at residential developed areas (i.e., Trailer Village, Pinyon Park, Norton Court trailers, and all other employee residential trailer sites at North Rim, South Rim, or Desert View developed areas).

Park staff should explore options for educating visitors in RVs and trailers at campgrounds in developed areas (specifically North Rim, Mather and Desert View Campgrounds) regarding park lighting guidelines, including take-home information to assist visitors in improving lighting in their hometowns. Tying “dark hours” to existing “quiet hours” can be effective in retaining the desired lightscape characteristics. Other long-term solutions should be pursued. Many campground visitors often expect the park to provide darker conditions at campgrounds than at other park areas to allow for night sky appreciation, and even a small amount of light pollution from a small number of visitors can damage this opportunity for other camping visitors.

Much of the mitigation of RV and trailer light pollution, whether in employee residential or visitor campground areas, will be complaint driven, based on park guidelines or ordinances, as are noise complaints.

Decorative or architectural lighting

No lighting that exists solely for decorative or architectural purpose will be permitted in any zone, with few exceptions, detailed below.

Seasonal lighting

Seasonal decorations using typical low-wattage unshielded bulbs are permitted on buildings in LZ-0 and LZ-1 from November 15th through January 15th (Flagstaff Zoning Code). Seasonal decorative lights will not be permitted in developed campgrounds, which are intended to allow for a more natural experience of the night sky.

Solar garden lights

Temporary small solar-powered lights (sometimes colloquially called solar garden lights or landscape lights) of approximately 50 lumens or less per fixture may be used to illuminate walkways or driveways in LZ-0, and LZ-1 (Flagstaff Zoning Code). These lights will not be

permitted in the NDZ or in LZ-00 and are not to be used for decorative purposes but rather along driveways, walkways, or uneven pathways for wayfinding and illuminating tripping hazards. Fifty lumens is approximately a 1.0 watt LED bulb or a 5 watt incandescent bulb, and these lights have typically a lower output of 0.3 to 0.5 watt LED lights. Multiple fixtures of this type should not exceed 500 lumens per site (i.e., the area associated with a single structure or infrastructure element), which will be approximately 10-20 lights depending on each light's lumen output.

Example of solar garden lights follows. Note that light spacing in these images is NOT the spacing that would be recommended by these lighting guidelines, rather these images are to identify the type of fixture meant by the term solar garden lights.



Flagpoles

It is standard practice for flags at some inner canyon ranger stations, specifically Phantom Ranch, Indian Garden, and Tuweep, and also at some entrance stations, to remain lit overnight for visitor wayfinding and ranger station identification. hikers with emergencies to be able to more easily locate the ranger station. Flags raised at other flagpoles should, when possible, be taken down overnight instead of lit. In any case where flags will be lit overnight, all guidelines for lighting in that zone will be applied to the flagpole light (NPS NST undated).

Historic light fixtures

If illumination from a historic light is determined to be necessary, but the fixture is not compliant with these guidelines, potential solutions include changing the bulb type, or reducing the light level. Turning off the light permanently by eliminating the electrical connection, provided alternate lighting can be installed, is another option for areas that require illumination currently provided by a historical light. (NPS NST undated).

Emergency lighting

Temporary emergency lighting is exempt from lighting guidelines, with the restriction that whoever is the onsite leader of that emergency is responsible for turning lights off and/or returning them to their usual method of control when there is no longer an emergency.

Light only WHEN needed

Proposed light curfew

After it is determined that illumination is needed for a specific reason at a location, that illumination should only be used WHEN it is needed. Many lights within park boundaries can be subject to a proposed 10pm to 6am curfew when lights should be extinguished or, if light is truly needed overnight and dimming controls have been installed, dimmed by at least 30%.

Alternately lights should be extinguished or dimmed when not in use, if hours of non-use are different than the curfew hours. (IDA-IES MLO, 2011) (Dick, Robert. Guidelines for Outdoor Lighting in RASC Dark-sky Preserves and IDA Dark Sky Places, 2012) (Chaco Culture National Historic Park Outdoor Lighting Guidelines, 2013) (Death Valley National Park Guidance for Outdoor Lighting, 2012)

Exceptions to the proposed light curfew

- Residential buildings will be encouraged to turn off exterior lights during curfew hours. Residents may want to leave exterior lights on during curfew hours for multiple reasons, such as leaving for or returning from work or recreational activities, expecting guests, using outdoor space, etc., and residents are left to their discretion when choosing to leave exterior lights on for specific purposes. However, residential lights should not be left on overnight all night every night without a specific purpose.
- Businesses open 24 hours or during curfew hours (i.e., hotels and lodges), though these businesses will be encouraged to dim their lights if feasible during curfew hours.
- Code requirements for 24- hour lighting.
- Illumination for athletic events, i.e., at a school athletic field: events shall be scheduled for completion by 8:45pm, and lighting shall be turned off by 9pm unless the event carries beyond its originally scheduled time of completion.

