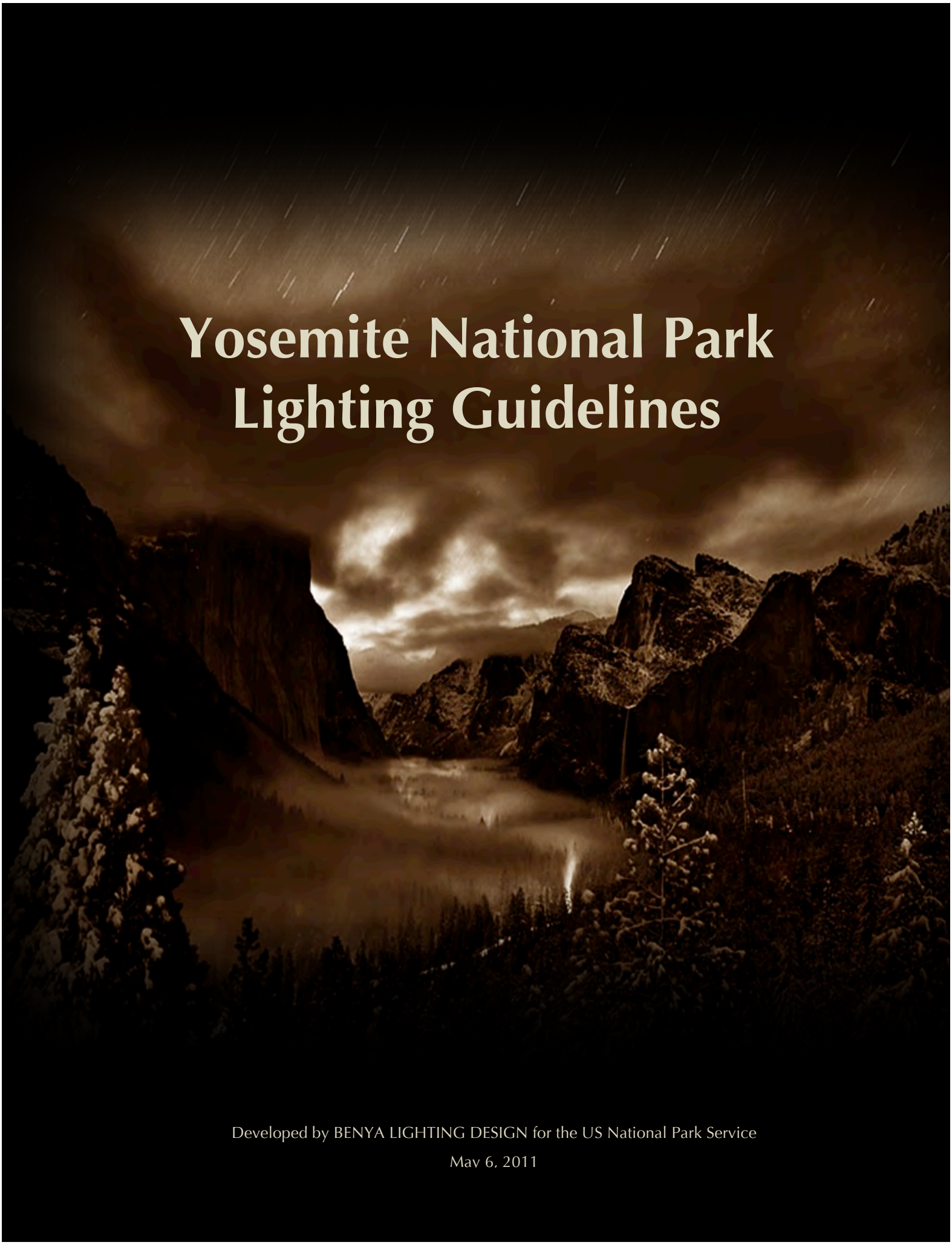

Yosemite National Park Lighting Guidelines

Developed by BENYA LIGHTING DESIGN for the US National Park Service

May 6, 2011

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Foreword

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Recognizing the threat of light pollution to the night at Yosemite, environmental leaders within the US National Park Service asked master planning consultants, EHDD Architecture of San Francisco, to address the issue. We joined the team in 1996 and began an odyssey spanning more than a decade of research, observation, learning, experimentation, moderate success, failure, and ultimately, breakthroughs in illumination science and dark sky philosophy permitting the development of these Guidelines.

Importantly, the span of time allowed for some amazing synchronicity. About the time that the first draft Guidelines was completed (1997), an important evolution of the dark sky movement began. The Illuminating Engineering Society (IES) issued a recommended practice, "Lighting for the Environment", RP-33, in 1999; the US Green Buildings Council (USGBC) introduced LEED 1.0 in 2000 and LEED 2.0 in 2002 in which dark skies preservation is a rewarded achievement; and in 2000 the International Dark Sky Association (IDA) began to post its Lighting Code Handbook of recommended lighting restrictions for community adoption. Our project team was thrilled to be consistent with, and in many ways, ahead of this important progress. These Guidelines are intended to be consistent with the ongoing dark sky movement and especially the work of all three of these important organizations, which since have developed more advanced standards.

Credit is due to many people who contributed to this work. The thoroughness, diligence and passion of the US National Park Service (NPS) and Delaware North Companies (DNC) personnel were truly exceptional and contributed greatly. Not enough good can be said in particular of key NPS personnel and their contribution ranging from architectural history and park policy to down-to-earth practicality. These Guidelines would simply not have been possible without their vision, perseverance, understanding and wisdom.

More lately in the project, the introduction of the Curry Village Employee Housing team including URS, the Architectural Resources Group, Auberbach Glasow French Lighting Design and O'Mahony and Myer added practical perspective and an opportunity to test significant experiments in a real life context.

Borden Lighting provided significant input on luminaire design and built the pole, bollard and wall light mockups.

Finally, we want to recognize the visionary leadership of the US National Park Service Night Sky Team. Since about the time that the International Dark Sky Association began, the Dark Sky Team has sought to preserve the night sky at all of our parks. Our work has been shared with them throughout such that their insight and experience could be gained and perhaps, the benefits of this work shared with other National Parks.

James R Benya and Devki RajGuru
May 6, 2011

Over-Arching Principles

Yosemite National Park
Lighting Guidelines

One of Yosemite's most profound experiences is at night, with the darkness of the mountains and the valley walls framing an umbrella of stars. Like other natural wonders, the night sky is a diminishing resource that Yosemite and other National Parks seek to manage and preserve. NPS Management Policies address the protection of the nighttime environment in parks, termed "natural lightscapes". These natural lightscapes are recognized by NPS as an important visitor resource and an integral part of the ecosystem. But they are seriously threatened by light pollution, even from within the park.

To prevent the further loss of this resource, and to promote its restoration, park superintendents are directed to minimize the light that emanates from park facilities, seek the cooperation of park visitors, and partner with surrounding communities and neighbors to reduce the impact of light pollution upon the park. The Management Policies direct parks to 1) restrict the use of artificial lighting in parks to those areas where basic human safety and specific cultural resource requirement should be met, and acknowledge that resource concerns may dictate that certain areas should not have artificial lighting; 2) use minimal impact lighting techniques; and 3) that such lighting should be shielded where necessary to prevent the disturbance of ecological processes and degradation of scenic values.

To ensure these directions are met, all new and replacement lighting in the park should meet these Guidelines.

Through the application of these carefully considered lighting techniques and thoroughly evaluated lighting technology, the safety and wayfinding of park visitors and staff can be addressed without any significant negative impact on Yosemite's night sky. This should be interpreted to mean that lighting should be provided as needed for developed facilities within the park, but generally not for most of the balance of the park, especially for areas away from developed facilities. The need for outdoor lighting should emphasize applications where accessibility, security and/or safety are principal concerns. Except for conflict zones and basic wayfinding, lighting should not be provided for streets, roads, or many of the park's walkways and bikeways. Lighting should be limited to those applications in portions of the park that are commonly used at night and genuinely need lighting. In keeping with NPS Management Policies, a careful evaluation of lighting needs should be part of every facility review, study, or project. Do not use lighting when it is not required, and discontinue current uses that do not meet these Guidelines.

