

COUNTY OF SAN DIEGO

GUIDELINES FOR DETERMINING SIGNIFICANCE
AND
REPORT FORMAT AND CONTENT REQUIREMENTS

DARK SKIES AND GLARE



LAND USE AND ENVIRONMENT GROUP

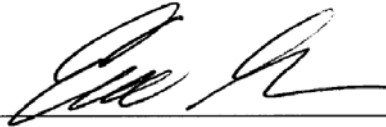
Department of Planning and Land Use
Department of Public Works

July 30, 2007

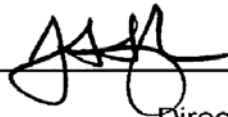
Modified January 15, 2009

APPROVAL

I hereby certify that these **Guidelines for Determining Significance and Report Format and Content Requirements for Dark Skies and Glare** are a part of the County of San Diego, Land Use and Environment Group's Guidelines for Determining Significance and Technical Report Format and Content Requirements and were considered by the Director of Planning and Land Use, in coordination with the Director of Public Works on the 30th day of July, 2007.



ERIC GIBSON
Interim Director of Planning and Land Use



JOHN SNYDER
Director of Public Works

I hereby certify that these **Guidelines for Determining Significance and Report Format and Content Requirements for Dark Skies and Glare** are a part of the County of San Diego, Land Use and Environment Group's Guidelines for Determining Significance and Technical Report Format and Content Requirements and have hereby been approved by the Deputy Chief Administrative Officer (DCAO) of the Land Use and Environment Group on the 30th day of July, 2007. The Director of Planning and Land Use is authorized to approve revisions to these Guidelines for Determining Significance and Report Format and Content Requirements for Dark Skies and Glare except any revisions to the Guidelines for Determining Significance presented in Section 4.0 must be approved by the DCAO.

Approved, July 30, 2007



CHANDRA WALLAR
Deputy CAO

COUNTY OF SAN DIEGO

GUIDELINES FOR DETERMINING SIGNIFICANCE

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LAND USE AND ENVIRONMENT GROUP

Department of Planning and Land Use
Department of Public Works

July 30, 2007

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EXPLANATION

These Guidelines for Determining Significance for Dark Skies and Glare and information presented herein shall be used by County staff for the review of discretionary projects and environmental documents pursuant to the California Environmental Quality Act (CEQA). These Guidelines present a range of quantitative, qualitative, and performance levels for particular environmental effects. Normally, (in the absence of substantial evidence to the contrary), non-compliance with a particular standard stated in these Guidelines will mean the project will result in a significant effect, whereas compliance will normally mean the effect will be determined to be “less than significant.” Section 15064(b) of the State CEQA Guidelines states:

“The determination whether a project may have a significant effect on the environment calls for careful judgment on the part of the public agency involved, based to the extent possible on factual and scientific data. An ironclad definition of significant effect is not always possible because the significance of an activity may vary with the setting.”

The intent of these Guidelines is to provide a consistent, objective and predictable evaluation of significant effects. These Guidelines are not binding on any decision-maker and do not substitute for the use of independent judgment to determine significance or the evaluation of evidence in the record. The County reserves the right to modify these Guidelines in the event of scientific discovery or alterations in factual data that may alter the common application of a Guideline.

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List of Acronyms

Caltech	California Institute of Technology
CEQA	California Environmental Quality Act
CSU	California State University
IESNA	Illuminating Engineering Society of North America
ILE	Institution of Lighting Engineers
LPC	Light Pollution Code
LRC	Rensselaer Polytechnic Institute, Lighting Research Center
NASA	National Aeronautics and Space Administration
NLPIP	National Lighting Product Information Program
SDSU	San Diego State University

INTRODUCTION

This document provides guidance for evaluating adverse environmental effects that a proposed project may have related to dark skies and glare. Specifically, this document addresses the following question listed in the California Environmental Quality Act (CEQA) Guidelines, Appendix G, I. Aesthetics:

- d) Would the proposed project create a new source of substantial light or glare which would adversely affect day or nighttime views in the area?

These Guidelines address dark skies in relation to recreation and community character, human health, and astronomical research. Dark skies at night are also important to plants and wildlife. Dark skies in relation to biological resources are addressed in the Guidelines for Determining Significance – Biological Resources.

1.0 GENERAL PRINCIPLES AND EXISTING CONDITIONS

The night sky is part of our environment. Before the commercialization of the light bulb about 130 years ago the night sky around the world was dark, so dark that the Milky Way could be seen. Now, light has amassed in cities and regions to a point that the artificial lighting of dark night skies (light pollution) has become an environmental issue. Approximately 40 percent of the U.S. population lives where night brightness is too intense for the human eye to use night vision. Two-thirds of Americans cannot see the Milky Way from their backyards and nearly all live in places with measurable light pollution. Dark night skies, for the first time in history, are becoming an extinct phenomenon. Researchers predict that at the current rate of increasing light pollution, by 2025 no dark skies will remain in the continental United States.

Outdoor lighting has become a part of our 24-hour modern society and is used to illuminate areas such as roadways, parking lots, private yards, signs, and work sites. Excessive outdoor lighting can brighten our dark skies impacting the community character of rural areas, views of the night sky, ecosystems, and astronomical research. Outdoor lights installed in homes, businesses, street lights and billboards are often too bright and aimed upwards or sideways. The light scatters through the atmosphere above and brightens the night sky, diminishing the view of the stars and other celestial bodies. Unnecessary lighting of the night accounts for excess fossil fuel consumption, which contributes to global warming. The International Dark-Sky Association estimates that one-third of all lighting in the U.S. is wasted, at an annual cost of about 30 million barrels of oil and 8.2 million tons of coal (Bower 2000).