Interior lights

Interior lighting should be turned off when inside areas are not being used. If possible, interior areas with large windows facing wilderness or the Naturally Dark Zone should not be used after dark. If this is not possible, blinds or another blocking alternative should be installed and used, or different illumination levels for day and night should be considered.

Light controls:

Light controls should be provided for each light. Light controls will ensure that each light is 1) turned off when sufficient daylight is available; 2) turned on only when there is inadequate daylight; 3) turned on only when it is needed; and 4) turned off or dimmed after high use activities have subsided. Dusk-to-dawn lighting using a photocell alone is rarely necessary and should be evaluated on a case by case basis. Any lights determined to be necessary dusk-to-dawn must be dimmed or subject to motion sensors during the proposed curfew period (NST NPS undated). All light fixtures should have full manual override (i.e., manual switches or an override option in a timer). Manual timers are discouraged given that they may need regular reprogramming due to seasonal changes and frequent power interruptions at the park.

Astronomical timers

Astronomical timers are specifically recommended when feasible to combine controls for seasonal changes in sunset/sunrise with a clock timer. These devices can be programmed for different operation during busy seasons or weekend operations (NPS NST undated). The flexibility and features of astronomical timers in particular allow for lights to be on only when needed, thus saving lamp life, and eliminating the need to be reset for seasonal changes or frequent power outages, thus reducing park staff time managing light control. Astronomical timers can also guarantee lights are regularly on at appropriate times without requiring reprogramming, better protecting visitor and employee safety for illuminating tripping or other hazards. Initial cost of quality astronomical timers is offset by having energy efficient, well-run facilities, reduced staff time devoted to light control, and reduced light replacement due to increased lamp life. Other automatic timers and smart lighting controls can be investigated and used when appropriate. Photocells in combination with timers to achieve a similar result to astronomical timers may also be appropriate. As with all equipment purchases, evaluating features, equipment durability and performance, user reviews, and methods for making instructions available to appropriate staff, should precede purchasing and implementing smart lighting controls.

Motion sensors

Motion sensors may not always be the best solution for reducing light pollution. Motion sensors must be sensitive to the difference between humans and abundant wildlife at the park. The intermittent on and off lighting may be more disruptive to humans and wildlife than a constant low level of lighting. Dimming lights to a very low light level for a predetermined amount of time during lower use levels, i.e., 8pm to 10pm or during proposed curfew hours, may be a better solution than using a motion sensor during that time, and should be evaluated on a case by case basis.

SHIELD lights and direct them downward

Shielding is a very effective mitigation; a fully shielded light typically produces 1/10th as much sky glow as an unshielded globe, and substantially less glare. Limiting glare allows for the use of less illumination for the same amount of visual performance. Reduced glare also allows people to dark-adapt more quickly and gives people a sense of “good lighting” even though actual illumination levels are far less than what they may be accustomed to (NPS NST undated).

Exterior lighting fixtures should at minimum be shielded so that no light is cast upward. The engineering term for this is “full cut-off”, also known as “fully shielded.” Fixtures described as “cut-off” or “semi cut-off” or “partially shielded” should not be used (NPS NST undated). Luminaires equipped with adjustable mounting devices, permitting alteration of luminaire aiming in the field, are not permitted (IDA-IES MLO 2011).

Naturally Dark Zone (NDZ)

Permanent artificial lighting from any other park zones should not be visible from within the NDZ. Given the widely varying topography at GRCA, full cut-off fixtures may not be sufficient to prevent light trespass from other lighting zones into the NDZ.

Viewshed Analysis

Consult the viewshed analysis map[s] in Figure[s ___] below to evaluate if a proposed light is in a location and/or at a height where it is likely to be visible in the NDZ. [Viewshed analysis maps to come.] If possible, position a test light and an observer to confirm whether or not the proposed light would be visible in the NDZ. If a light is confirmed to be visible, or likely to be visible in the NDZ, additional shielding and/or a custom shielding solution must be applied to the fixture so it is not visible in the NDZ. If additional or custom shielding is not possible, the light should not be installed.

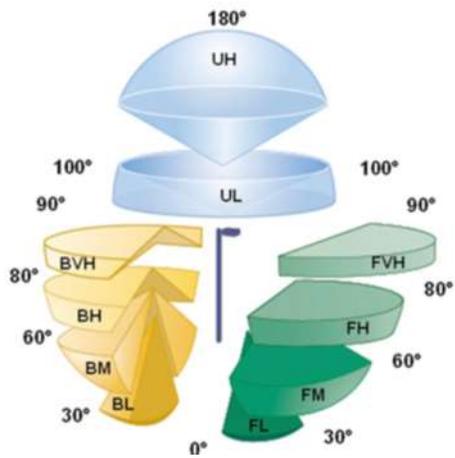
Viewshed analysis, in combination with the park's lighting inventory, can also be used to identify existing lights that are likely to be visible in the NDZ, and specifically where those lights are likely to be visible. Anecdotal reports have identified some of these lights. It may be possible to work with backcountry hikers or river runners to confirm whether or not additional lights identified by viewshed analysis are visible in the NDZ. This combination of viewshed analysis and observations will inform light retrofit plans for altering, removing, or restricting usage fixtures visible in wilderness areas.

