Lighting Design Select References

Topic: CARmax Wappinger Exterior Lighting
LDI Project Number: NY-202206
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*****The following information is quoted from the websites of the organizations*****

Illuminating Engineering Society (IES)
Established in 1906, the Illuminating Engineering Society is the recognized technical and educational authority on illumination. Their mission is to improve the lighted environment by bringing together those with lighting knowledge and by translating that knowledge into actions that benefit the public. The IES provides a variety of professional development, publications, networking and educational opportunities to our membership of engineers, architects, designers, educators, students, contractors, distributors, utility personnel, manufacturers and scientists in nearly 60 countries. Through their American National Standards Institute (ANSI) accredited process, the IES publishes and maintains the Lighting Library®, with over 100 standards written by subject matter experts on their technical committees.

- IES standards and illuminance level recommendations are referenced, and quoted, by local, state, and federal building codes across the United States.
- The IES is an ANSI Accredited Standards Developer (ASD); only ASDs can submit standards for approval as American National Standards.

American National Standards Institute (ANSI)
The American National Standards Institute oversees standards and conformity assessment activities in the United States. The American National Standards Institute (ANSI) is a private, non-profit organization that administers and coordinates the U.S. voluntary standards and conformity assessment system. Founded in 1918, the Institute works in close collaboration with stakeholders from industry and government to identify and develop standards- and conformance-based solutions to national and global priorities.

International Dark Sky Association (IDA)
The purpose of the International Dark Sky Association is to protect the night from light pollution. IDA gives talks, presentations and exhibits at conferences and tradeshows. IDA's Annual General Meeting brings together a wide-range of policymakers, scientists, thought leaders, grassroots advocates, government representatives and others to discuss night sky preservation.

- The IDA does **not** write, publish, or develop standards, but has worked with the IES to create a template, model lighting ordinance, to help municipalities develop outdoor lighting standards.
- The IDA is **not** an ANSI ASD.
- A majority of IDA Board Members are employed in businesses of, or related to, the stars: astrophysicists, astronomers, astro-tourism guides, astro-photographers, and planetarians. As such, the IDA relies on lighting expert organizations (like the IES) to collaborate toward publication of lighting standards that are supportive of IDA mission objectives.

Attached References
Excerpts from the following references are attached:

- IES G-1 Security Lighting for People, Property, and Critical Infrastructure
- IES HB-10 The Lighting Handbook, 10th Edition
- IES RP-2 Recommended Practice for Retail Lighting
- IES RP-33 Lighting for Exterior Environments

cause nuisance glare even when resulting illuminance levels are low. There are several methods used to control light trespass: reducing luminaire mounting height, increasing pole setback from property lines, and/or using optical designs that restrict high-angle luminous intensity. Conversely, spill light received from luminaires on an adjoining property generally should not be relied upon unless proper maintenance of such nearby systems can be ensured.

5.6.2 Sky Glow. Although not specifically a security lighting issue, *sky glow* considerations will be involved in overall facility design based on good practices and possibly local ordinances. Light emitted directly above the horizontal, reflected from the ground, or reflected from objects on the ground contributes to sky glow, which impedes views of the nighttime sky. Uplight may be greatly reduced by specifying luminaires emitting zero or minimal direct uplight, by producing light levels no higher than actually needed, and by reducing light levels during any periods of reduced need.

5.6.3 Community Responsive Design. In addition to meeting the security demands of the protected area, security lighting needs to be appropriate in relationship to the surrounding community and environment. To the extent practical, security lighting designs should minimize light trespass and sky glow. In addition to surveying existing neighborhood lighting applications, designers should consult any local lighting ordinances. (For more on local government codes and requirements, Lighting Zones, and the *Joint IDA/IES Model Lighting Ordinance [MLO]*, see **Annex F.**)

6.0 Security Zones

It is helpful to consider the various functional areas and operational needs of the facility, when assessing an existing site or planning a risk containment program for a developing design. The design team should consider such factors as times of use, movement of persons within the facility, physical and staff resources, and vulnerable or potentially "hot" spots.