The Light Pollution Code (LPC), also known as the Dark Sky Ordinance, was adopted "to minimize light pollution for the enjoyment and use of property and the night environment by the citizens of San Diego County and to protect the Palomar and Mount Laguna observatories from the effects of light pollution that have a detrimental effect on astronomical research by restricting the permitted use of outdoor light fixtures on private property" (Sec. 59.101).

1.1 Benefits of Dark Skies

Dark skies have benefits to nature, humans and astronomical research.

1.1.1 Recreation and Community Character

The dark sky is a natural resource and a spectacular natural wonder highly valued in San Diego County. It allows views of the constellations and astronomical phenomena and is often considered part of the character of undeveloped areas and rural communities. Only with a dark sky can the Milky Way be viewed. Whether living in a community under a dark sky or experiencing it during a camping trip, people generally regard the stars that can be seen in the dark sky as beautiful and inspiring.

1.1.2 Human Health and Safety

Humans need periods of darkness to maintain the body's circadian rhythms. These cycles affect behavioral rhythms, daily changes in blood and urine chemistry, and the production of melatonin, a hormone involved in regulating the sleep-wake cycle, body temperature, endocrine functions and a number of disease processes including heart attack, stroke and asthma (U.S. Department of Health and Human Services 2005).

1.1.3 Astronomy

Dark skies are essential to the study of the celestial bodies. Astronomical research has contributed to a greater understanding of our solar system, supported advances in space travel, improved telecommunication systems, defense and surveillance systems, advanced weather forecasting and atmospheric physics, and provided insight to energy production. The maintenance of dark skies in San Diego County is vital to the two world-class observatories that depend on them for astronomical research; Palomar and Mount Laguna Observatories. These observatories are such important fixtures of San Diego County that the County Seal includes an observatory atop a mountain (see right).



Only a few high-quality astronomical research sites exist in the United States. As two of the best, Palomar and Mount Laguna Observatories currently meet all of the criteria to be classified as premier astronomical sites. The five criteria for a high-quality site include:

- a) Elevation over 5,000 feet above sea level. A moderately high elevation is necessary to reduce the scattering of light by dust in the lower atmosphere and to place observatories above the marine layer. Very high mountains are of diminished value because of increased cloudiness and snowfalls, and frequently very high winds.

- b) Clear, cloud-free night sky. Mount Palomar and Mount Laguna are the nation's best continental mountain sites in this respect with an average of 6.4 cloud-free hours per night.
- c) Proximity to the Pacific Ocean. The prevailing on-shore winds at the moderate altitudes of the local observatories provide dust-free and smooth laminar air flow over the observatory mountain tops, which results in stable celestial images. In contrast, the Atlantic Ocean has primarily warm air currents, which when combined with cool air can cause atmospheric turbulence that produces inferior and blurred images. Desert sites, while dark, generally suffer from convective turbulence produced by the daily heating and nighttime cooling cycle, and also from increased dust contamination.
- d) Distance from urban areas. The site must be far enough from large lighted areas, generally 30-40 miles, so that the sky over the observatory will not be brightened appreciably. In relative terms, the 200-inch mirror at the Palomar Observatory is strong enough to detect the striking of a match at a point as far away as San Francisco.
- e) Freedom from nearby sources of light, dust and smoke. A light source at a 1 mile distance has 1,600 times the impact on an observatory as an equivalent light at 40 miles distance. Smoke and dust, even in extremely small amounts, are also highly detrimental to observatories because they increase the scattering of stray light down into the telescope from above.

Sites in the continental United States that meet these criteria are found only in West Texas, Central New Mexico, Arizona, the Central California coast, and San Diego County.

1.1.3.1 Palomar Observatory

Palomar Observatory, located at the top of Palomar Mountain (5,500 feet elevation) in northern San Diego County, is privately owned and operated by the California Institute of Technology (Caltech) and is used to support some of California's and the United States' premier scientific research programs. Caltech shares use of their Hale Telescope at the Palomar Observatory with astronomers from Cornell University and the National Aeronautics and Space Administration's (NASA) Jet Propulsion Laboratory. The observatory's newest telescope was added to the mountain in 2006. The principal instruments at Palomar include the:

- 200-inch Hale Telescope;
- 48-inch Samuel Oschin Telescope;
- 60-inch reflecting telescope; and
- Palomar Testbed Interferometer, operated by the Jet Propulsion Laboratory.

In 1934, Palomar Mountain was selected after testing numerous locations for the right atmospheric conditions as the best site to replace the Mount Wilson Observatory. Mount Wilson, in the San Gabriel Mountains of Southern California, offered excellent atmospheric conditions but even when it was selected suffered greatly from the skyglow caused by the lights of Los Angeles. Corning Glass Works in New York State successfully cast the new 200-inch Pyrex glass disk, later to become the 200-inch mirror of Palomar's Hale Telescope, the most integral component of the newly commissioned telescope, in December 1934. Greatly delayed by World War II, the 200-inch telescope was dedicated in 1948. While technology has improved in the last fifty years, the actual Hale Telescope and the observatory facility is as effective now as it was when installed. Through the use of modern electronic detectors and adaptive optics the Hale Telescope surpasses the resolving power of space-based telescopes.

Scientific research at the Palomar Observatory has been remarkably successful and productive. The Hale and the other telescopes at Palomar have been used on virtually every clear night to provide astronomers with the information they need to continue to advance the science of astronomy. The scope of research ranges from studies of near-earth asteroids and distant worlds within our solar system to the stars that comprise the Milky Way, and the uncharted and unknown galaxies beyond our own.