Interior lights

Blinds, shades, curtains, window tinting, or other forms of minimizing light spread from interior spaces should be used where possible to reduce light trespass into the outdoor environment. Blinds should be provided in all park housing, and residents will be encouraged as part of the housing policy to close their blinds at night when interior lights are on. Park staff will work with concessionaires to encourage visitors to close blinds, curtains, or other window coverings after sunset (where available), and to establish feasibility of installing window coverings or tinting if necessary.

“BUG” Ratings for exterior lighting

The Illuminating Engineering Society Technical Manual 15, “Luminaire Classification System for Outdoor Luminaires,” recommends evaluating fixtures based on three factors: Backlight, Uplight, and Glare (also called BUG ratings). BUG ratings are available from some light manufacturers based on photometric testing of the light fixture. These ratings include a letter and number. The letter will indicate the type of feature being rated: B for backlight, U for Uplight, and G for Glare. The number will correspond to a specific photometric reading from the light fixture that has been defined by the IES and is thus consistent among manufacturers. The use of these ratings is relatively recent as of the writing of these guidelines. If it is available, it will be included on the packaging of a light fixture or in specifications from a manufacturer. It is expected that these ratings will be available for an increasing number of light fixtures in the future, but they will not likely be available for all fixtures as of the writing of these guidelines. If BUG ratings are not available, the following guidance will assist in choosing lights using similar criteria. (Illumination Engineering Society Technical Memorandum 15-11, Luminaire Classification System for Outdoor Luminaires, 2011) (IDA-IES MLO 2011)



- UH: Uplight High
- UL: Uplight
- BVH: Backlight Very High (included in Glare)
- BH: Backlight High (included in Glare)
- BM: Backlight Medium
- BL: Backlight Low
- FVH: Frontlight Very High (included in Glare)
- FH: Frontlight High (included in Glare)
- FM: Frontlight Medium
- FL: Fronlight Low

Backlight (Yellow area in diagram labeled BVH, BH, BM and BL)

Backlight ratings will not always be useful for evaluating light trespass potential at Grand Canyon National Park. Backlight ratings are intended to measure light thrown behind the light and potentially outside the area intended to be lit and potentially trespassing onto neighboring properties. Throughout much of the park, lighting for safety includes illuminating for proximity of large animals, elk in particular. Rather than minimizing a light’s directional backlight according to property, roadway, or pathway boundaries as is recommended for many urban or suburban areas, it may be preferable to maximize the light spread to illuminate areas to the side of a pathway or roadway where large animals may be present.

Light trespass into wilderness areas or sensitive wildlife habitats, specifically the Naturally Dark Zone, can vary dramatically depending on light location and nearby topography. Backlight ratings might be useful depending on the light locations, but they will not always be sufficient for evaluating exactly where light trespass will occur given the widely varying topography at Grand Canyon. Spatial viewshed analysis should be consulted to evaluate the extent of light trespass.

That said, there will be occasions where backlight ratings will be a useful measure, for instance, in wall-mounted lighting, where light spread back onto the wall is both wasteful

and has the potential to create a hot spot with glare on the wall. Wall mounted lighting, or lighting at other locations where a backlight rating should be used, should have a Backlight rating of B0 (Backlight - Zero).

Uplight (Blue area in diagram, labeled UH and UL)

Uplight ratings evaluate light shining above a 90 degree angle. If a BUG rating is available from a manufacturer, an Uplight rating of U0 (Uplight - Zero) is equivalent to using a full cut-off (also called a fully shielded) light fixture. All new or retrofitted lights for which an uplight rating is available should have an Uplight rating of U0 (U - Zero), with exceptions as noted below. (NPS NST undated) Lights that emit no light above the horizontal, functionally the same as a U0, can be used when Uplight rating is not available.

Historic fixtures are often unshielded. Any potential changes to historic fixtures should be done in consultation with appropriate park staff, specifically a historic architect or cultural resource specialist. In some cases it may be determined that it is possible to retrofit the fixture with a fully shielded fixture that is congruent in design to the historic fixture. If it is determined that retrofitting historical fixtures is not possible due to cultural considerations, bulb brightness in these fixtures must be drastically reduced to minimize glare. Specifically these bulbs should 1) produce no more than 300 lumens (approximately the light emitted by a 40 watt incandescent bulb), unless code restrictions (i.e., National Fire Code Egress requirements) require more light and 2) should be off whenever possible, in particular between the hours of 10pm and 6am. In addition, any historic unshielded fixtures should be diffused if possible (i.e., using translucent glass instead of transparent glass), if diffusion is consistent with historical or cultural considerations, to be determined by consultation with appropriate park historic or cultural specialists.