Security zones are established *when security is an issue* and there is a need to provide security protection for persons, property, or critical infrastructure. Security zones are not exterior Lighting Zones (LZs), as defined in the *Model Lighting Ordinance.* Whereas exterior LZs are derived from the surrounding site development, security zones are designed around vulnerabilities and target-hardening practices. The project will typically contain various security zones within the area project. The security zone lighting plan should accommodate variations in terrain, climate, obstructions, and integration and support to other security resources, while being mindful of who and/or what is being protected.

When planning or evaluating security lighting, designers will find it useful to divide the facility into zones such as perimeter, pedestrian, building, vehicle, storage, equipment, and restricted areas. During the planning process, designers may title and plan for various other zones for evaluation of specific security lighting, as the project requires. Each zone may require consideration of a differing set of vulnerability and response factors.

6.1 Perimeter Zone

Lighting to enhance perimeter fencing or open areas may be installed for either esthetic or security reasons. *When security is an issue,* the perimeter illumination can perform any or all of the following functions: enhance observation (passive deterrent); enhance the ability of walking or stationary security personnel (active deterrent); and support the effectiveness of closed circuit television (CCTV) monitors. In situations where exterior perimeter protection is a critical element of the overall security design, designers should consider the recommendations in **Section 8.2.2.**

6.2 Pedestrian and Vehicle Movement Zone

Pedestrian and vehicle movement areas require increased visibility and different quality considerations than other zones. In parking lots, where both people and vehicle movements interact, pole mounted light sources are the more common solution. Relatively low fixture mounting heights require reduced pole spacing (more poles) and/or increased luminous intensity at the higher angles approaching 90 degrees from nadir.[14] Floodlights aimed at higher angles can create direct glare and

security applications in particular. However, as with other developing technologies, not all of the benefits or shortcomings have been thoroughly examined.[16] For more information on color metrics, including a newly developed method for evaluating color rendition, see IES TM-30-15, *IES Method for Evaluating Light Source Color Rendition*.

7.1.2 Color Rendering Index. How do the colors of surfaces and objects appear under a light source? Do colors look the same at night as they do during the day? It is as important to be able to *differentiate* between the colors of two adjacent items (such as a person's clothes next to a bush) as it is to be able to *describe* the color of a possible suspect's clothes or vehicle.

The color rendering index (CRI) metric essentially measures the average degree of color shift that objects undergo when illuminated by a particular light source, as compared with the same objects when lighted by a "perfect" reference source of equal CCT and 100 CRI. The higher the CRI, the better the color rendering ability of the light source. Research has shown that almost any nominally white light source with a CRI of 80 or higher allows more accurate and confident color identification at the illuminances used in public spaces at night. Low pressure sodium (LPS) lamps do not allow accurate color identification under any illuminance level.

The "special" color rendering index for strong red colors, denoted R_9, has recently increased in usage and is useful as a supplement to CRI. For example, some of the newer LED products have a high CRI but do a poor job of revealing red colors. This can occur when other colors are rendered exceptionally well, thereby compensating for the deficiency in red when the averaged CRI is calculated. Due to nuances in the calculation method, an R_9 value greater than zero (not negative) is considered adequate for appropriate facial recognition and video surveillance systems.

7.2 Luminaire Mounting Heights

Taller poles typically result in greater areas of coverage, and thus fewer poles required for a given area. Higher-mounted luminaires are also less prone to vandalism. In many localities, however, pole height is restricted as a means of reducing light trespass. When lower mounting heights are used, more poles and lower-output luminaires will likely be required to maintain adequate uniformity without increased glare (see **Figure 12**).