1.1.3.2 Mount Laguna Observatory

San Diego State University (SDSU) and the University of Illinois jointly operate the Mount Laguna Observatory. Located at an altitude of 6,100 feet on the eastern edge of the Cleveland National Forest near the Anza-Borrego State Park, 45 miles east of downtown San Diego, the Mount Laguna Observatory is one of the best astronomical research sites and educational facilities in the nation. The Observatory was dedicated on June 19, 1968, only seven years after Astronomy became a new department on the SDSU campus. The Department currently is building a larger 100-inch glass telescope with a projected cost of approximately \$6 million (Etzel, 2007). San Diego State University is the only institution in the 23-campus California State University (CSU) system to have both a degree-granting Astronomy Department and major research-grade observatory facilities. Approximately one third of other CSU campuses have astronomers as faculty members and offer astronomy classes. Visiting researchers and students also use the SDSU facilities at Mount Laguna. Sky conditions at Mount Laguna enable the astronomers to conduct their observations almost year-round. The Observatory maintains the Buller 21-inch telescope for public outreach and operates a free Summer Visitors Program jointly with the United States Forest Service during which the public is given an astronomical lecture and then given the opportunity to look through the Buller telescope.

For those reasons stated above, the County is committed to ensuring that these valuable resources continue to operate and function for future generations. Conscious efforts must be made to protect the Palomar and Mount Laguna observatories from the effects of light pollution that has a detrimental effect on astronomical research. One way is by restricting the permitted use of outdoor light fixtures on private property.

2.0 EXISTING REGULATIONS AND STANDARDS

The following list details the most significant regulations that address light pollution and glare impacts in the State of California and the County of San Diego.

2.1 State Regulations and Standards

California Environmental Quality Act (CEQA) [Public Resources Code 21000-21178; California Code of Regulations, Guidelines for Implementation of CEQA, Appendix G, Title 14, Chapter 3, §15000-15387. http://ceres.ca.gov/topic/env_law/ceqa/guidelines]

Under the California Environmental Quality Act (CEQA), State and local agencies are required to consider impacts to aesthetic resources.

California Energy Code [California Code of Regulations, Title 24, Part 6.]

The California Energy Code creates standards in an effort to reduce energy consumption. The type of luminaires and the allowable wattage of certain outdoor lighting applications are regulated.

2.2 Local Regulations and Standards

The San Diego County Light Pollution Code [(Title 5, Div.9, Sections 59.101-59.113 of the County Code of Regulatory Ordinances) as added by Ordinance No 6900, effective January 18, 1985, and amended July 17, 1986 by Ordinance No. 7155 and April 20, 2005 by Ordinance No. 9716.]

The Light Pollution Code (LPC), also known as the Dark Sky Ordinance, was adopted "to minimize light pollution for the enjoyment and use of property and the night environment by the citizens of San Diego County and to protect the Palomar and Mount Laguna observatories from the effects of light pollution that have a detrimental effect on astronomical research by restricting the permitted use of outdoor light fixtures on private property" (Sec. 59.101). Parties involved in the development of LPC included representatives from the San Diego County Department of Planning and Land Use, the Department of Public Works, as well as members of the lighting industry, community planning and sponsor groups, representatives from both of San Diego County's observatories, and San Diego Gas and Electric Company (SDG&E).

The LPC regulates applicants for any permit required by the County for work involving outdoor light fixtures, unless exempt. Exempt fixtures include certain ones existing prior to January 18, 1985, those producing light via fossil fuels, those on or connected with facilities and land owned or operated by the federal government or the State of California, holiday decorations, and U.S or California illumination. Special provisions are made for airports and correctional institutions (Sec. 59.108).

The Code was established to limit harmful effects of outdoor lighting on the Palomar and Mount Laguna Observatories. The LPC designates all areas within a fifteen (15) mile radius of each observatory as Zone A, with all other areas of the County designated as Zone B. Zone A has more stringent lighting restrictions, including limits on decorative lighting, so that night skies are dark enough for clear viewing through the telescopes at the observatories,.

San Diego County General Plan, Conservation Element (Part X), Chapter 7 Astronomical Dark Sky [http://www.ceres.ca.gov/planning/counties/San_Diego/plans.html]

The San Diego County General Plan Conservation Element's Chapter on Astronomical Dark Sky discusses the importance of maintaining dark skies in the County. This chapter makes several findings pertaining to suitable observatory site criteria. It also sets out several policy and action programs designed to limit light pollution and ensure the protection of dark skies, including minimizing the impacts of development on the useful life of the observatories, assisting in the regulation of dark sky conservation, amending ordinances to control potentially significant adverse effects to Palomar and Mount Laguna Observatories, and designing future roadways and development in a way suitable for the protection of dark skies near the observatories.

San Diego County Zoning Ordinance, Performance Standards [Section 6320, 6322 and 6324, <http://www.co.san-diego.ca.us/dplu/zoning/index.html>]

Section 6320 of the Zoning Ordinance has performance standards for glare for all commercial and industrial uses in residential, commercial and identified industrial zones. All commercial and industrial uses subject to this section shall be operated in a manner that does not produce glare, which is readily detectable without instruments by the average person beyond the stated zones in this section. Section 6322 controls excessive or unnecessary outdoor light emissions which produce unwanted illumination of adjacent properties by restricting outdoor lighting usage. Section 6324 establishes limitations upon lighting permitted in required yards by section 4835; of particular importance is the limitation upon light trespass (not to exceed a value of 0.2 foot-candles measured five feet onto the adjacent property).