Very low level marker lighting (i.e, LEDs embedded in pathways or roadways) may, in some locations, be preferable to other lighting options. These, by definition, cannot be shielded, but may create a far lower overall impact in light pollution than other lighting options, such as pole lighting or bollards. These lights should not emit more than 50 lumens per fixture (approximately the light emitted by an 0.3 watt LED or 3 watt incandescent lamp)

Glare (Upper portions of yellow and green areas in diagram, labeled BVH, BH, FVH, FH)

Glare ratings will be the most useful part of BUG ratings when evaluating lights for the park. Glare ratings measure the light emitted from a fixture between the 60 and 90 degree angle below the horizontal. The light bulb must be adequately recessed inside the fixture edges and the fixture designed to reduce or eliminate light emitted from the fixture between 60 and 90 degrees below the 90 degree horizontal mark. This specification restricts sideways light more than a fixture with an Uplight rating of zero (also known as a full cut-off or fully shielded fixture.) When BUG ratings are available from the light fixture manufacturer, all new or retrofitted lights should have a G0 (Glare – Zero) rating. This rating divides the area with Glare potential into two sections, so that 10 lumens of light can be emitted by the fixture between the 80 to 90 degree section, and no more than approximately 600 lumens may be emitted between the 60 and 80 degree section.

Glare from LED lights can be particularly noticeable because LED emitters are very directional. Ideally LED emitters should not be visible from normal standing height near any LED lights.

Summary

Using IES BUG ratings when available from the manufacturer, always using light fixtures that are at minimum fully shielded, light trespass beyond the intended area of use must be eliminated by custom modification if necessary, regardless of the zone in which the light is located.

Use the MINIMUM AMOUNT of light necessary

Light emitted from any fixture only spreads a certain distance; beyond that it is dark. The brighter the light emitted from a fixture, the darker the darkness around it will seem. In a park environment with a substantial amount of unlit areas, it is safer to maintain a generally low level of lighting to allow quicker and safer dark adaptation than to allow overly bright light levels that limit dark adaptation. Successfully implementing low illumination levels also requires good control of glare, which is primarily achieved through shielding. Transitions of lower to higher intensity lighting, and vice versa, will also assist in creating the safest situation for users as it allows the eye to adapt gradually. (NPS NST undated)

In addition, parks are sensitive environments, and because there is no amount of lighting completely free of environmental impacts, resource protection additionally dictates that the minimum amount of light be applied to meet the task. It is common in parks to apply substantially lower illumination than is typically recommended in urban environments; 250-500 lumens is an ideal brightness for a wide variety of park lighting applications (roughly equivalent to a 7 watt CFL or 5 watt LED). (NPS NST undated)

The lumen output of individual light fixtures should also be kept in perspective with the mounting height. Higher mounting heights often require less fixtures, but higher lumen output; while lower mounting heights, especially bollard (i.e. post) lighting the opposite is true. Using too bright of a fixture in a low mounting height will create a very bright “hot spot” on the ground surface. This will skew the range of brightness values perceived by the eye, resulting in glare and a poor adaptation level. Thus there is a desire, both from the human need perspective and the environmental perspective, to have relatively uniform lighting when lighting is required and to avoid hot spot and large jumps in illumination level.

Uniformity can be calculated as the ratio between the maximum light level in an area and the average light level throughout the same area. In areas where relatively consistent light is important (i.e., at ADA accessible parking locations), the uniformity ratio should be kept small in order to ensure a consistent overall spread of light. There are some tasks and applications where uniformity is important, while other situations, such as pathway illumination, where uniformity is far less important or often not desirable.

Lighting levels for specific applications in each park Lighting Zone are available in Table 1, titled “Lighting Applications and Light Levels by Zone.”

Light designs should include calculations to confirm performance to recommended light levels using modern computer lighting programs (Yosemite 2011) (IDA-IES MLO 2011). When this is not possible, test existing or proposed lights with a light meter.

Select lamps with WARMER COLORS

The color tint of white light is often measured in Kelvins (K), a scale in which warm-toned white light has smaller values (1800-3000K) and cold-toned light has larger values (5000K and higher) (Yosemite 2011). Cooler white light can provide better visual acuity, color rendition, and performance in many situations, but often has a disproportionately high impact upon human dark adaptation, nocturnal wildlife, and ecosystem function [note]. Because of this greater impact, white light should be used only in certain specific locations where color rendering is essential to cultural values or human safety, otherwise lamps with a warmer tone (i.e., those that are yellowish, amber, or red) should be used to minimize off-site aesthetic and environmental impacts and preserve human eye dark adaptation. Lighting should be \leq (less than or equal to) 3500° Kelvin when color rendition is critical to the task, and \leq 2500° Kelvin otherwise (NPS NST undated). Lighting with color temperature \leq 2500° Kelvin will reduce glare, reduce insect attractions, minimize impact to human dark adaptation, and minimize ecological effects. Narrowband amber LED is the preferred outdoor lighting color in natural areas.