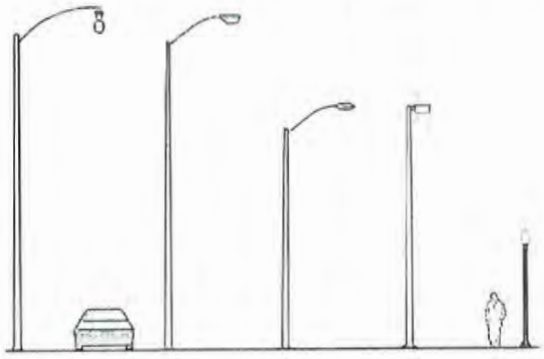

Figure 12. A typical family of luminaires exemplifying various pole heights and luminaire configurations.
(Illustration courtesy of Clanton and Associates, Inc.)

7.3 Lighting Controls

Many lighting ordinances require a reduction in light levels at certain times of the evening or during periods of reduced activity. Establishment of such curfews is a logical method to reduce both energy use and light pollution. However, the lighting designer should first evaluate security requirements to determine how, when, or whether curfew-related restrictions should be relaxed or modified. For example, retail employees may be at greater risk than customers may, since employees usually arrive earlier and depart later, when fewer people are present. Lighting levels and on/off switching can be controlled through vacancy, motion, or dimming controls. These options could enhance security functions.

The least expensive means of reducing light levels and energy usage is to turn off selected lighting fixtures. However, the resulting gaps in coverage greatly reduce uniformity. Dimming offers an attractive alternative since all luminaires remain energized and uniformity remains; however, special ballasts or drivers are required, and these increase initial cost.

For non-residential applications, security lighting fixtures are usually controlled automatically. An exception would be in a guardhouse application where light is needed only occasionally for undercarriage

- Supporting parking spaces should have a minimum of 32 lx (3.0 fc), consistent with the guidelines for parking lots, as discussed in Section 8.2.8.
- After-hours vestibule lighting should be designed in such a way that glare does not generally prevent users from seeing inside the vestibule from the outside as they approach from the surrounding access ways, and does not generally prevent users who are inside the vestibule from seeing the surrounding area outside.
- Users should have an unobstructed view of all accessible areas of the after-hours vestibule from the exterior of the vestibule. If necessary, this requirement can be met by supplementary security devices such as mirrors, camera and monitors, fencing, and barriers.
- Illuminance at the machine and the surrounding area should provide good-to-excellent definition of facial features at a distance up to 9.1 m (30 ft).
- Illuminance levels should support all CCTV camera operating requirements.
- Users should have a reasonably unobstructed view from the face of the unit out to a distance of 15 m (50 ft) in all unobstructed directions, and potential areas of concealment should be eliminated. If necessary, this requirement can be met by supplementary security devices such as mirrors, active CCTV monitoring camera and monitors, fencing, and barriers.
- Luminaires installed below 3.7 m (12 ft) should be should be tamper-resistant.

A post-installation assessment is strongly recommended, in accordance with the protocol provided in **Annex B**. The final design should not produce glare in the eyes of the customers or others in the area.

8.2.5.4 Exterior Vestibule Installations. Interior ATMs and AHDs come in an ever-widening variety of installations and applications. It is common to find these devices in convenience stores, supermarkets, gas stations, hospitality centers, airports, malls. Some ATMs are attended, while others are simply placed in an interior location where observers or passersby provide intermittent presence. The degree, quality and frequency of attendance should be taken into account when considering security and security lighting design. Attended device installations are those that have employees available to provide a presence and varying degrees of supervision at or near the transaction point.

Generally, unattended ATMs and ADHs place the customers at greater risk of attack. However, the quality of attendant training and job descriptions are important to consider. It is common for the ATM or AHD to be installed in a location where the attendant has a job description that does not include customer support or oversight of the ATM or AHD. At a minimum, interior ATMs and AHDs should meet the following guidelines:

- 108 lx (10 fc) minimum at the face of the ATM, and a minimum of 323 lx (30 fc) at any preparation counter or stand within 3.0 m (10 ft) of the ATM.
- Interior lighting within 3.0 m (10 ft) of the device should be raised to 108 lx (10 fc) with an average-to-minimum ratio of 3:1. These conditions can be found in bars, restaurants, and hallways where subdued lighting is applied for effect.