3.0 TYPICAL ADVERSE EFFECTS

3.1 Nighttime Lighting

Rapid growth and urban sprawl in southern California has resulted in significant increases in nighttime light, which is produced primarily by upward pointing or upward reflected light from outdoor lighting. This type of lighting illuminates the nighttime sky from below, just as the sun does from above in the daytime and can be detrimental to astronomical observations by impacting dark skies. Nighttime light that spills outside its intended area and lighted signs can be annoying to neighbors and potentially harmful to motorists, cyclists, and pedestrians. Further, the health of humans and natural wildlife can also be adversely affected from nighttime light.

Nighttime lighting in excess of what is necessary for its purpose is called light pollution. Light pollution cannot be completely eliminated, but it can be minimized to save dark skies and to decrease energy consumption. For this reason, nearly all outdoor lighting can be said to produce some amount of light pollution, which contributes to “skyglow” seen by the casual observer.

The Rensselaer Polytechnic Institute, Lighting Research Center (LRC) states light pollution results in three primary effects, “skyglow, light trespass and glare.”

- a) Skyglow is the result of brightening of the night sky from both artificial (outdoor) and natural (atmospheric and celestial) light.
- b) Light trespass is a result of spill light shining in undesirable locations, such as a neighbor’s backyard or bedroom window. Spill light is light cast beyond the parameters of useful light or the intended area to be lit.
- c) Glare is a continuous or periodic intense light that is greater than the luminance to which the eyes are adapted and may cause annoyance, discomfort or visual impairment.

3.1.1 Skyglow

Skyglow brightens the night sky. The sky has a certain minimal brightness even in the most pristine, unspoiled environment and each additional source of light contributes to nighttime lighting and can increase sky brightness. A typical suburban sky is five to ten times brighter than the natural sky. In city centers the sky may be twenty-five to fifty times brighter (Brucato, March 2002).

Increased development with artificial lighting components that can contribute to skyglow, include roadway/walkway lighting, security lighting, decorative and landscape lighting, building lighting (including residential, commercial, industrial), and site lighting. Lighting of vertical surfaces such as billboards, signs, buildings and landscaping is especially problematic, because the light is often emitted upward into the atmosphere, resulting in uplight and ultimately increased skyglow. Skyglow is caused by artificial light shining into the sky being reflected back to the earth by moisture and air pollutants, such as dust and other particulates. Uplight is direct upward light that illuminates the night sky at an angle greater than 90° from nadir. As a point of reference, nadir is 0° or the ground and is the opposite of zenith. Zenith is the point directly skyward at an angle of 180°.

At one time, street lighting was considered the largest single source of skyglow contributing 25% to 30% of all skyglow in urbanized areas. However, in areas such as Los Angeles where lighting fixtures were retrofitted with cutoff lenses, this figure has been drastically reduced. In San Diego County, most cities have been retrofitting street lighting fixtures to reduce light pollution (Petersen, April 2002). After streetlights, area lighting (parking lots), outdoor sales lighting (car sales, etc.), and recreation sites

(stadiums, etc.) are considered the most significant sources of skyglow (Brucato, March 2002).

The LRC states, “Skyglow is of most concern to astronomers because it reduces their ability to view celestial objects. Skyglow increases the brightness of the dark areas of the sky, which reduces the contrast of stars or other celestial objects against the dark sky background.” Therefore, outdoor lighting in the vicinity of the two observatories is a critical concern and can directly impact their nighttime views.

3.1.2 Light Trespass

Light trespass is a result of spill light shining in undesirable locations, such as a neighbor’s backyard or bedroom window. Typical examples include streetlights or floodlights that are not angled or shielded correctly and invade areas on a neighbor’s property that are desired to be kept darker. Spill light shining into neighboring homes at night can disrupt sleep patterns and internal cycles in humans. In addition, disturbing natural patterns of light and dark in adjacent habitats influences many aspects of animal behavior and life cycles, and can disrupt whole ecosystems (Harder 2002).

Exterior light sources can create light trespass according to type, location, wattage, height, direction of lighting patterns, type of shielding, when in use, and whether the light is steady or pulsating. The Commission Internationale de l’Eclairage and the LRC compare the effects of higher and lower mounted luminaires as outlined below:

Higher mounting heights can often be more effective in controlling spill light, because floodlights with a more controlled light distribution (i.e., narrower beam) may be used, and the floodlights may be aimed in a more downward direction, making it easier to confine the light to the design area. Lower mounting heights increase the spill light beyond the property boundaries. To illuminate the space satisfactorily, it is often necessary to use floodlights with a broader beam and to aim the floodlights in directions closer to the horizontal than would occur when using higher mounting heights. Lower mounting heights make bright parts of the floodlights more visible from positions outside the property boundary, which can increase glare.

Figures 1 and 2 show how a higher mounting height compares to a lower mounting height for providing a given amount of light.