Ultraviolet (UV) light is also disruptive to biological systems and should be minimized when possible, particularly in LZ-00 and LZ-0. Insects are attracted to both blue light and UV light (NPS NST undated, RASC)

Narrow Spectrum Amber LED, Low Pressure Sodium (LPS), blue-filtered LED, or yellow CFLs with color temperatures \leq 2500° Kelvin are the preferred type of bulb in locations where general illumination for safety or security is the primary concern and color rendition for tasks is not necessary, specifically:

- Pedestrian walkways and driveways
- Parking lots
- Outdoor security
- Residential or low to medium use egress

(Flagstaff Zoning Code)

Warm White LED or Warm White CFLs (\leq 3500K) are the preferred type of bulb in locations where color rendition is required to preserve the effectiveness of an activity, specifically:

- High use public building egress where historic cultural values are important
- Outdoor maintenance or repair areas where maintenance or repair work may be necessary on a regularly scheduled, task specific (i.e., boat de-rigging), or emergency basis.
- Sign or exhibit lighting
- Outdoor recreational and athletic field areas
- Outdoor seating areas
- Service Station canopies
-

(Flagstaff Zoning Code)

No white lights above 2500K should be illuminated continuously from dusk to dawn; instead they should have timers, switches, motion sensors, or other means of limiting the amount of time they are illuminated.

Use the most ENERGY EFFICIENT lamps and fixtures

Select lamps that provide the greatest luminous efficacy in lumens per watt, after giving consideration to other design constraints and objectives. Luminous efficacy should not trump environmental protection standards in Zones 00 and 0, however, or in protecting the Naturally Dark Zone. Also consider the fixture efficiency and application of light. The most energy savings can be gained by electing not to install the light in the first place, by operating it for a limited amount of time, by reducing the amount of light to the minimum necessary, and by preventing stray light and directing the light only at the intended task. Luminaire efficiency ratings combine the efficiency of the fixture, the lamp, and the lamp ballast or LED driver. Some fixtures, especially historic fixtures, decorative fixtures, and older designs have efficiencies as low as 25%, so that 75% of the light never makes it to the intended target. (NPS NST undated)

Energy efficiency is mandated by Executive Order 13423 and 13514, and is critical in reducing the NPS carbon footprint. It is probable that the park can reduce outdoor lighting energy use by over 80% using these multiple mitigations. Some parks have even reached 98% energy savings (using only 2% as much electricity) by mitigating the impacts of outdoor lighting through multiple strategies. (NPS NSNS undated)

Other considerations

Shuttle bus and car headlights

The location of overlooks on Hermit Road and the East Rim Drive are such that shuttle bus and car headlights may occasionally be seen from large areas within the inner canyon Naturally Dark Zone. Light impact from vehicles has not frequently been addressed in other park's lighting guidelines. Bus and car headlights are necessary for moving vehicles and cannot be managed in the same manner as permanent exterior lighting. That said, light pollution from moving vehicles may, in some locations, be higher than the light allowed for permanent lighting for the zone of a particular area (such as Hermit Road). The impact of shuttle bus and car headlights shining into the Naturally Dark Zone can be significant. Potential mitigations for this issue should be explored. Examples include educating and encouraging visitors to turn off vehicle lights when parked at overlooks and to use regular headlights (not high beams) when entering or exiting park overlooks, or to explore adding native vegetation where possible to shield or minimize vehicle light trespass into the Naturally Dark Zone.

Portable lights, including headlamps

Temporary small portable lighting, i.e., flashlights, lanterns and headlamps, may be necessary for human travel, tasks, or work in areas in lighting zones that would otherwise have minimal or no artificial lighting. Portable lights with high lumen ratings that may be appropriate for some

applications (i.e., caving or bicycling) are not necessary or appropriate for most uses in a park environment. Brighter headlamps will interfere with human dark adaptation and will make it more difficult to see outside the headlamp's light spread than when using either red light or a low (50-100 lumen) headlamp setting.

Best management practices for park staff working with and in the backcountry include:

- Educating visitors regarding portable light use in public park documents where possible, e.g., The Guide, Trip Planner, Backcountry Permits, inner canyon and trailhead kiosks, etc.; use information from this SOP for guidance in consultation with the park's Backcountry Working Group.
- Practicing and encouraging responsible portable light use, specifically that when stationary or in a campground portable light use should be 1) used in red lamp mode; 2) if red lamp mode is not available, on the lowest illumination setting available 3) held whenever possible by hand or around the neck and not around the head. Portable light use in all campgrounds should be limited between the hours of 10pm and 6am to task required lighting only.
- Allowing exceptions to the above guidance for portable light use for hiking or other mobile activity at night in rough and/or unfamiliar terrain (including Corridor trails) OR unless hands-free use and more light is needed temporarily for safety, i.e., setting up camp stove, cooking, cleaning up food, setting up or taking down a tent. Excessively bright headlamp and flashlight use is in particular damaging to other visitors and staff toward which the light is directed.
- Exploring longer term options for requiring visitors to comply with these best practices for portable lighting, including the possibility of instituting portable light lumen limits or recommendations in the Naturally Dark Zone and LZ-00.
- Campfires, including social and cooking fires, are not considered artificial or portable lighting for the purposes of these guidelines.