8.2.6 Parking Lots. When security is not an issue, recommended practices for lighting parking lots and garages are available in IES RP-20-14, *Lighting for Parking Facilities*. Walkways and bikeways within the public right of way are covered in ANSI/IES RP-8-14, *Roadway Lighting*. Other walkways and bicycle paths issues are covered in IES DG-5-94, *Lighting for Walkways and Class 1 Bikeways. When security is an issue*, the recommended security and safety illuminance for open parking facilities should be at least a maintained average of 32 lx (3.0 fc) on the pavement and to a height of 1.5 m (5.0 ft). A uniformity ratio not greater than 4:1, average-to-minimum, should be maintained throughout the hardstand. Sidewalks, footpaths, and grounds around or supporting open parking lots should be illuminated to no less than 6 lx (0.6 fc), with an average-to-minimum uniformity ratio no greater than 4:1 (see **Figure 21,** for example). (For information on illumination of parking lots serving sensitive controlled spaces, homeland security operations, or the military, see **Section 8.2.1.6.**) For security purposes, exterior lighting should have a high CRI (80 or higher). At this level, guests are better able to differentiate colors. This is also important for surveillance cameras, which record facial and vehicle colors accurately with this CRI recommendation.

Figure 21. Well-shielded luminaires in an employee parking lot provide uniform illumination for workers leaving after normal business hours and excellent surveillance opportunities for observers from an upper floor in the building. (Photo courtesy of OSS – Law Enforcement Advisors®)

Figure 22. Instant-on, reflectorized fluorescent prison lighting appears as a "wall of light" to inmates. Patrol personnel and vehicles cannot be detected during patrol. (Photo courtesy of Magnaray)

New designs in exterior wall packs, floodlights, pole-mounted fixtures, and parking garage luminaires are all available with multiple lighting technologies that allow for instant-on features. (For an example of an instant-on application for a perimeter fence, see **Figure 22**.) Some fixtures come equipped with individual occupancy sensing controls that control multi-level ballasts. Individually selected fixtures can dim down to reduced power usage (40 percent to 70 percent of full power) when no activity is present, to conserve energy. When the fixture's built-in occupancy sensor picks up activity or a thermal signature, the ballast instantly goes to full power for a pre-set duration. With no activity detected, the fixture returns to its dimmed down state at reduced power. This configuration works well with security cameras and guards who monitor security systems. As the lighting level increases, each lighting fixture takes on the role of a sentry, letting trespassers know they have been detected. Security personnel who survey monitors can easily determine that an event triggered an occupancy sensor and caused a fixture to switch to full power in a specific area. These types of lighting technology are available with light sources in a range or CCTs with high CRIs and instant on technology, including fluorescent, induction, and LED.

8.2.7 Parking Garages. The security threat to unescorted people and unsecured property in covered parking garages can be very high. Isolated floors, numerous places to hide, lack of unobstructed surveillance, and limited escape routes often combine to create this condition. *When security is an issue* in multilevel parking facilities, the recommended minimum illuminance is an average of 65 lx (6.0 fc) on the pavement, with approximately the same values measured at 1.5 m (5.0 ft) above the pavement, and with an average-to-minimum uniformity ratio not greater than 4:1. (See **Figure 23** for an example of good uniformity.) These illuminance levels are maintained whenever access is allowed to the parking areas. It is important for glare to be avoided in such installations. Structural elements afford concealment of luminaires. When coupled with a low ceiling, the designer may be challenged to provide uniform lighting in the space, especially between parked cars.

Figure 23. Multiple structural elements coupled with a low ceiling can make it difficult to achieve uniformity, especially between parked cars. In this example, the designer was successful. (Photo courtesy of Larry Leetzow)

Planners need to consider the following issues when designing lighting and other security components for parks open at night:

- Prior history of crime in the park and surrounding areas
- Social conditions and citizen use of the park
- Hours of public access
- Local cultural values
- Traffic patterns and access
- Patrol frequency
- Light pollution and light trespass

Where security is an issue in parks and public spaces, the recommended average maintained horizontal illuminance for open parking facilities in or adjacent to parks should be no less than 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio not greater than 4:1.