Figure 1
Beam Angle with Floodlight at a High Mounting Height

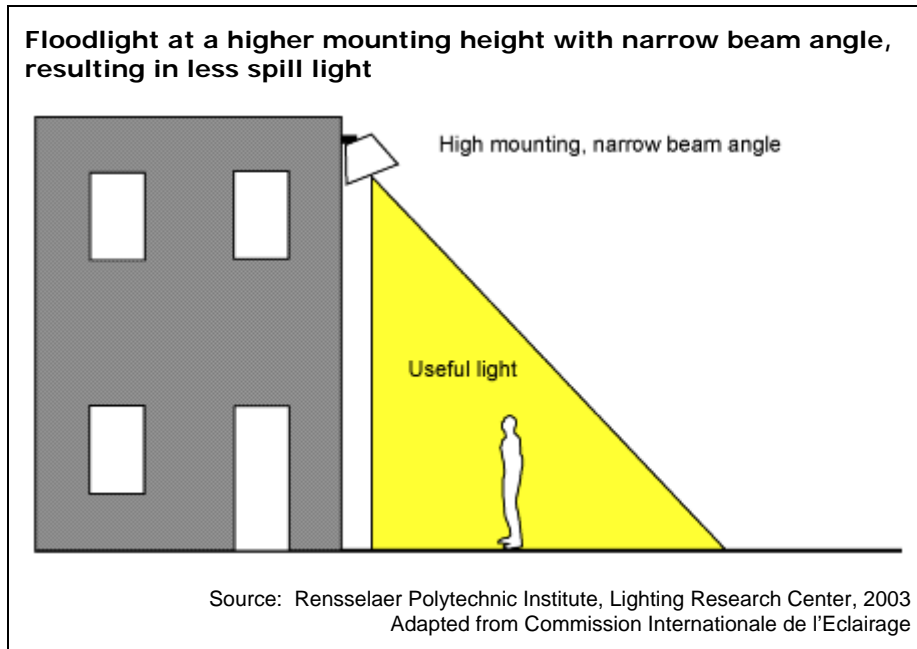
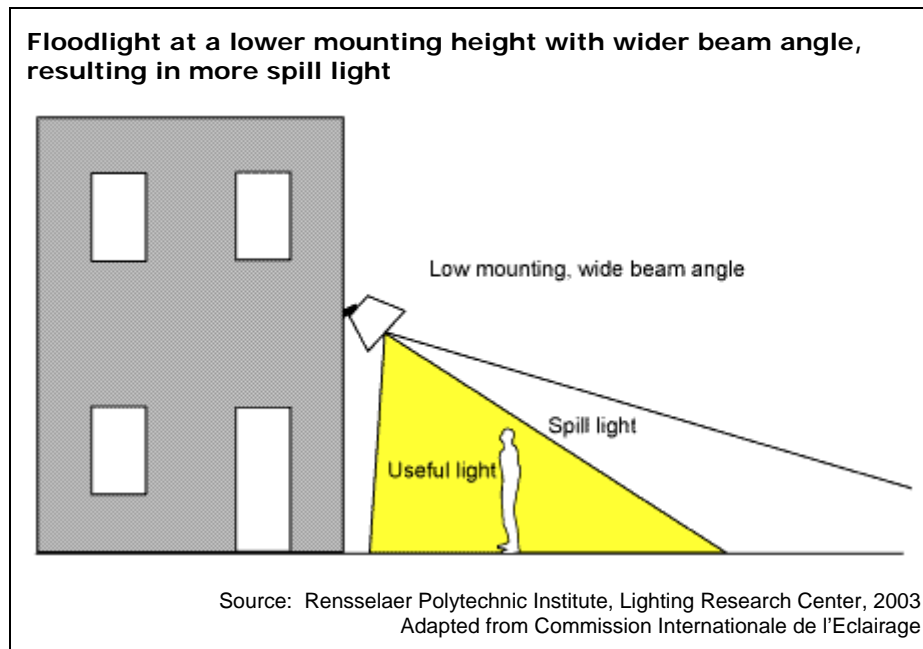


Figure 2
Beam Angle with Floodlight at a Low Mounting Height



3.1.3 Glare

Glare is the result of sharply reflected light caused by sunlight or artificial light reflecting from highly finished surfaces such as window glass or brightly colored surfaces, and the direct view of a bright, unshielded light source. The LRC details that glare can be uncomfortable (discomfort glare) or disabling (disability glare). The level of receptors' sensitivity to glare can vary widely. Older people and infants are usually more sensitive to glare due to the age of or developmental stage of their eyes. Glare decreases visibility, which is usually contrary to the reasons for installing outdoor lighting.

A project can cause glare through the type of exterior building materials used, the type of activities undertaken, or the type of exterior lighting employed. Potentially reflective exterior building materials can affect motorists, cyclists, pedestrians or other persons within sight of the project dependent upon the position of the sun, outdoor lighting and/or building materials. Additionally, activities can create glare dependent upon the type of activity performed, the hour the activity is performed, where on the property the activity is performed, and what types of shielding/screening are employed.