Historic landscapes and structures

Cultural landscapes, historic buildings, structures, small-scale landscape features, and districts can be significant to the history of a National Park. These property types are often listed or eligible for listing on the National Register of Historic Places. NPS management practices require us to manage such resources in a way that retains their historic character through preservation. Such places reflect the history of park development, architectural trends of the past, National Park Service initiatives, community planning, and other important aspects of our history. Providing lightning necessary for safety within historic districts and cultural landscape areas and on individual buildings and structures will require careful planning and considerations to preserve the characters that make historic properties eligible for the National Register. Working with these kinds of properties may result in additional expenses related to lighting needs that must be considered early on in the planning process.

Light maintenance and park environment

- Long term sustainability in the operation and maintenance of outdoor lighting solutions should be maximized. The total lifecycle cost should be weighed in a sustainability assessment. For instance, staff time required to change light bulbs that require frequent replacement should be weighed against the cost of a fixture or bulb that requires less frequent replacement.
- For lamps with replaceable bulbs, bulbs and bulb ballasts will be standardized to ensure appropriate light level, color, quality, and ease of replacement.
- Unnecessary light fixtures will be removed, relocated, or, in the case of historical fixtures, disconnected from an electrical source and left in place.
- Park locations experience extremes of temperature, elevation, and exposure. As a result, light sources must be suitable for all expected operating conditions. Lights, bulbs, and related equipment must be rated for extreme weather conditions, i.e., heat and cold, dryness, thunderstorms, blizzards, etc.

Snow Accumulation and Clearing

Design lighting with consideration for snow removal. Assume that mechanized equipment will be used. Locating lighting away from pavement is essential. Use taller lighting equipment to permit lighting to remain effective in heavy snowfall (Yosemite 2011).

Pedestrians and Bicycles

Design lighting in consideration of the park's use by pedestrians and bicycles. Snowmobiles may also be used on the North Rim. Particularly avoid light fixtures and poles that will be prone to damage or causing injury, such as bollard lights near pathways (Yosemite 2011). Pedestrians should be encouraged to wear light colored or reflective clothing when walking along or crossing roadways.

[Visual flowchart to come to simplify identifying the zoning and guidelines.]

**Table 1:
Lighting Applications and Light Levels by Zone**

This table is not a prescription to light all areas to the maximum light level, but guidelines for average and maximum light values only after alternatives to lighting have been considered and it is determined that illumination is necessary.

Light levels are expressed in footcandles. Multiply by 10 for lux. Area lighting designs should include computer printouts of projected illumination levels, demonstrating compliance with these guidelines. Footcandles are standard measurements used by lighting designers, and can be measured with an illuminance meter. If footcandle (or lux) measurements are not possible, see Appendix A for fixture and bulb recommendations for specific applications. See the Definitions and Acronyms section for details about terms used in this table.

[note- there is a lot that can be done with motion sensor or pedestrian-switched lighting, flashing or other warning lights when pedestrians are present, etc other than lighting. I think it is important to mention those here.

Application	LZ-00	LZ-0		LZ-1	
	Light Level and Uniformity same as LZ-unless noted otherwise	Where and When	Light Level and Uniformity	Where and When	Light Level and Uniformity
Roads posted 25mph or less	Where: High Pedestrian conflict areas When: on during high use or 24 hours, extinguished or dimmed during curfew hours	Where: High pedestrian conflict areas When: on 24 hours, dimmed during curfew hours	Light level: Avg 0.05 fc, Max: 0.3 fc Uniformity 6:1	Where: High Pedestrian conflict areas When: on 24 hours, consider motion control	Light level: Avg 0.2 fc, Max: 1.5 Uniformity 6:1
Roads posted >25mph	Where: High Pedestrian conflict areas When: on during high use or 24 hours, dimmed during curfew hours	Where: High pedestrian conflict areas When: on 24 hours, dimmed during curfew hours	Light level: Avg 0.05 fc, Max: 0.3 fc Uniformity 6:1	Where: Some intersections and High pedestrian conflict areas When: 24 hours	Light level: Avg 0.2 fc, Max: 1.5 fc Uniformity 6:1
Parking Lot – ADA accessible	Where: limited to portions of lots marked for ADA accessible use (if any) and requiring night access, including ramps to adjacent buildings and/or walkways When: extinguish or dim lights after use hours	Where: limited to portions of lots marked for ADA accessible use, if any, and requiring night access, including ramps to adjacent buildings and/or walkways When: dim lights after use hours	Light level: Avg 0.5 fc Max: 2.5 fc Uniformity 4:1 Put curfew hours light level in this cell, and express at FC, not as percentage.	Same as LZ-0	Same as LZ-0
Parking Lot – High Night Activity	N/A	Where: Minimal lighting, illumination for some of the lot, drives and surrounding walkways, but not necessarily uniform When: shut off after use hours	Light level: Avg 0.05 fc, Max: 1.0 fc Uniformity 10:1	Where: Uniform illumination for the entire lot, driveways and walkways. When: Shut off or dim after use hours and during curfew hours	Light level: Avg 0.1 fc Max: 1.0 Uniformity 4:1
Parking Lot – Moderate Night Activity	N/A	Where: Minimal lighting, illumination for some of the lot, drives and surrounding	Light level: Avg 0.05 fc, Max: 1.0 fc Uniformity 10:1	Where: Minimal lighting, illumination for some of the lot, drives and surrounding	Light level: Avg 0.05 fc, Max: 1.0 fc Uniformity 10:1