In locations where loitering and criminal attacks are likely to occur, illuminated levels should be at least 11 lx (1.0 fc) horizontal at ground level and to a height above ground of 1.5 m (5.0 ft), with an average-to-minimum uniformity ratio not greater than 4:1. Glare should always be avoided.

When security is an issue, park trails and walkways open to the public at night need to be illuminated to at least 6 lx (0.6 fc) at grade and at 1.5 m (5.0 ft) above grade along the axis of the walkway, along the length of the trail. Both sides of the pathway should have illumination out to a distance of 9.1 m (30 ft), with an average-to-minimum ratio of 4:1. Where trails are situated in woods, landscaped areas, or broken terrain, lighting should blend with the environment whenever practical. Creative combinations of light sources and mounting devices can assist in these applications. Glare and sky glow need to be taken under consideration and controlled.

8.2.8.2 Nature and Parks. Parks primarily set aside for the enjoyment of natural habitat emphasize maximum use of natural features while minimizing the impact of built-up structures. Exceptions to this general rule are parks that have installed parking, rest areas, restaurants, hotels, and laundry facilities. In such instances, park officials should refer to the park guidelines above, and to other applicable parts of **Section of 8.2**, with an eye toward limiting the area covered for safety and security lighting. Limiting glare and sky glow is particularly desirable.

8.2.9 Retail Stores and Centers. Many retail centers and superstores today are high volume operations, well in excess of 9,300 m^2 (100,000 ft^2), offering a vast array of services while attracting thousands of customers a day. Many operate 24 hours a day or late into the night, and parking lots for these facilities are large and often congested. A large percentage of violent crime at retail facilities occurs in parking lots where customers and employees are often isolated and vulnerable. The size and complexity of the store or center does not seem to matter to would-be attackers. Proper illumination is a critical component of the overall security plan for retailers.

When security is an issue, illuminance levels should be at least 32 lx (3.0 fc) on the pavement, with an average-to-minimum uniformity ratio not greater than not greater than 4:1 in parking lots, including parking and support areas used by employees and vendors. To conserve energy and provide additional security for stores with a late-night or 24-hour operation, additional illumination should be provided closer to the entrances where customers will be parking during these low-activity, high-vulnerability hours. Illuminance in this area should be at least an average of 54 lx (5.0 fc) on the pavement, with a uniformity ratio not greater than 4:1 average-to-minimum. The size of the area provided with this additional illumination is determined based on projected customer count during these hours, and on the history of crime on the property and in the neighborhood. In such a design, the light sources not within the 54-lx (5.0-fc) zone can be cycled off or provided with instant-strike sensors. In such an arrangement, the customer is encouraged to park closer to the store; visibility by fellow customers and store personnel is improved, and the customer has less distance to travel. If security is an issue, illuminance in the area of delivery docks, outdoor trash compactors, and recycling bins in the back of the store should be at least an average of 32 lx (3.0 fc) on the pavement, with a uniformity ratio not greater than 4:1 average-to-minimum. This will provide adequate performance and security lighting for delivery personnel as well as for employees needing to work or move about in these areas.

Considering the complexity of many retail centers, designers and crime prevention specialists should survey the various businesses located in the center regarding their individual security lighting needs. A review of the other specific applications addressed in **Section 8.2** will help in this effort. For example, if automatic teller machines are located on the property, the designer should refer to **Section 8.2.5**; for restaurants and eating establishments, **Section 8.2.10**.

Approach roadways to the complex and rear areas of stores should be illuminated based on IES RP-8-14, *Roadway Lighting,* and IES RP-20-14, *Lighting for Parking Facilities - Revised.*

8.2.10 Restaurants and Eating Establishments. Local and franchise restaurants are typically late-night operations, and many are 24-hour operations. Neighborhood establishments often rely on patrol officer patrons for intermittent security presence inside their establishments while consuming discounted menu items. In addition to the presence of uniformed customers, these officers can be valuable resource against local criminal activity. Others, such as national chains, have developed system-wide security plans, policies and training, while regularly tracking and reacting to reported crime statistics. For the various categories, patron and employee security is a high priority. For facilities allowing consumption of alcoholic beverages on site, the designer should consider the guidelines provided in **Section 8.2.19**.