Because of the park's extremely low ambient light levels, recommendations of the Illuminating Engineering Society (IES) of North America may need to be adjusted to be appropriate. Light levels and other IES recommendations are intended to be applied to developed areas with higher ambient light and usually recommend too much light in rural and natural areas. These Guidelines are based on special research that interprets the intent of IES recommendations into the park environment and should be followed for all applications.

"Light *pollution is not the inevitable side effect of progress, but is instead indicative of wasteful and inefficient outdoor lighting. The loss of the night sky is unnecessary. Protecting dark skies doesn't mean throwing civilization back into the dark ages; it simply requires that outdoor lights be used judiciously, respecting our human environment, wildlife, and the night sky that belongs to us all."* *US National Park Service Night Sky Team*

A Question of Design

Yosemite National Park
Lighting Guidelines

Long before the invention of the electric lamp, mankind was making sources of light to be used to provide illumination to compensate for humans' relatively poor night vision. Since the days of candlelight and oil, the enclosure of the light source has been an important architectural detail. The shape, material, mounting, color and other qualities of lighting are often considered prominent in the hierarchy of architectural details. After all, luminaire *style* is a primary consideration by day, while lighting *effect* dominates by night.

Prior to the development of these Guidelines, there were no standards for any lighting at Yosemite. Lighting has been chosen on the basis of individual projects and was most likely based on the architectural and engineering standards of the day. Little thought seems ever given to the standardization of light sources, much less the style of the luminaires in which they were to be housed. Yet there seems to be a belief that there should be a "Yosemite" or "National Park" style that should take precedence among lighting choices.

Lighting styles, however, change over time as evolving light sources lead to a wide variety of technical options. Combined with the concurrent evolution of architecture, literally thousands of lighting choices are available for each individual project. The challenge of making a proper decision is made more difficult by the need to employ luminaires that shield light sources from upward and sideward light.

In fact, the development team for these Guidelines made a concerted attempt to define the lighting style that achieves the illusive timelessness that is the National Park style. The style of recommended lighting systems in this document, to which we refer as "dome-and-bell" is the result of several rounds of architectural evaluation, beginning with a first opinion from master architect George Homsey in 1996. Derived from the early 1900's industrial ethos, the currently recommended style seems to achieve an appearance that is hard to distinguish by time or use. Most new installations and mockup tests between 2002 and 2010 employ the bell-and-dome luminaire style, including the LED adaptive systems.

The drawback to any single style is the many tradeoffs and compromises. In this case, "rusticity" is probably sacrificed despite the many applications throughout Yosemite where a luminaire of more rustic nature might be a better choice. When called for, individual projects might consider luminaires and posts or poles of similar technology and photometry to recommended products but altered to better meet project appearance requirements.

Figure 1 Rusticity: wood post structure, Hetch Hetchy, with an industrial style luminaire

Key Research

Yosemite National Park
Lighting Guidelines

Light Levels

Prior to this work, a major paradox hung over every lighting project at the park. For exterior lighting, lighting designers and engineers generally design to meet light level recommendations developed by the Illuminating Engineering Society (IES). IES recommendations serve as the criterion for normal standard of professional care, and in general engineers refuse to design to lower light levels lest they expose themselves to professional liability. However, historically speaking, IES recommendations have been for lighting ordinary lighting applications in the normal urban and suburban environment – not near a wilderness or in a National Park.

The amount of light suitable for an urban or suburban application is far too much for the intentional natural darkness of Yosemite. The IES Board has acknowledged this general deficiency in their recommendations and has pledged to develop more environmentally responsive recommendations commencing with their Tenth Edition Lighting Handbook. The Handbook is scheduled for release in 2011, and while not published as of these Guidelines, it is understood that lighting recommendations will be subdivided into Lighting Environmental Zones. The applicable zones for Yosemite National Park will be LZ0 for most of the park, and LZ1 for the developed portions of the Valley Floor and Wawona.

There having been no prior standards or research on appropriate light levels in extremely low ambient settings, key research permitting the development of lighting standards applicable to Yosemite and other low ambient light level locations was conducted. This included a series of test situations in which the consensus of expert, safety, design, construction, management, NPS personnel and the general public was recorded and analyzed. This work is believed to be as scientifically sound as many IES recommendations. For the record, test results are presented as appendices, and for the purposes of these Guidelines, the values herein should inform or even supersede those of the IES or any other organization.

The IES Board agreed to acknowledge that there were many situations where permanently installed electric lighting is not needed or advised. In the park, this translates into deciding when lighting should be present, when it is optional and when it is to be avoided. Interviews with federal solicitors general in 1997 established that the responsibility of the NPS and the concessioner is to provide appropriate lighting for accessible locations, meaning the developed areas where persons including those with disabilities should have a reasonable expectation of night access without portable lighting. Beyond these areas, lighting should only be purposeful and persons needing light should carry flashlights. The key exceptions are circulation and safety lighting in and around hospitality facilities and employee housing, where late night and early morning activities are to be expected.

These findings are critical to being able to maintain the natural night environment at Yosemite and other parks in wilderness settings. Even for parks in or near highly developed areas, these principles can also be applied as long as the park itself is maintained as an island of natural darkness with buffer zones to address the interface with normal development.

Adaptive Lighting

This Guidelines team considered the possibility of lighting controls capable of changing both the amount of light and the color of the light over the course of the night. This is called ***adaptive lighting***.

Light level reduction is based on the premise that the pollution caused by electric lighting can be dramatically reduced by turning lights down or off after normal evening activity periods. This is based largely in common sense – when there is little or no need, turn off the lights. But it is also based on adaptation. When moving from indoors to outdoors, one is more likely to be adapted for darkness late at night and throughout the early morning, especially if indoor light levels are reduced at night, too.

Color change is another means to reduce environmental impact. White light is comprised of all colors of light, including red, orange, yellow, green, blue and violet. In nature, the shift of light color from white to red, orange and yellow signifies the end of the day and beginning of the night. The continued presence of violet, blue and green is unnatural and interrupts the normal circadian behavior of all flora and fauna, but persisting red and yellow light have comparatively little effect. Most light sources emit white light with all of its components. LED lighting is unique in that red and orange-yellow LED light sources, mixed together, can produce a significant amount of useful light without any violet, blue or green components. Lighting systems of this type left on all night will have minimum environmental impact. A side benefit will be reduced or eliminated insect attraction. For more detailed information, an International Dark Sky Association white paper on the topic is included in the Appendix.

Yosemite Standard Products

Several LED luminaires capable of both light level and color changing were mocked up and tested. The results were extremely good and the concept was selected for ongoing study and use permanent use in most applications. Technical aspects of the luminaires are described in the lighting standards section of this report. A control circuit automatically reduces the light levels and change light color approximately 2 hours after sunset. A simple time delay time circuit was chosen for simplicity; there is no need for setting of internal time clocks or other adjustments, and a group of lights can be controlled by standard time clocks or photocells. To accommodate valley floor activities, longer time delay might be used there, but probably not more than three hours.

Future project teams are strongly encouraged to be fully aware of the intent of this work and the ramifications. The standard lighting systems described in these Guidelines are specifically designed to permit all night operation in areas where human activity drops considerably 2-3 hours after sunset. If needs differ, conventional solutions using all-night white light may be necessary.

The Guidelines team considered the use of motion activated lighting and ultimately chose not to make a strong recommendation one way or the other. Motion controlled lighting is a natural extension of LED lighting systems and an additional energy saving means. However, motion controls need to be weighed against the potentially annoying cycles of on and off that might be created. For this reason alone design teams are encouraged to evaluate each situation and when warranted, use motion-controlled lighting in lieu of the adaptive level-and-color changing system promoted herein.