3.2 Measuring Light

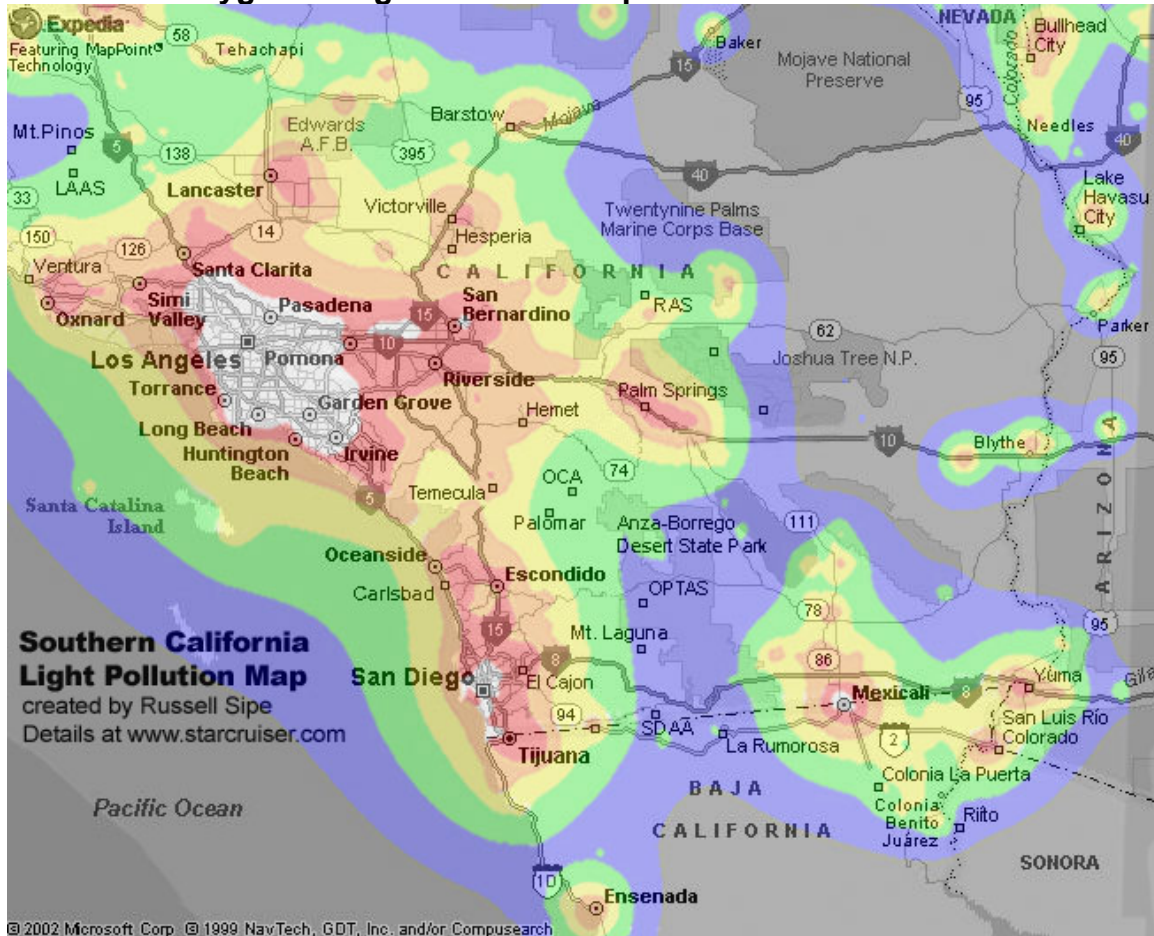
The County relies on standard measurements of luminous intensity to measure illuminance (light falling on a surface area) or luminance (light reflected from a surface area) (Petersen, February 2002). The standard measurements the County uses are:

- a) Foot-candle is the primary measure of light intensity; one foot-candle equals one lumen per square foot.
- b) Lumen is a unit of measurement used for the light, equal to one foot-candle falling on one square foot of area.
- c) Lux is a unit of illumination equal to one lumen per square meter or equal to the illumination of a surface uniformity one meter distant from a point source of one candle.
- d) Light pattern is the area of direct illumination from a light source.
- e) Light source is any artificial device that produces illumination, including incandescent bulbs, fluorescent and neon tubes, halogen and other vapor lamps, and reflecting surfaces or refractors incorporated into a lighting fixture. Any translucent enclosure of a light source is considered to be part of the light source.
- f) Point of Overlap is the highest point vertically from ground level at which adjacent light patterns overlap.

Astronomers measure skyglow in "magnitudes per square arc second", which is a measure of sky brightness. Illuminance and luminance are based on ground level

measurement. Skyglow is composed of both natural and artificial components. Figure 3 is a color-coded map that illustrates the effects of nighttime light on skyglow in Southern California as measured at the zenith (directly overhead) in the “visual” band (yellow region of the spectrum).

Figure 3
Skyglow – Light Pollution Map of Southern California



© 2002 Microsoft Corp. © 1999 NavTech, GDT, Inc. and/or CompuSearch
 Source: Russell Sipe, 2002 http://www.sipe.com/starcruiser/observatory/html/observations_report03_01.html 2002
 Adapted from Cinzano et al. 2001 “The first World Atlas of the artificial night sky brightness.”

The data employed were obtained by the US Air Force Defense Meteorological Satellite Program to model artificial sky brightness (Cinzano et al., 2001). The sky brightness (skyglow) values were overlaid onto a map of Southern California (Sipe, 2002), which clearly shows the effects of light pollution from urban development.

The seven color-coded zones correspond to:

1. Black – Natural skyglow, with only traces of light pollution
2. Blue – Light pollution a maximum 10% increase over natural skyglow
3. Green – Light pollution a maximum 50% increase over natural skyglow

4. Yellow – Light pollution a maximum 100% increase over natural skyglow
5. Orange – Milky Way no longer visible (rural areas adjacent to suburbs)
6. Red – Less than 100 of the brightest stars visible (suburban areas)
7. White – Only the brightest stars visible (urban core areas)

Presently at Mount Laguna, the skyglow in the “visual” or yellow region of the spectrum is less than 10% above the natural level at the zenith on dark moonless nights. However, total skyglow there has increased by 50% over the last 30 years, and the increase has been in all wavelengths (colors). Over the last 20 years, such measures at the zenith have shown about a 30% increase in the blue and yellow spectrum, and much less in the red. In the red spectrum, Mount Laguna Observatory is still a very viable dark astronomical site, comparable to the very remote and dark site at Apache Point, New Mexico. From Mount Laguna, the view of the sky toward the City of San Diego appears much brighter to the naked eye than it did 20 years ago, but much of it is in the isolated wavelength of the sodium D-lines at 5900 Angstroms, which can be effectively removed by electronic detectors via filtering (Etzel, March 2002).