The effectiveness of syndicated restaurants that are initially not a part of the neighborhood fabric depends heavily on quality site selection, tested plot and facility design, operational and security policies, staff training, and integration of layers of security. Critical among these security features is *security lighting.* Areas of meaningful security concern to managers are customer drive-thru or take-out windows, general parking, refuse disposal areas, and places where employees perform tasks outside the building after dark.

Customers are especially vulnerable to attack on "blind" sides of the restaurant and at the drive-thru lane or take-out lane, particularly when patrons are transacting business at the payment or order window(s). Customer attention is on tendering of payment, collecting purchased food, or receiving change. An attacker typically approaches the patron between the building and the left rear of the automobile. Building and lighting designs should allow window-service personnel to view the driver's side of cars, as this is a major deterrent to this type attack. The best designs provide a setback from the window-service area to the rear of the building, and a side window from which the store's personnel have a 180-degree view from building wall to building wall. Store security mirrors are also an effective deterrent to unobserved approaches (see, for example, **Figure 25**).

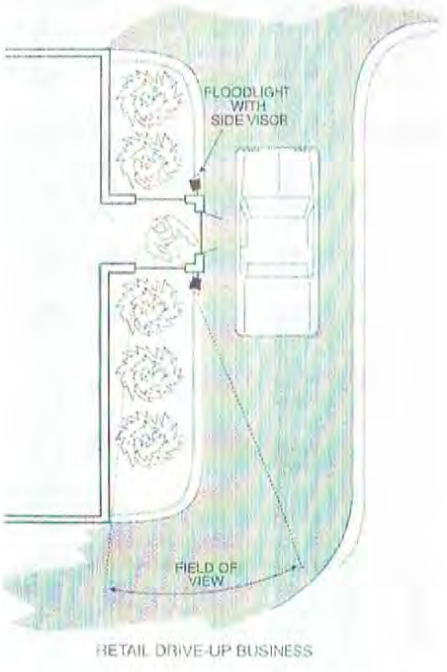

Figure 25. in this design, light is emitted from the floodlights to project down the lane and parallel to the car to enable detection of intruders from the rear corner of the building. (Illustration courtesy of Occupational Safety Systems, Inc.)

When security is an issue, the average maintained illuminance for the area within 9.1 m (30 ft) of the exterior service window(s) is 65 lux (6.0 fc) on the pavement, and equal illuminance levels at 0.9 m (3.0 ft) and 1.5 m (5.0 ft) above the pavement, with an average-to-minimum uniformity ratio not greater than 3:1. General parking areas, sidewalks, footpaths, play areas, and areas adjacent to the structure should be illuminated to at least an average maintained illuminance of 32 lx (3.0

Colleges and universities in the US that receive federal funds are now required to publish their crime and certain disciplinary offense statistics through a uniform reporting system known as the Clery Act. The Act also requires institutions of higher learning to notify students and staff of immediate threats affecting the school, students, or staff. Such warnings are made immediately following confirmation of the emergency and are generally sent in the form of emails, text messages to cell phones, and automated phone call announcements to pre-registered numbers provided by students and staff. (For more information on the *Clery Act* and *foreseeability of crime,* refer to **Annex B**.) Designers and stakeholders responsible for campus security should refer to reported Clery data when planning new facilities or upgrading existing facilities. This review should include lighting design that that can support mass evacuations in case of an on-campus emergency.

Campuses with dormitories or offsite fraternity or sorority houses should review and consider implementation of the guidance provided in **Sections 8.2.6, 8.2.7,** and **8.2.13**.