Application Guidelines

Yosemite National Park
Lighting Guidelines

Primary Considerations

Decisions involving electric lighting to be used in the park should be made in consideration of ***Application Guidelines*** and ***Equipment Standards.*** These standards have been developed in full consideration of Executive Orders 13423 and 13514 and their use can help achieve their requirements.

The intent of ***Application Guidelines*** is to establish how to select lighting equipment for typical applications and for specific projects. This will ensure a commonality of use and purpose for lighting throughout the park. In addition, the Guidelines provide guidance to designers to aid in the interpretation of the Guidelines and Standards to accommodate individual project needs and to permit revisions as technology changes the available options. Recommended lighting levels and other Criteria are provided.

The intent of ***Equipment Standards*** is to establish a family of luminaires and lighting systems that are used repeatedly throughout the park. This will ensure a commonality of appearance, maintainability, dark sky preservation and energy efficiency. In general, luminaires, poles and other lighting equipment should be chosen from these Standards. For specific projects, unique non-standard luminaires may be used if approved by NPS as long as the principal characteristics of standard lighting systems are maintained.

Application Guidelines

Lighting for the park should be designed to strike a balance between the darkness of nature and the minimum lighting necessary for the human activities occurring at night.

When undertaking a design, **first establish whether lighting is needed.** For most of the human activities in the park, the recommended lighting application is listed in Table A. Other applications should be weighed carefully. **Do not assume that lighting is always needed.**

Executive Order 13423 and 13514 generally require the use of energy efficiency and sustainable design practices in Federal facilities. The requirements of these Guidelines and Standards typically comply with this Order.

These requirements are considered equal to or more stringent than the US Green Buildings Council LEED Sustainable Sites Credit 8 as applied to Lighting Zones 0 and 1. However, should a conflict between these requirements and LEED occur, the designer should reconcile the difference in the more stringent manner.

Table A – Lighting Application Guidelines

Note: this list is not inclusive. If similar applications are identified at other projects or sites, provide appropriate lighting consistent with this table.

Lighting Situation Type	***Lighting Recommendations***	***Representative Locations***
Roads posted 25 mph or less	Lighting only at shuttle stop and conflict zones; shut off after shuttle hours.	Roads leading into and throughout the Valley floor
Roads posted >25 mph	At only at intersections and conflict zones; consider adaptive lighting	Highways
Parking Lot - High Activity	Relatively uniform illumination for the entire lot, driveways and surrounding walkways; shut off after use hours	Parking lots adjacent to Yosemite Lodge, Yosemite Village, The Ahwahnee, and Wawona; day use and employee lots
Parking Lot - Moderate Activity	Illumination for most of the lot, drives and surrounding walkways, but not necessarily uniform; use adaptive lighting	Parking lots adjacent to Curry Village and Yosemite Lodge
Parking Lot- Low Activity	Little or no lighting; use adaptive lighting for accessible parking stalls and accessible ramps	Parking lot adjacent to Housekeeping Camp
Walkways and Bikeways – High Night Activity	Relatively uniform lighting for walkways and bikeways; use adaptive lighting. Consider extremely low level wayfinding lighting.	Within Yosemite Lodge, Yosemite Village, The Ahwahnee, Wawona; between Village and Lodge.
Walkways and Bikeways – Medium Night Activity	Lighting for main and secondary walkways and bikeways, but not necessarily uniform. Use adaptive lighting.	Within Curry Village including employee housing; between village and NPS offices and residential areas
Walkways and Bikeways – Low Night Activity	Minimal wayfinding lighting for main walkways only. Use adaptive lighting.	Within Housekeeping Camp; between major facilities
Gas Station	General and task lighting; shut off or reduce lights when gas station is unattended. Consider a motion-controlled light for a small service area for after hours needs.	Near Wawona, Tuolumne Meadows (seasonal)
Service Yard	Minimum safety lighting; adaptive or motion controlled lighting.	NPS/DNC Area near Yosemite Village
Outdoor Eating/Patio Area	Relatively uniform lighting for dining area and access path; off after use hours. Consider adaptive lighting for extended use areas.	At Yosemite Village, Yosemite Lodge, The Ahwahnee, Curry Village
Lodging Building Entry	General lighting under canopies and portes cochere; uniform lighting of approach drives and surrounding area; consider adaptive lighting.	Wawona, Lodge, The Ahwahnee, Curry Village
Cabin and Guest Room Exterior	Wall mounted lighting; adaptive lighting.	Wawona, The Ahwahnee, Lodge, Curry Village
Retail Exterior	General lighting under canopies and areas around store entry; turn off after business hours	Yosemite Village, Lodge
Shuttle Stop	Lighting under canopy; spill light limited to immediately surrounding area; turn off after shuttle hours.	Throughout Valley floor
Remote rest and visitor support facilities	Adaptive low level lighting, confined to the interior spaces and exterior areas at entrances. Motion controlled interior lighting,	Throughout park
Bulletin board/kiosk	Adaptive low level lighting; only for signage critical to night uses and wayfinding	Throughout park

Light Sources

The color tint of white light is 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). Between 3000 and 5000K, light is said to be "neutral" in tone. See Figure 1. Traditional incandescent lighting is about 2700K, a warm toned light considered normal for residential and hospitality lighting in North America. For reasons of consistency and appearance, light sources should be 3000K or less with a minimum CRI of 70. Amber or yellow light sources (with lower CRI) may be used where insect attraction is a problem. Light sources should be chosen for energy efficiency, long life and low maintenance. Because some locations in the park experience extremes of temperature, elevation and exposure, light sources should be suitable for all expected operating conditions. The following light sources are acceptable:

- LED 2700-3000K "warm" white lamps. LED's superior life, energy efficiency, instant starting and low temperature performance are superior. Product evolution is adequate to warrant widespread use of this technology. Red, red-orange and amber LED sources may be used for adaptive lighting.
- Ceramic metal halide lamps, 20 watts and 39 watt 3000K only. In general, these are the most powerful light source to be used outdoors. Warm up and restrike time preclude use where motion sensor switching or power quality issues are present. Higher wattage lamps can be considered for the few applications where warranted, such as the gas stations.
- Compact fluorescent, 9 watt, twin tube and 13 watt double twin tube (2700K only). Because of low starting temperature and low cost components, this light source can be used for some basic outdoor lighting applications.
- Halogen IR, 20 watt, 12 volt MR16 lamp. Uses are generally limited to accent lighting applications. LED alternatives should be considered. Tungsten lighting for any other purpose should not be used without the express permission of NPS.

Ballasts should be rated for starting the lamp at 0°F or lower. Electronic ballasts should be used whenever possible. Transformers for low voltage lighting systems may be solid state or magnetic, depending on the application. LED drivers should be rated for outdoor use and to properly drive the LED sources in each luminaire.

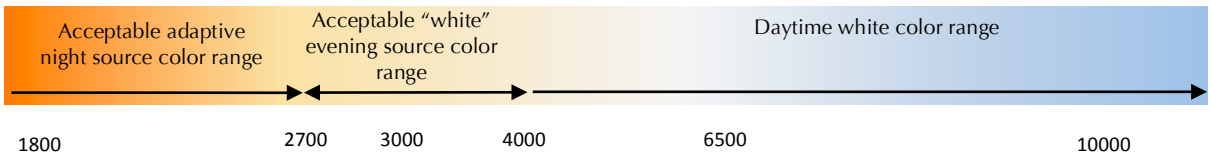


Figure 2 - Color Scale of White Light (K)

The energy efficiency of a light source is measured in lumens per watt and is called ***efficacy***. Efficacy is important but should be weighed against maintenance and durability.