		walkways, but not necessarily uniform When: shut off after use hours		walkways, but not necessarily uniform When: shut off after use hours	
Parking Lot – Low Night Activity	Little or no lighting When: shut off after use hours	Where: Little or no lighting When: shut off after use hours	Light level: Avg 0.01 fc, Max: 0.05 fc (Benya, 2013) Non-uniform lighting acceptable	Where: Little or no lighting When: shut off after use hours	Light level: Avg 0.01 fc Max: 0.05fc (Benya, 2013) Non-uniform lighting acceptable
Walkways and Bikeways – High Night Activity including ADA accessible walkways with night use	N/A	Where: Relatively uniform lighting for walkways and bikeways near ADA areas or where curbs or other hazards exist near or along walkway. Otherwise only guidance lighting and not uniform path illumination. When: dim lighting during curfew hours	Light level: Avg 0.05 fc Max 0.5 fc Uniformity 8:1	Where: Relatively uniform lighting for walkways and bikeways near ADA areas or where curbs or other hazards exist near or along walkway. Otherwise only guidance lighting and not uniform path illumination. When: dim lighting during curfew hours	Light level: Avg 0.1 fc, Max: 1.0 fc Uniformity 8:1
Walkways and Bikeways – Medium Night Activity	N/A	Where: Minimal for main and secondary walkways, not necessarily uniform, or intersections only When: shut off or dim lighting during curfew hours	Light level: Avg 0.05 fc, Max: 0.5 fc Uniformity 12:1	Where: Minimal for main and secondary walkways, not necessarily uniform. Or intersections only When: shut off or dim lighting during curfew hours	Light level: Avg 0.05 fc, Max: 0.5 fc Uniformity 12:1
Walkways and Bikeways – Low Night Activity	Where: Lighting not recommended OR Minimal wayfinding for main walkways. When: shut off during curfew hours	Where: Minimal wayfinding for main walkways When: shut off during curfew hours	Light level: Avg 0.01 fc, Max: 0.05 fc Non-uniform lighting is acceptable	Where: Minimal wayfinding for main walkways When: shut off during curfew hours	Light level: Avg 0.01fc, Max 1.0 fc Uniformity not critical
Steps along walkways and bikeways	N/A	Where: Provide illumination for every step in public areas and at public buildings, Guidance and presence detector recommended for sensitive areas When: same as other walkway lighting in the same area	Light level: Avg 0.1 fc, Minimum at center of each step Max 0.5	Where: Provide illumination for every step in public areas and at public buildings When: same as other walkway lighting in the same area	Light level: 0.1 fc minimum at center of each step, Max 0.5
Gas Station: Driveway	N/A	Where: Minimal or no driveway lighting, guidance lighting or reflective paint may be used instead When: shut off or dim when unattended. Consider motion control for after hours	Light level: Avg 0.1 fc, Max: 1.0 fc Uniformity is not critical	Where Minimal driveway lighting, guidance lighting or reflective paint may be used instead When: shut off or dim when unattended. Consider motion control for after hours	Light level: Avg 0.1 fc, Max: 1.0 fc Uniformity is not critical
Gas Station: Pump area (pump island and 10 feet on either side)	N/A	Where: Task lighting only When: dim when unattended. Consider motion control for after hours	Light level: Avg 1.0 fc, Max: 5.0 fc Uniformity 4:1	Where: Task lighting When: dim when unattended. Consider motion control for after hours	Light level: Avg 5.0 fc, Max: 20 fc Uniformity 4:1
Work Areas (SAR, Fire, Outdoor Maintenance Area, Pumps, Electrical boxes, Fueling Stations)	N/A	Where: Task lighting as determined by usage. When: shut off or dim when unattended or not in use. Consider motion control for after hours	Light level: Avg 1.0 fc, Max: 5.0 fc Uniformity 4:1	Where: Task lighting as determined by usage. When: shut off or dim when unattended or not in use. Consider motion control for after hours	Light level: Avg 5.0 fc Max: 20 fc Uniformity 4:1
Storage yards	N/A	Where: No lighting unless storage yards will be accessed at night. If lighting is	Light level: Avg 0.1 fc, Max: 1.0 fc Uniformity 4:1	Same as LZ-0	Same as LZ-0