8.2.17 Vehicle Display and Sales Lots. Many lots will have planned average illumination on the surface of the lot of 215 lx (20 fc) or more. Because vehicle color is important to the potential customer, fixtures and light sources are selected with a maximum color range. It is common for vehicle display lots to have more than $10 million in inventory displayed at any one time. This amount climbs dramatically when you consider inventories of heavy equipment and lots for over-the-road trucks. Given the amount of inventory combined with the need for high-volume sales, it is little wonder that vehicle sales businesses often benefit from major code variances,[53] where lighting codes exist. There is some security lighting consideration in all of the illumination that is highlighting the displayed vehicles and striking the surface of the lot.

Dealers often do not fence their lots and do not restrict access to the vehicles after normal business hours. Perimeter security is limited in many cases to guard rails and ditches that do necessitate a minimum amount of criminal ingenuity in order to steal a displayed vehicle. Despite these vulnerabilities, not all display lots are guarded by trained security personnel. Clearly, *security is an issue* for dealers, and many vehicle retailers could benefit from a detailed physical security assessment (see **Annex A**). Beyond what is current marketing practice for many dealers, a full color spectrum illumination pattern producing 86 to 108 lx (8.0 to 10 fc) with an average-to-minimum ration of 3:1 is recommended for reasonable security, when combined with other *active* security measures.

8.2.18 Sporting and Concert Events. When evaluating security lighting at a location with a sporting or concert facility, and the playing field is included in the analysis process, it is recommended that the assessment team refer to IES RP-6-15, *Sports and Recreational Area Lighting. When security is an issue,* pathways, wayfinding, and parking areas should have average maintained illuminance of 32 lx (3.0 fc), with an average-to-minimum uniformity ratio not greater than 4:1. For additional parking garage guidelines, refer to **Section 8.2.7**. Designers should consider the illumination on the field and in the viewing areas, exit ways and tunnels, and parking areas to allow for an orderly eye adjustment from the brighter lights of the field to the parking lot or public transportation areas.

8.2.19 Taverns, Bars, and Clubs. Businesses open to the public, and social clubs that serve alcoholic beverages, are governed by owner practices, dram shop[56] regulations, and state laws. In many localities, public laws and ordinances consider it a privilege, not a right, to serve alcoholic beverages on a business premises. Clubs' interiors need to be intimate. However, designers and operators should not choose intimacy over safety and security; a balanced approach should be used. By their very nature, taverns, bars, and social clubs serving alcoholic beverages are establishments *where security is an issue.*

General parking areas, sidewalks, footpaths, play areas, and areas adjacent to the structure, should be illuminated to at least an average maintained illuminance of 32 lux (3.0 fc) at grade, with an average-to-minimum uniformity ratio not greater than 4:1. The entrance to the facility should be illuminated for security, safety, and identification of customers. Often

- Small flashlight
- Digital camera to aid memory recall
- Distance measuring device (e.g., tape, wheel roller, or laser)

Two people are optimum for most assessments and taking light measurements. The survey team should not ignore considerations for personal protection, especially in locations that are considered moderate-to-high risk areas. An assessment template or survey guideline needs to be created that ensures that all critical areas are included in the assessment. A lighting survey for senior citizen housing, for example, should include assessment of the lighting on both sides of the property lines, at the bus stops, at parking lot entrances, in the parking lots, in the common areas inside and outside the building, along walkways, under the canopy or vestibule, in the entrance and lobby, at the elevators and inside the elevators, in front of the mailboxes, inside and outside the emergency exits, and in the stairwells and corridors.

A.8 Recording Light Values

Illuminance measurements should be noted in the survey plan. (For details on taking and recording photometric readings, refer to **Annex B**.)

A.9 Technical Specifications

As part of the survey process, technical specifications of lamps, luminaires, locations, aiming angles, mounting heights, and controls should be examined to see whether existing conditions require change. Important lighting equipment considerations include:

- Quantity of light (lumen output of each luminaire)
- Spatial distribution of light (zonal lumens, beam angles)
- Spectral distribution of light (color attributes of the lighting)
- Temporal distribution of light (flicker)
- Maintenance requirements
- Optional accessories; e.g., external shields or louvers

** Light meters should be calibrated (and periodically recalibrated) according to manufacturer's recommendations. Refer to IES *LM-50-13, IES Approved Method for Photometric Measurement of Roadway and Street Lighting Installations*, for appropriate field measurement procedures.