With the exception of halogen lamps listed above, all recommended sources meet minimum expectations of efficacy. Caution is required in selecting new light sources because

the most efficient LED sources tend to have excessive short wavelength light, which is not acceptable. However, LED and other light sources are expected to become extremely efficacious in the future without this issue, and projects should employ the most efficacious source that meets these Guidelines and project requirements. Note: in a limited number of genuinely historic applications, incandescent lighting is called for. The requirement to provide historically correct lighting should be approved by NPS.

Controlling Light Pollution

Light pollution includes:

- ***Artificial sky glow***, the illumination of airborne particles by upward light that obscures astronomy and star gazing. The primary cause is poorly shielded lighting that emits light straight into the sky.
- ***Light trespass***, the unwanted radiation of light onto others property, particularly into interior spaces. The primary cause is poorly shielded lighting that permits light to be emitted at angles offensive to neighboring properties,
- ***Glare***, occurring when poorly designed or excessive illumination causes visual discomfort or disability. The primary cause is too much lighting for the situation, exacerbated by poorly shielded lighting emitting light directly into the eyes of people.

Control of light pollution is a problem at both the local and regional levels. All forms of light pollution should be controlled at the park as poor lighting practices will have the greatest impact. But the sky glow effects can occur as far as 120 miles from the source, thus long-term administration plans should include cooperation with neighboring communities to prevent impacts throughout the region.

Light pollution can be significantly reduced or eliminated by the use of well-shielded luminaires. All luminaires should have solid sides and tops and direct all light below the horizontal plane.

The requirement to have a solid top and shielding is essential and there are very few exceptions, which include:

- Landscape lighting: the lighting of landscape features should be avoided as a general rule. In extremely special cases where landscape lighting is demanded, a small amount might be used for the application. However, the light source per luminaire should not exceed 500 lumens and should be shielded.
- Festive lighting: the use of LED string lights may be permitted for seasonal accents and as decoration on the exteriors of food service, beverage service, and retail facilities.

In both cases, this lighting should not even be considered unless there is a compelling historic or functional context supporting their use. Such lighting should be extinguished at the end of normal business hours and not used in place of well-controlled general lighting meeting these Guidelines.

The following lighting standards meet or exceed the intent of this section. Individual projects should make every effort to employ these lighting standards as described. Projects which cannot use these standards for architectural, historical or practical reasons should be informed by the character of the standard luminaires and every effort should be made to achieve a similar light-pollution-free installation.

Other Application Considerations

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.

Pedestrians and Bicycles Design lighting in consideration of the park's use by pedestrians and bicycles. Particularly avoid light fixtures and poles that will be prone to damage or causing injury, such as bollard lights near pathways.

Remote areas LED lighting systems permit very low wattage lighting powered by small photovoltaic (PV) panels and storage batteries. In remote summer use sites, this type of lighting is ideal for small amounts of convenience lighting at campsites, rest facilities, and other limited lighting needs. Note that these systems require direct sunlight on the PV panels; and the storage batteries are sensitive to cold temperatures and require maintenance. Systems suitable for year-round use can be expensive and hard to locate due to the low solar angles of winter sun.

Light and Power Levels

The development of these Guidelines included a complete examination of the applicability of Illuminating Engineering Society (IES) light level recommendations (see the section on Key Research). Based on scientific study and consensus of stakeholders conducted several times throughout the Guidelines development process, it was determined that most historic IES recommendations are excessive for the needs of the park. For this reason, lighting design levels should be chosen from Table B. In general, these are classical outdoor lighting criteria and calculations should be used to confirm performance using modern computer lighting programs.

However, IES recommendations change and are expected to become more stringent over time. Each project should be conformed to updated IES recommendations including the 10th Edition IES Lighting Handbook and IES RP-33, Lighting for Exterior Environments.

To control energy use, lighting designs should comply on a project-by-project basis to California Title 24, Part 6. The Lighting Zone for the Yosemite Valley Floor and Wawona is LZ1.

Lighting Technology

This report was written at a time when lighting technology is rapidly changing. It is likely that within 5-10 years, most of the specific lamps, ballasts and other lighting equipment will become obsolete, and it will be incumbent on the designers of specific projects to interpret the intent of this document before making product selections. Moreover, ongoing research may change recommended lighting spectra, light levels, and other recommendations or requirements of this document, and other adjustments may also be necessary

However, it is unlikely that the basic guiding principles (see page 15) will change. When in doubt, revert to these principles while adopting new lighting technology to the park, and good results are likely.

Table B- Design Lighting Levels

Uniformity expressed as average to minimum ratio;
Light levels in maintained footcandles (fc). Multiply by 10 for lux
NOTE: these values should be conformed to the IES 10th Edition Lighting Handbook.
Do not exceed these light levels, as excessive lighting will create light pollution.

Lighting Situation and Level of Night Activity	***Classical illumination criteria***		***Application Notes***
	Average	***Absolute Maximum***	
Streets, roads and drives			
All	0.2 avg. fc @ 6:1 uniformity	1.5 fc at any single point	Restricted to intersections; generally not continuous
Parking Lots			
ADA accessible	0.5 avg fc @ 4:1 uniformity	2.5 fc at any single point	Limited to portions of lots marked for ADA accessible use and requiring night access, including ramps to adjacent buildings and walkways
High activity	0.2 avg. fc @ 4:1 uniformity	1.0 fc at any single point	Uniformity is important
Medium activity	0.1 avg. fc @ 10:1 uniformity		Uniformity is not critical
Low activity	0.1 average fc		Non uniform lighting acceptable
Walkways and Bikeways			
High activity (including ADA accessible walkways with night use)	0.2 avg. fc @ 8:1 uniformity	2.0 fc at any single point	Uniformity is important
Medium activity	0.1 avg. fc @ 12:1 uniformity	1.0 fc at any single point	Uniformity is not critical
Low activity	0.1 average fc		Non uniform lighting acceptable
Plazas and grounds within a developed and active area	0.1 avg. fc		Uniformity is generally not critical; increase lighting at changes in grade and where accessibility issues require
Steps	0.1 fc minimum at center of step	5.0 fc at any single point	Provide illumination for every step
Building Entrances			
Active major buildings, all ADA accessible entrances (drip line of canopy and twice the width of doors, or 10' out from entrances without canopies)	2.0 avg. fc	5.0 fc at any single point	Downlighting preferred
Residential and hospitality buildings (twice the door width by 6 feet from door)	0.5 avg. fc	2.5 fc at any single point	Uniformity is not critical
Building exterior entrance (inactive, 40 sf max)	0.1 avg. fc		Uniformity is not critical
Gas Stations			
Driveway	0.5 avg. fc	2.0 fc at any single point	Uniformity is not critical; turn off or reduce after attended hours.
Pump area (pump island and 10 feet on either side)	5.0 fc @ 4:1 uniformity	20 fc at any single point	Uniformity is important; turn off or reduce after attended hours.
Other			
Bulletin boards and kiosks	1.0 fc avg. vertical	5.0 fc at any single point	Rarely used; use adaptive lighting with night levels 1/5 of maximum or less
Storage yards	Average of 0.1 fc	1.0 fc at any single point	Consider the use of motion controlled lighting, no lighting unless required

Luminaire Selection Guidelines

General

Like many historic national parks, Yosemite's facilities have been developed over more than a century of architecture and construction. Most of the historically important structures at Yosemite were built around 1920-1930, an unremarkable period in architectural lighting. Moreover, there are very few historically relevant outdoor lights, save the lighting attached to The Ahwahnee and other historic structures. Nonetheless, architects and park historians agree that exterior lighting equipment should appear by day to fit a general design attitude of historical reference. In and about newer structures, the lighting may appear more modern, but in general, the vast majority of the existing building stock and outdoor use areas demand luminaires of timeless style that seem to have "always been there".