		necessary, consider motion control.			
Egress at active public or park administration buildings, including ADA accessible entrances (drip line of canopy and twice the width of doors, or 10 feet out from entrances without canopies)	Where: Ranger stations and utility buildings may have egress, step, and flagpole lighting. When: all lights will be off when buildings are unused by the public and during curfew except flagpoles, which must use downward facing low level lights. Exceptions are emergencies or when repairs to any infrastructure must be made at night. Light level: Avg. 0.05fc, Max 0.3fc	Where: Egress and pathways to and from buildings, especially to and from parking lots. No perimeter lighting. When: turned off within 30 minutes of building closure OR dimmed when not in use	Light level: Avg 1.0 fc, Max: 3.0 fc	Where: Egress and pathways to/from building, especially to/from parking lots. No perimeter lighting. When: turned off within 30 minutes of building closure OR dimmed when not in use	Light level: Avg 2.0 fc Max: 5.0 fc
Residential and Visitor Lodging Egress (active): (twice the door width by 6 feet from the door).	N/A	Where: Egress, under canopies and pathways to and from building, especially at steps and to and from parking lots. No perimeter lighting. When: dim or shut off during curfew or when not in use.	Light level: Avg 0.5 fc, Max: 1.0 fc Uniformity is not critical	N/A	N/A
Residential and Visitor Lodging Egress (inactive):	N/A	Where: Egress only When: shut off during curfew or when not in use	Light level: Avg 0.05 fc, Max: 0.5 fc Uniformity is not critical	N/A	N/A
Shuttle Bus Stops	N/A	Where: Lighting under canopy, spill light limited to immediately surrounding area When: shut off after shuttle hours	Light level: Avg 0.2 fc Max: 1.5 fc Uniformity 6:1	Same as LZ-0	Same as LZ-0
Remote rest and visitor support facilities, including remote restrooms	Where: Restrooms will have egress lighting When: extinguished during curfew hours Light level: Avg. 0.1fc, Max 0.5fc	Where: Low level lighting confined to interior spaces and egress exterior When: adaptive and motion controlled Restroom lights: dimmed during curfew hours	Light level: Avg 0.1 fc, Max: 1.0 fc Uniformity is not critical	N/A	N/A
Bulletin board/kiosk	No lighting at kiosks or bulletin boards in this zone.	Where: Only for signage critical to night uses and wayfinding, businesses open 24 hours (i.e., hotels). Tightly controlled for no light trespass. Small LED lamps in display case recommended, this also applies to interior displays that have potential for light trespass into wilderness areas (i.e., Yavapai Museum) When: shut off or dimmed during curfew hours, consider using motion control.	Light Level: Avg 1.0 fc, Max 2.0.	Same as LZ-0	Same as LZ-0
Vending machines	N/A	Vending machines lights must be deactivated if not inside a building or enclosure, or if the vending machine light is visible outside the building or enclosure. Deactivating light in a vending machine is achieved by removing the light bulb, or disconnecting electrical current to the bulb,	N/A	Same as LZ-0	Same as LZ-0

		while leaving the remainder of the machine fully functional.			
Roadway signs	Roadway signs should not be illuminated, use retro reflective coating or other methods for visibility.	Same as LZ-00	N/A	Same as LZ-00	N/A
Restroom Interiors	Where: Only in campgrounds, not in remote overlook areas. When: dimming controls should be available during curfew hours	When: Dimmed at night, interior <10x the exterior egress light. Consider bi-level occupancy sensors to minimize light spill out windows	Light level: Avg 1.0fc Max 2.5fc	Same as LZ-0	Same as LZ-0

Light applications and light levels in Table 1 were first taken from Yosemite National Park Lighting Guidelines, Table A – Lighting Application Guidelines and Table B -- Design Lighting Levels. However, given conditions at Grand Canyon National Park, noted above in the “Lighting Zones” section (Benya 2013), lower light levels are called for in most applications. Light levels in this table that are lower than Yosemite’s are based on the following documents:

Benya Burnett Consultancy. Grand Canyon National Park South Rim Visitor Center Lighting Concept Design – Summary Report. August 8, 2013.

Death Valley National Park Guidance for Outdoor Lighting in Death Valley National Park International Dark-Sky Park Designation Nomination Package. November 2012.

Denali National Park and Preserve Interim Specifications and General Guidelines for Outdoor Lighting. March 2013