Measuring skyglow is not an easy task; it is a dynamic measurement, affected by such factors as the time of night, the amount of dust in the high atmosphere, and clouds, especially coastal clouds. Astronomers measure the effects of skyglow when they want to measure the brightness of a star, galaxy, or quasar. They make two measurements: (1) the combined brightness of the object and the surrounding patch of sky and (2) a patch of blank sky (no stars, etc.) of exactly the same area. Subtracting (2) from (1) gives the brightness of the object being studied. Since the astronomers are interested in the object itself, they generally do not make a note of the sky brightness. The current sky brightness at Palomar Observatory is approximately twice the natural level (Brucato, March 2002).

Increasing skyglow from light pollution places severe constraints on the ability of astronomers to observe fainter objects regardless of filtering or enhanced techniques. For example, if the sky brightness increases by a factor of two, one needs to double the exposure time to obtain an accurate answer. Typically, the exposure times required in astronomy are hours and doubling the time needed to obtain a result can be a severe penalty (Brucato, March 2002). Furthermore, if it takes four hours of observation time to view some of these objects now, then the “inflationary” effects of light pollution will likely make it impossible to observe certain objects because they are not observable for eight hours during a night. In general, as sky brightness increases the limited observing time will make it impossible to observe as many objects. It would force the observatories to restrict their research projects to fewer kinds of objects and limit them only to brighter celestial (natural) objects (Etzel, March 2002).

4.0 GUIDELINES FOR DETERMINING SIGNIFICANCE

The following significance guidelines should guide the evaluation of whether a significant impact to dark skies or from glare will occur as a result of project implementation. A project will generally be considered to have a significant effect if it proposes any of the following, absent specific evidence to the contrary. Conversely, if a project does not propose any of the following, it will generally not be considered to have a significant effect on dark skies or from glare, absent specific evidence of such an effect:

- 1. The project will install outdoor light fixtures that do not conform to the lamp type and shielding requirements described in Section 59.105 (Requirements for Lamp Source and Shielding) and are not otherwise exempted pursuant Section 59.108 or Section 59.109 of the San Diego County Light Pollution Code.***
- 2. The project will operate Class I or Class III outdoor lighting between 11:00 p.m. and sunrise that is not otherwise exempted pursuant Section 59.108 or Section 59.109 of the San Diego County Light Pollution Code.***
- 3. The project will generate light trespass that exceeds 0.2 foot-candles measured five feet onto the adjacent property.***
- 4. The project will install highly reflective building materials, including but not limited to reflective glass and high-gloss surface color, that will create daytime glare and be visible from roadways, pedestrian walkways or areas frequently used for outdoor activities on adjacent properties.***
- 5. The project does not conform to applicable Federal, State or local statute or regulation related to dark skies or glare, including but not limited to the San Diego County Light Pollution Code.***

The first and second significance guidelines, which rely on the lamp and shielding requirements and hours of operation standards established in the LPC, have been determined to effectively reduce impacts on dark skies. The standards are the result of a collaborative effort from technical lighting experts, astronomers, and County staff to effectively address and minimize the impact of light pollution on dark skies. The standards were developed in cooperation with lighting engineers, astronomers, SDG&E, Palomar and Mount Laguna observatories, San Diego County Department of Planning and Land Use and Department of Public Works, and local community planning and sponsor groups. The LPC was written specifically to ensure that new outdoor lighting would have minimal impacts on astronomical observatories.

The third significance guideline relies on the light trespass restriction specified in the County Zoning Ordinance to effectively reduce impacts on dark skies. It also aims at reducing or eliminating light trespass into neighbors' yards and windows and/or into

adjacent habitats. As with the LPC, the light trespass requirements are the result of a collaborative effort from technical lighting experts, astronomers, and County staff to effectively address and minimize the impact of light pollution on adjacent properties.

It should be noted that there is always some level of naturally occurring nighttime illuminance. For instance the typical illuminance from moonlight is 0.03 foot-candles. Coupled with artificial lighting in our 24-hour society nighttime illuminance is typically higher than the natural occurring prevalent level, especially in urban and suburban areas. Therefore, a project that will directly illuminate adjacent properties and contribute to a level of light trespass in excess of established foot-candles will generally result in a potentially significant impact. As specified in the Zoning Ordinance, the property line, as opposed to structures, has been chosen as the point where light trespass or unwanted light may affect a neighbor.

These provisions of the Zoning Ordinance were adopted specifically to ensure that new outdoor lighting would have minimal impacts on neighboring properties.

The fourth significance guideline minimizes unnecessary daytime glare impacts to motorists, cyclists, pedestrians or individuals from reflected sunlight. With today's advances in engineering, non-reflective building materials can be used to minimize glare. Any new structure that uses highly reflective building materials may result in glare impacts and this should not occur. It should be noted that conformance to the LPC (Guidelines 1 and 2) also limits nighttime glare from outdoor lighting and non-conformances may result in glare impacts too.

This fifth significance guideline directs consideration of the project's compliance with all applicable Federal, State and local statutes and regulations including the San Diego County Light Pollution Code or any other statute or regulation that may be applicable and has not been listed in this document. If such other statute or regulation is identified, the significance of the project's failure to conform to it would depend upon factors such as the purpose of the regulation or statute and the degree of the project's failure to conform to it.

A Photometric Study may be required if adequate information does not exist to assess the project's adverse effects or to determine the significance of the adverse effects relative to the Guidelines presented above.

5.0 STANDARD MITIGATION AND PROJECT DESIGN CONSIDERATIONS

The following section provides a list of standard mitigation and project design considerations that may reduce the potentially significant impacts of new light sources on daytime and nighttime views, including skyglow, light trespass and glare. Most of the considerations mentioned below tie directly to requirements specified in the LPC and/or Zoning Ordinance.