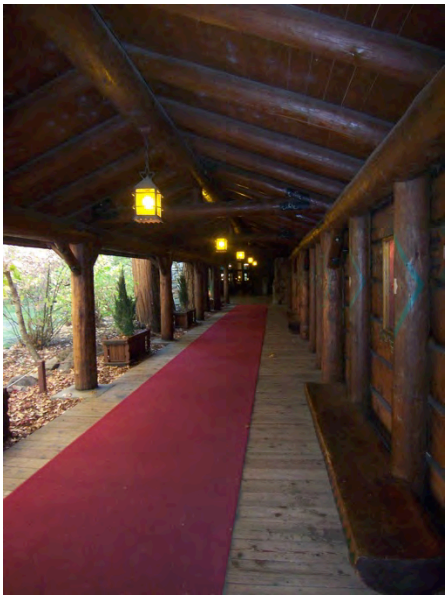


Figure 3 - Decorative Lighting at The Ahwahnee

Basic Guiding Principles

Lighting is visible day and night. By night, proper shielding and design practices should result in functional lighting that is not glaring and may be appealing. By day, luminaires become part of the architectural fabric and their appearance should be architecturally appropriate and usually as neutral in style as possible.

The **first principle** is to install lighting only where needed. Conservation and preservation of the night environment depends on there being little or no lighting of the park.

The **second principle** is to employ only the minimum amount of light that is needed at each location. Light levels should be much lower than ordinary commercial lighting. Adaptive lighting that reduces light levels after evening activity hours should be employed as much as possible. Turn lights off when not needed.

The **third principle** is to prevent stray light. This includes upward light that causes sky glow and sideways light that causes glare and light trespass. Stray light is usually caused by poor lighting practices, but signs, vending machines and other innocuous uses of light also cause it.

The **fourth principle** is to design interior lighting and controls for lower levels at night to ease the night transition from interior to exterior.

The **fifth principle** is to avoid ornamentation in lighting except where absolutely needed. Ornamental lighting plays a significant role in architecture, but when used outdoors tends to encourage light pollution. Use low wattage sources, provide upward and sideward shielding, and/or locate under overhangs or canopies.

The **sixth principle** is to employ long life, energy efficient, low maintenance light sources. In almost all cases the total lumens per luminaire should be less than 5000. In no case should the total luminaire output exceed 9,000 lumens for any reason.

The **final principle** is to employ durable lighting equipment designed to withstand weather and physical abuse, requiring little or no service over 20 or more years of use. Serviceable parts should be designed for hand tool repairs. Solid-state lighting (LED) should be considered for most uses due to exceptional life and low maintenance.

Style

The emphasis on preserving the night environment often conflicts with lighting style issues. Most traditional lighting creates excessive uplight. Among traditional styles with full shading, there are very few choices. In the image at the right, a industrial shade luminaire is mounted using conduit fittings and is painted dark green. This is one of the primary historical bases for the recommended lighting systems in these Guidelines. Variations include mounting atop a pole or post at almost any height, or to the side of a building as shown. However, because this style became popular in 20th century architecture, a style unique to the park is preferable.

Figure 4 – Industrial Shaded Light

Lighting Fixture Types

Designs should be developed from among the following luminaire types.

General Uses

- **Tall pole Lights** Mounting heights nominally 12-20′ above grade. For parking lots, roadways, intersections, and large areas such as conflict zones.
- **Short pole Lights** Mounting heights nominally 8-10′ above grade. For parking lots and area lighting near buildings, and pedestrian area lighting including bikeways and walkways where illumination under all weather conditions is required.
- **Bollards** Pathways and walkways where the risk of damage due to pedestrian and bicycle traffic and snow removal is minimal and for which low level lighting is desirable (sources below eye level and at low illumination levels).
- **Wall Lanterns** Attached to buildings, generally adjacent to a door.
- **Path/step Lights** Small luminaires integrated into walls, fences and other structures

Lighting for Service and Utility Areas Only

- **Pole Mounted Area Lights** For service yards, service vehicle parking areas, etc.
- **Wall Mounted Area Lights** For service yards and adjacent to service building entrances

Extremely Limited Uses

- **Landscape Lighting** Limited to situations of compelling historic or functional context
- **Sign Lighting** Limited to critical signage, top down lighting required
- **Decorative Lighting** Limited to historical or architecturally critical lighting at lowest possible levels

Equipment Standards

Yosemite National Park
Lighting Guidelines

Standard Lighting Systems

The following lighting systems were developed specifically to meet these Guidelines and should be used whenever possible.

Image	Product	Applications
	**Tall Pole** *Straight-arm or crook arm, flared bell housing, fully shielded HID source.* *Alternatives may include short arm shallow bell luminaires and wedge shaped luminaires (see below) and LED sources.*	Parking lots, roadways, area lighting
	**Short Pole** (with or without arm supports for top housing. *Adaptive LED luminaire with indirect source and spun metal reflector and cap.* *Alternatives may include shallow bell luminaires and wedge shaped luminaires with adaptive LED sources.*	Walkways, bikeways, parking lots, area lighting
	**Bollard** *Adaptive LED luminaire.* *Alternatives may include wedge shaped luminaires with adaptive LED sources.*	Low level lighting of walkways, generally near buildings

	**Sconce** (lantern) *Adaptive LED luminaire* *Alternatives may include wedge shaped luminaires with adaptive LED sources.*	Structure walls near doors and along walkways adjacent to structures.
	**Shallow Bell Shapes** (alternate) *Compact fluorescent, LED and HID luminaires with short arms.* *Match existing luminaires installed at Curry Village Employee Housing.*	As an alternative to the other shapes, especially if matching existing lighting systems.
	**Wedge Shapes** (alternate) *A modern shape for use on or near modern structures. Adaptive LED, LED or HID sources as called for.*	As an alternative to the industrial bell shapes with lamps and optics to provide similar performance. As approved on a project specific basis.

General Specifications

Color

The preferred color is Tiger Drylac 44/60034, "Breccia Smooth Matte", textured matte dark rust colored powdercoat paint similar to the color of corten steel. Other colors may be selected for compelling reasons, such as matching an adjacent building detail color. Natural metal finishes such as corten steel may be possible, but powdercoat paint is generally more durable and environmentally responsible.

Mounting

Yosemite's temperature extremes and winter snows suggest durable mounting materials. In most cases, aluminum poles and arms should be used for pole lights. Anchor bolt bases are preferred for ease of replacement when luminaires or poles are not severely damaged. The use of wooden posts and structures may be considered but long term maintenance considerations favor metal poles and arms.

Standard Product Specifications

Considerable effort has gone into the process of developing standard products that meet the Application Guidelines, as follows.

Tall Pole Lights

Uses

Tall pole lights may be used where area safety and task lighting is required, including parking lots, service facilities and entrance safety stations, as project conditions warrant. The standard mounting height of the lighting is 19 to 20 feet above adjacent grade. Roads are not to be lighted, but if appropriate, tall poles might be used to illuminate drop-off areas or similar locations where there is an increased amount of traffic and potential conflict with pedestrians and cycles. Example luminaires were installed at Wawona Gas Station in 1998 and the Curry Village Employee Housing in 2006-2007.

Technical

Tall pole lights should employ high performance optical systems capable of achieving good uniformity over areas to be illuminated. The luminaire should use a high performance fully shielded optical system. Each luminaire should use lamp(s) totaling not more than 1500 initial lumens for most applications. When required for applications such as gas stations or specific safety applications the total luminaire lumens may be increased but never more than 7000 initial lumens. Layout procedures are consistent with industry standards and lighting criteria from these standards. Use of a modern point-by-point computer program is required to confirm the performance of specific layouts. House side (backlight) shields should be employed in most applications to prevent trespass to neighboring areas. As a general rule, avoid luminaires in the center of areas due to the need to move plow and pile snow. Most of the parking lots at the park are small enough to permit lighting from the perimeter.

Poles may be composite, aluminum or fiberglass. The engineer for each project should select the pole type and direct burial or anchor base and designed according to snow plowing, wind and soil conditions. In areas where vehicles might strike the pole or base, consider Sonotube-cast concrete bases 30″ above grade and poles 16.5′ to 17.5′ feet tall. In pedestrian and bike areas, a short concrete base may be employed. Direct burial poles, if used, should be selected so that the luminaire lens does not exceed 20 feet above adjacent grade. Wood poles should be carefully evaluated, as they typically require more maintenance than powder coated metal poles.

Design Considerations

Tall poles should employ a fully shielded bell housing luminaire with a short arm or shepherd's crook pole. Two or more fixtures can be mounted to the same pole if called for. Poles luminaires are generally available in typical distribution patterns and should be located to provide appropriate lighting levels and uniformity.

Figure 5 –Tall Pole Lights at (*l.)* Wawona Gas Station (*r.)* Crane Flat Gas Station. This design was developed prior to the completion of these Guidelines. Fewer lumens (lower wattage lamps) should be used on similar installations in the future.

Installed poles can be found in the park (left) at the Wawona Gas Station using 100-watt metal halide lamps, and (right) in the gas station at Crane Flat using 70-watt metal halide lamps. At the Curry Village Employee Housing parking lot, 20-watt metal halide lamps were used where tests of acceptance of low light levels were successfully conducted.

Architectural Area Lighting manufactured the installed pole lights. However, the style is common throughout the lighting industry and because of rapidly changing lamp technology, no specific brand is recommended. LED options are expected to become commonplace in the future and should be investigated, including the ability to reduce light levels at night or perhaps, change light color in the manner described for the short pole light.

Short Pole Lights

Uses

Short pole lights should be used as a general light source throughout the park. Their height allows them to be installed several feet away from the path or area being lighted to protect them from bicycles to snow removal equipment. The standard mounting height of the lighting is 8 feet above adjacent grade. The standard pole is an adaptive lighting system capable of both light level change and color change. Prototype luminaires were developed and tested at the park in the summer of 2009 and the winter of 2009-2010.

Technical

Short pole lights should employ an LED-powered indirect optical system. The design of the prototype luminaires and pole address many issues of maintenance including a bug- and bird-nest shedding skin and simple electric circuitry. The soft optics reduces potential LED glare and are capable of achieving acceptable uniformity over areas to be illuminated.

Figure 6 - Short Pole Luminaires

The luminaire should use a modern, low-tech optical system in which the uplight of the lamps is mixed and diffused by the reflector. Poles may be composite, aluminum or fiberglass. The engineer for each project should select pole type and direct burial or anchor base and designed according to snow plowing, wind and soil conditions. Two fixtures can be mounted to the same pole if called for.

Typically, short poles will employ 500 to 1000 lumens of LED lamps. One half of the lamps will be 2700-3000K white LED, the other half a mixture of red and amber LED's with no radiation at wavelengths shorter than 500 nm. An integral driver will operate all lamps for approximately 120 minutes after being energized, and then begin a slow fade to just red and amber lamps. Layout procedures are consistent with industry standards and lighting criteria from these standards. Use of a modern point-by-point computer program may be required to confirm the performance of specific layouts.

Design Considerations

The evolved design of the bell housing is the result of several years of considerations and two mockups. Support arms for the top are optional. Use of either direct burial or anchor base poles should be determined by the engineer responsible for the project.

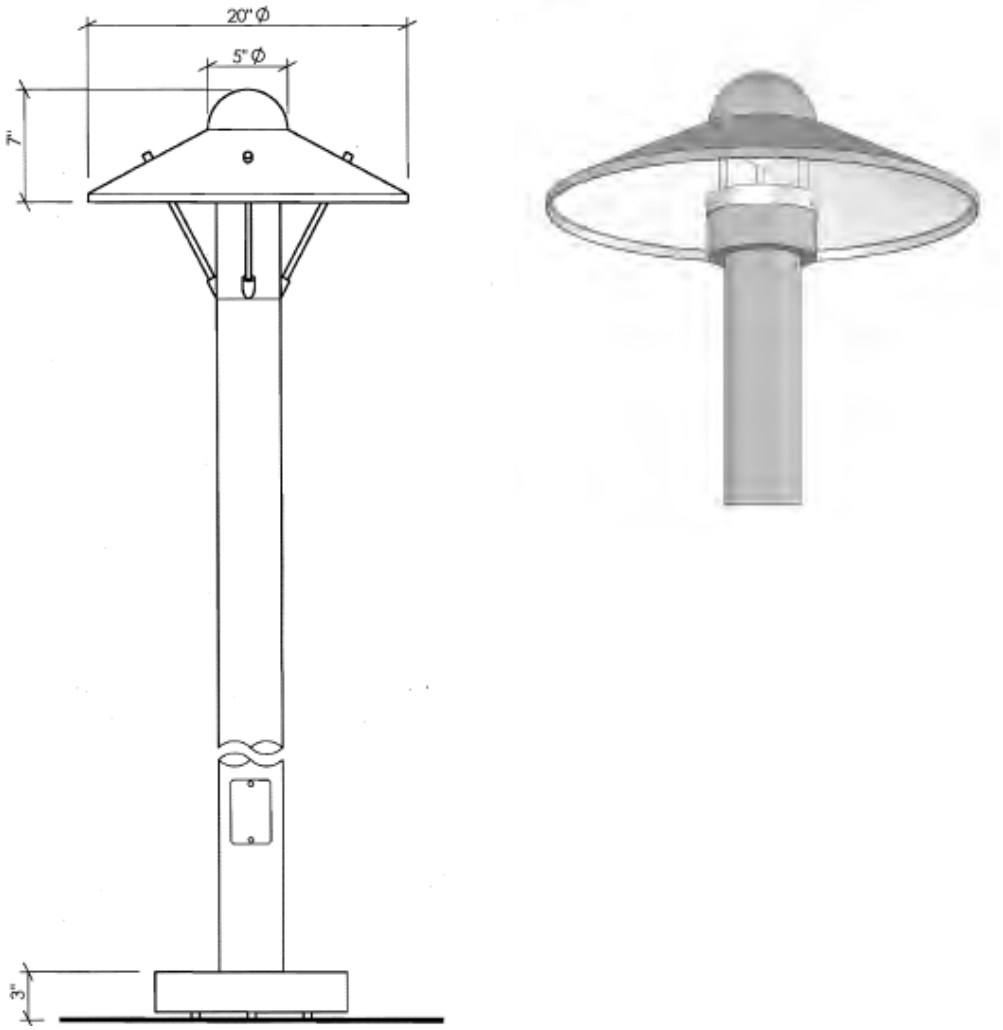


Figure 7 - Technical Detail Short Pole

(Left) The final mockup version of the short pole luminaire. (Right) subsequently developed armless version. Note pole height can vary; 8′ overall is the minimum recommended height; taller poles will cover a larger area. Mockups built by Borden Lighting, San Leandro, 2009 from a design developed by Borden Lighting, Benya Lighting Design, and the Yosemite NPS, DNC and URS personnel.

Bollards

Bollard lights may be used a local low-level light source throughout the park. Their low profile allows them to be installed with a minimum architectural impact. The standard height of bollard lighting is 3.5 feet above adjacent grade. The bollard can employ a standard lighting system or an adaptive lighting system capable of both light level change and color change. A prototype luminaire was tested at the park in January, 2010. Bollards should not be used where they can be damaged by snow removal or pedestrian or bicycle accidents. When these concerns are apparent, use a short pole set back from the path.