5.1 Skyglow

As explained by the Institution of Lighting Engineers (ILE) the most significant factors that contribute to skyglow are “light output and lamp spectral characteristics, light distribution from the luminaire, reflected light from the ground, and aerosol particle distribution in the atmosphere.” Therefore, if the light entering the night sky can be reduced, skyglow can be mitigated. The following list provides types of standard mitigation and project design considerations that can reduce skyglow:

- Use full cutoff luminaires, as defined by the Illuminating Engineering Society of North America (IESNA), to minimize the amount of light emitted upward directly from the luminaire. A fully shielded outdoor light ensures that light rays emitted from the fixture are projected below the horizontal plane passing through the lowest point on the fixture from which the light is emitted (LPC Section 59.105).
- Restrict the hours of operation of outdoor lighting to hours of active use (LPC Section 59.107 and ZO Section 6322).
- Require low-pressure sodium light sources, which allow astronomers to filter the line spectra from telescopic images (LPC Section 59.105).
- Condition new development projects to prohibit the post-construction addition of outdoor lighting that was not included in the proposed project.

5.2 Light Trespass

To minimize light trespass the following types of mitigation and project design considerations can be used, as suggested by the IESNA:

- Select luminaires that control the intensity (candela) distribution (LPC Section 59.105).
- Use well-shielded luminaires (LPC Section 59.105).
- Keep floodlight angles aimed low enabling the entire beam to fall within the intended area to be lit.

5.3 Glare

To minimize glare the following types of mitigation and project design considerations can be used, as suggested by the IESNA:

- Use full cutoff and semi-cutoff lighting. Cutoff designations limit the intensity values in the glare zone and provide shielding (ZO Section 6324).
- Adjust mounting height to reduce spill light (ZO Section 6324).
- Focus exterior illumination, including floodlights and spotlights, downward and into the project site. A combination of shielding, screening, and directing the

lighting away from off-site areas shall be used to minimize “spill-over” effects onto off-site roadways, properties and open space areas.

- Use landscaping to serve as filtering devices to soften the impact of direct exterior, reflected exterior, and building interior lighting.
- Limit signs with flashing, mechanical, strobe, blinking lights, moving parts, or lighted monument signs.
- Restrict the hours of operation of outdoor lighting to hours of active use (LPC Section 59.107 and ZO Section 6322).
- Use low-level pedestrian lighting (e.g. bollards) on the site for pedestrian pathways.
- Use lowest intensity project lighting necessary for security and safety purposes while still adhering to the recommended levels of the IESNA.

6.0 REFERENCES

- American Electric Lighting, Thomas & Betts, Lighting Division, Manufacturer Specifications, Memphis, TN.
- Bower, J. The Dark Side of Light. Audubon. March-April 2000.
- Brucato, Robert J. Assistant Director, Palomar Observatory, Personal Communication, January-March 2002.
- California Code of Regulations
Guidelines for Implementation of CEQA, Appendix G, Title 14, Chapter 3, §15000-15387.
- California Public Resources Code
California Environmental Quality Act (PRC §21000-21178).
- Cinzano, P., Falchi, F., & Elvidge, C.D., "The first World Atlas of the artificial night sky brightness" Monthly Notices of the Royal Astronomical Society, vol. 328, pp. 689-707, 2001.
- County of San Diego
General Plan, Conservation Element (Part X), Chapter 7 Astronomical Dark Sky.
Light Pollution Code (Sections 59.101-59.113 of the County Code of Regulatory Ordinances)
Zoning Ordinance, Performance Standard, Section 6320.
- Etzel, Paul. Director, Mount Laguna Observatory, Personal Communication, January-March 2002.
- Etzel, Paul. Director, Mount Laguna Observatory, Personal Communication, April 2007.
- Flanagan, J. The night sky – safeguarding a cultural icon. Common Ground, Pp. 18-25. Summer 2003.
- Harder, B. Degraded Darkness. Conservation in Practice 5(2):21-27. 2004.
- Institution of Lighting Engineers. Guidance Notes for the Reduction of Light Pollution, Warwickshire, United Kingdom, 2000.
- International Light Inc. Light Measurement Handbook, 1997.
- Mount Laguna Observatory
Observatory Associates Newsletter, p. 10, March 1992.
Observatory Website,
<http://mintakasdsu.edu/facilities/Facilities.html> and <http://mintaka.sdsu.edu/>.
- Palomar Observatory. Visitor Brochure.
- Petersen, Patricia. Senior Civil Engineer, Department of Public Works, County of San Diego, Personal Communication January-July 2002.
- Rensselaer Polytechnic Institute. Lighting Research Center. National Lighting Product Information Program (NLPPI), Lighting Answers, Volume 7, Issue 2, March 2003.
- Sipe, Russell, "A Map of Light Pollution in Southern California" Star Cruiser Observatory #444, Observations – Issue #3 April 15, 2002.
Website,
http://www.sipe.com/starcruiser/observatory/html/observations_report03_01.html

[Attachment A]

SUMMARY OF MODIFICATIONS AND REVISIONS

Guidelines for Determining Significance and Report Format and Content Requirements for Dark Skies and Glare were originally approved on July 30, 2007. The following is a summary of revisions made since original document approval.

First Modification, January 15, 2009, by Bobbie Stephenson, Land Use Environmental Planner, and approved by Eric Gibson, Director DPLU:

- Added a paragraph to the Introduction to reference the Guidelines for Determining Significance – Biological Resources, which address the impacts of artificial light on adjacent habitats.
- Added information about the lighting of night skies to the introductory paragraph of Section 1.0, General Principles and Existing Conditions.
- Added Section 1.1.1, Recreation and Community Character and Section 1.1.2, Human Health and Safety.
- Added brief statement of when a photometric study is required to the end of Section 4.