Technical

There are two recommended bollard lights. One is in a style to match the short pole light and should employ an LED-powered indirect optical system. The design of the prototype luminaire and pole addresses many issues of maintenance including a bug- and bird-nest shedding skin and simple electric circuitry. The soft optics reduces potential LED glare and are capable of achieving acceptable uniformity over areas to be illuminated. The luminaire should use a modern, low-tech optical system in which the uplight of the lamps is mixed and diffused by the reflector. The luminaire base is a steel or aluminum tube. For each project determine whether to employ direct burial or anchor base. These bollards will employ 500 to 1000 lumens of LED lamps. One half of the lamps will be 2700-3000K white LED, the other half a mixture of red and amber LED's with no radiation at wavelengths shorter than 500 nm. An integral driver will operate all lamps for approximately 120 minutes after being energized, and then begin a slow fade to just red and amber lamps.

The second type employs a fully shielded wedge shaped standard lamp luminaire mounted to a post concrete or granite post. A low wattage compact fluorescent lamp or an LED source can be used. Luminaire light sources should not exceed about 1000 lumens in most cases. Color changing LED should always be considered when all night operation is intended. See the wall luminaire section, below for more discussion of the wedge luminaire.

Typically, layout procedures are consistent with industry standards and lighting criteria from these standards. Use of a modern point-by-point computer program may be required to confirm the performance of specific layouts.

Figure 8 - Bollards

Design Considerations

The specific design of the rounded-top bollard is the result of several years of considerations and two mockups. The post and light bollard was installed at Yosemite Lodge in 1998 and is an appropriate style for the architecture and application. They have proven to be durable, and the height of the post and the mounting height of the luminaire can be modified to raise the luminaire to address snow or other conditions of the site.

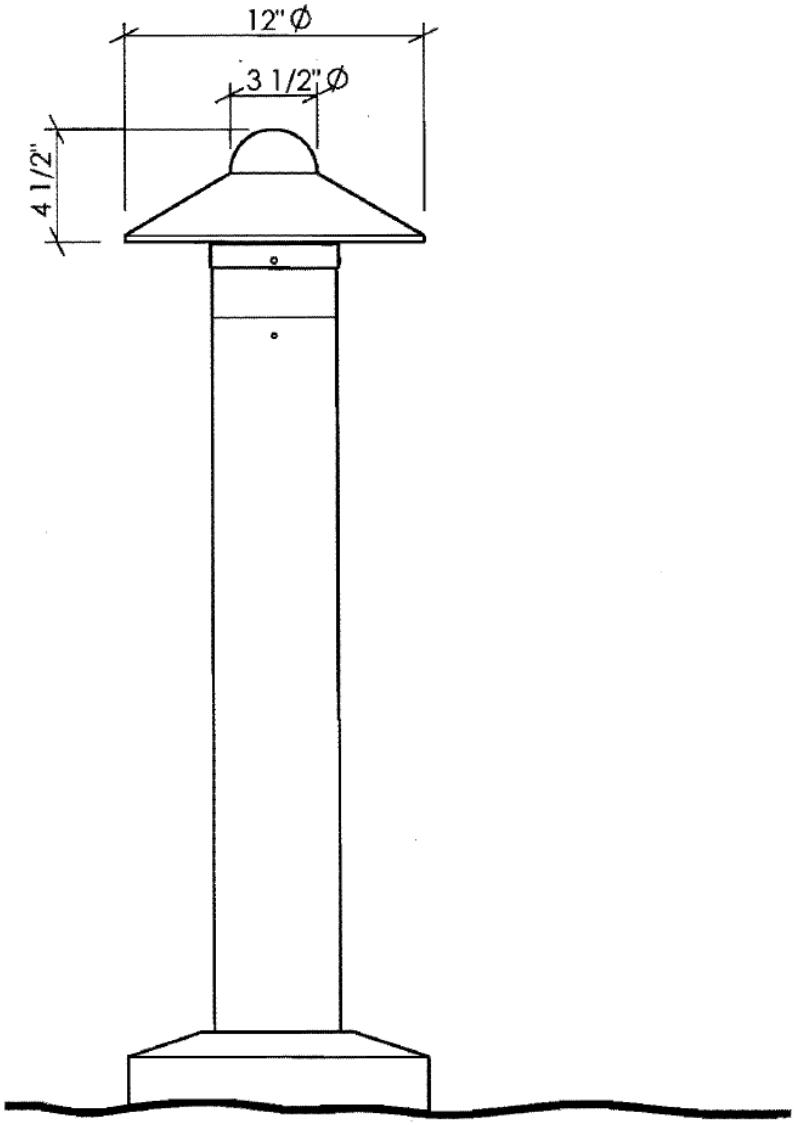


Figure 9 – Preferred Bollard

The final mockup versions of the bollard luminaire. Mockup built by Borden Lighting, San Leandro, 2010 from a design developed by Borden Lighting, Benya Lighting Design, and the Yosemite NPS, DNC and URS personnel.

Wall Lights (sconces and lanterns)

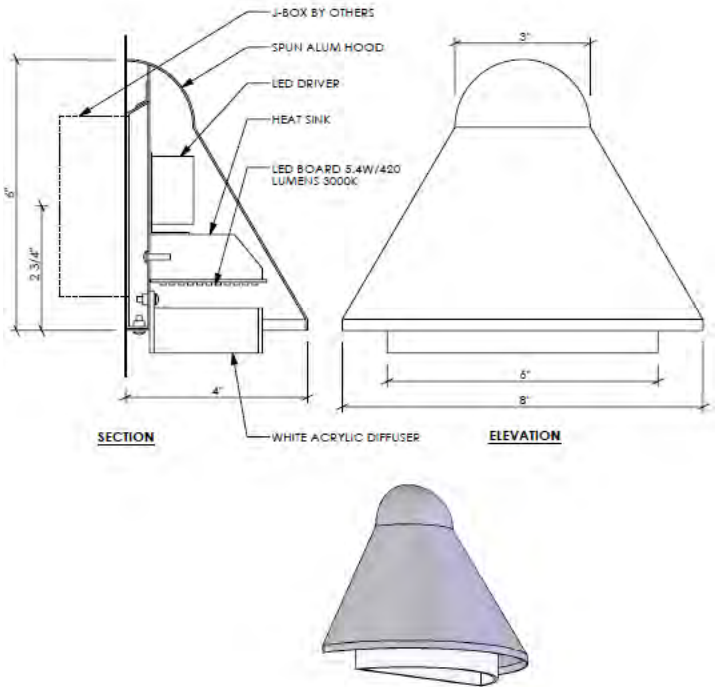
Uses

Wall Lights should be used where needed throughout the park. They should be used to illuminate entry doors, steps, and circulation areas near buildings. In most cases, there is already an existing luminaire to replace; in new construction, use wall luminaires sparingly. There is no standard height as wall lights and wall lights should be installed where they appear architecturally appropriate.

For locations not visible to the public and enclosed, such as equipment or material storage areas, consider the less costly commercial "wall pack" later in this section.

Technical

There are two recommended wall lights. One is in a style to match the short pole light and bollard and should employ LED lamps. A prototype luminaire has been reviewed by NPS and with the exception of the acrylic diffuser in the illustration below, has been found acceptable. These wall lights should employ up to 1000 lumens of LED lamps using 2700-3000K white LED. Color changing in a manner similar to the pole and bollard may also be considered when wall lights are designed to be on all night. However, the majority of these lights are intended to be switched on the wall and the color function would not achieve its intended purpose.



The mockup version of the wall luminaire. Mockups built by Borden Lighting, San Leandro, 2010 from a design developed by Borden Lighting, Benya Lighting Design, and the Yosemite NPS, DNC and URS personnel. Final version should have a white lens rather than the diffuser shown.

The second type employs the same wedge luminaire used on the alternative bollard. Also up to 1000 lumens of LED lighting should be the basis with adaptive lighting capability.

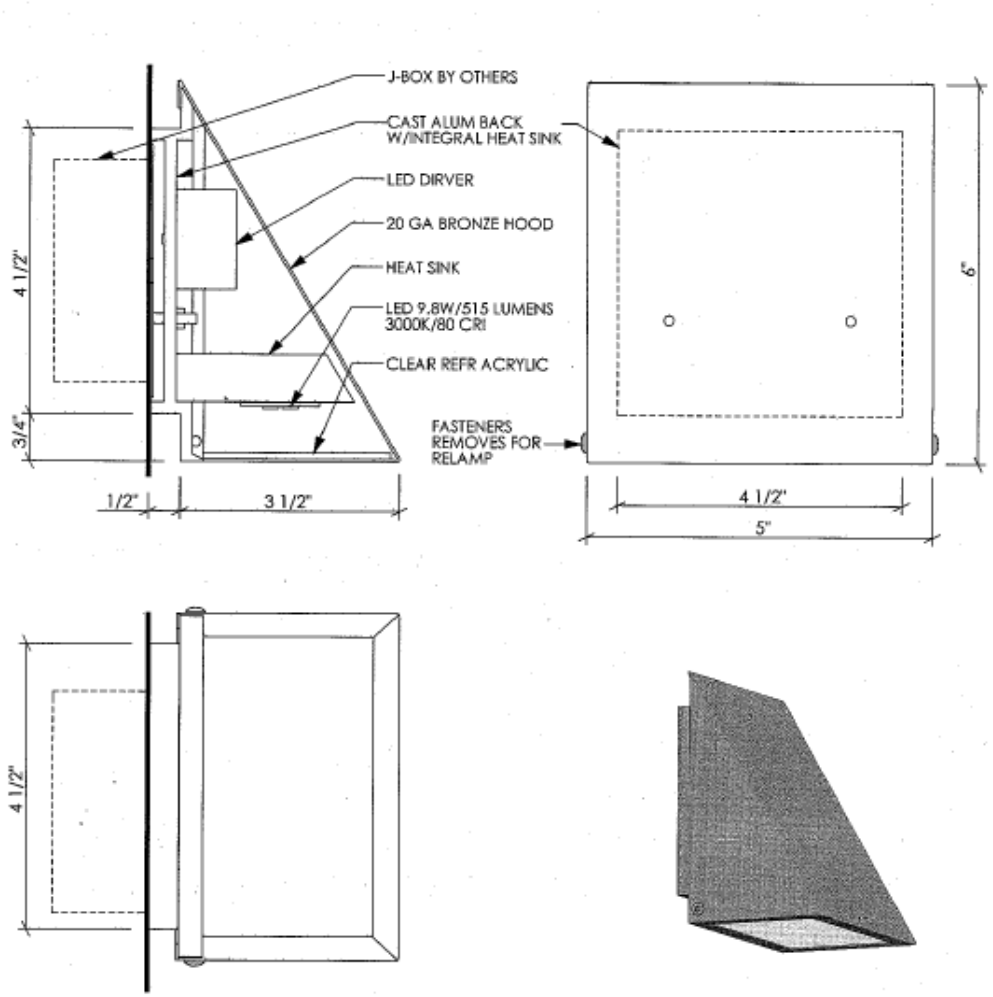


Figure 11 - Wedge Shaped Wall Light

Drawing of the wall luminaire by Borden Lighting, San Leandro, 2010 from a design developed by Borden Lighting with comments from Benya Lighting Design, and the Yosemite NPS, DNC and URS personnel.

For either, procedures are consistent with industry standards and lighting criteria from these standards. Use of a modern point-by-point computer program may be required to confirm the performance of specific layouts.

Design Considerations

The specific design of the wall light is the result of several years of considerations and a mockup. The color and finish of the wall light may vary according to architectural considerations, but generally should be a naturally weathering metal like bronze or a durable paint, typically forest green or brown. Luminaires installed on posts as bollards at Yosemite Lodge are natural bronze.

Although compact fluorescent lamps might be considered in these luminaires, the cost of equivalent LED sources should be evaluated as the lack of maintenance is appealing.

Solar Power

For remote locations, solar power might be employed. As in any solar powered installation, the photocells should get direct sun for as much of the day as possible. Also, storage battery size is critical, especially if the light source is to function in winter.

There are two approaches to solar power:

- Remote photovoltaic (PV) panels with storage battery feeding a group of lights
- Luminaires with integral PV and storage batteries

The former is best if there are a number of luminaires, as the PV can be aimed towards the sun most easily. The latter might be considered for spot uses. Note that access to the direct sun is critical and will limit the use of this technology, especially on the Valley Floor. A motion (occupancy) sensor will prevent operation when no one is present.

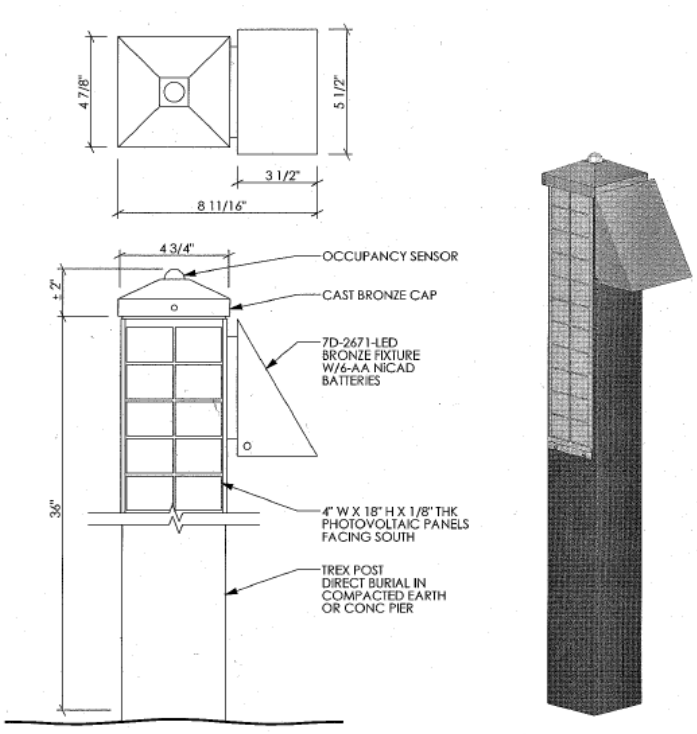


Figure 12 - Self Contained Solar Bollard

The Future - New and Evolving Ideas in Lighting

LED lighting and other technologies are rapidly changing the way lighting is applied. In the long run, these technologies will affect the core philosophies of lighting as durable, long life, low-voltage and low-wattage light sources allow lighting design solutions previously thought to be too costly, too hard to maintain or in some cases, impossible to build.

In addition to the leading edge capabilities of adaptive lighting and superior energy efficiency in conventional lighting, LED sources can be sufficiently small and durable to be used in several ways that literally bend the rules of lighting laid out in these guidelines. Currently envisioned possibilities include:

LED "dot" lights that create wayfinding paths. Each LED gives off about 6 lumens, or about 1/2 of a candle's light and uses 0.1 watt of electric energy. Extremely low power requirements make this system ideally powered by solar panels. Wayfinding lights can be installed in paving, fences, and other mountings where they can be made durable but useful. More powerful systems should be avoided, as they will desensitize night vision.

LED low-level lights to illuminate steps and paths. Operating at around 1 watt and producing about 40 lumens, these small and durable lights can illuminate main trails to about 0.10 fc, or about 10 moons, with a luminaire every 25 feet. Luminaires can be mounted into retaining walls, stair stringers, and any other structure or object such as fence posts.

LED linear lights operating at around 4 watts per foot and producing over 250 lumens per foot, enough to illuminate a bulletin board or sign to easily read light levels or to provide artful linear lighting accents at low light levels and with low power use.

These Guidelines were developed around an existing infrastructure of large and mostly inefficient light sources requiring considerable power and having heat, durability and maintenance constraints. In contrast, solid-state lighting appears to offer many design choices and options that may provide superior lighting without the environmental penalty. As long as the environmental benefits that drove these Guidelines are met, future designers should not hesitate to explore new lighting methods that provide the same (or better) park experience with less environmental damage.