A.10 Use of Light Values

Light measurements should be performed in a manner facilitating comparison with predicted values and applicable criteria. *When security is an issue,* measurement of light values on properties allowing public access should be performed and recorded on a recurring basis.

A.11 Additional Factors of Lighting

In addition to taking objective light meter readings and evaluating technical specifications, subjective aspects should be considered. It is wise to consider the advice of non-technical personnel, representing both sexes and a range of ages, in evaluating psychological responses. For example, consideration should be given to how the physical senses are impacted when passing through each lighted area. Does the ambient lighting create a sense of fear or security? Are the shadows harsh, creating very dark areas, or are they soft, permitting one to look into the shadows easily?

A.12 Light Pollution, Light Trespass, and Glare

The surrounding environment will affect lighting needs on the property. Adjacent street lighting or light spillover from adjacent properties may interfere with CCTV cameras by producing too much backlighting against which an intruder's face will appear in silhouette. Conversely, neighboring property management or civil authorities may complain of spill light. Ambient light that spills over onto neighboring properties or into the wrong internal area(s) can be controlled with internal or external light shields, as one option.

Glare can work for or against an effective security lighting system. Glare reduces visibility when low-mounted luminaires are aimed out and away from the property to be protected. This will create glare in the eyes of the potential trespasser, while allowing personnel or cameras positioned behind or directly under the lights to view the perimeter without being detected. The glare makes the criminal uncertain about what is in the area and how well it is guarded. To be effective, the secure area should be left dark and the low-mounted luminaires should floodlight all the approaches to the area. Glare, however, in the wrong areas can limit the ability to see a perpetrator. Just as glare can hinder the trespasser, it can also hinder the police officer or security officer who is patrolling from the perimeter. If glare is used within a

facility, it should be carefully placed so as not to inhibit the operation of cameras or security personnel assigned to protect an area. Unnecessary or unwanted glare can be minimized by using higher fixture mounting heights and steeper aiming angles, thereby putting the light where it is needed, while reducing the visibility of the actual light source (direct glare), and minimizing light pollution and light trespass.

A.13 Special Needs

In addition to the security requirements already discussed, the visual needs of senior citizens should be considered. Older eyes have special needs. (For more information on security lighting for the elderly and sight challenged individuals, refer to **Section 8.2.14 Senior Living Multi-residence Facilities** and to ANSI/IES RP-28-16, *Lighting and the Visual Environment for Seniors and the Low Vision Population.*)

A.14 Structuring the Assessment

Assessments should be as thorough and visually graphic as possible. **Figures A1** and **A2** show examples of lighting maps that were designed based on a lighting assessment in a northeastern US community. The crime data is for the year 2000, and results are indicated using icons. For each building development, lighting values were taken in footcandles and plotted on the site maps.

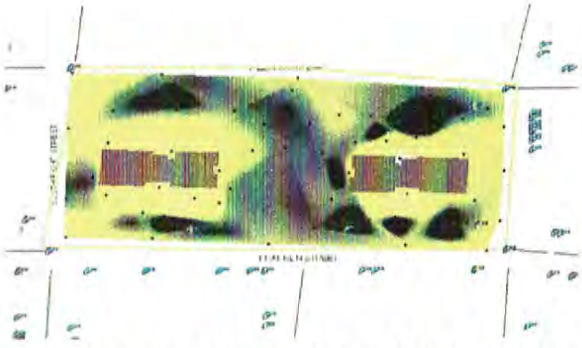

Figure A1. This is an example of crime and light mapping used for crime assessment associated with high-rise buildings for the elderly. Black dots are the locations where readings were taken around the property, while the light blue pistol symbols indicate where a reported crime occurred on or adjacent to the property over a given period. The red "human" figures represent where an individual was injured during a criminal event. (Provided courtesy of SPARTA Consulting Corporation)

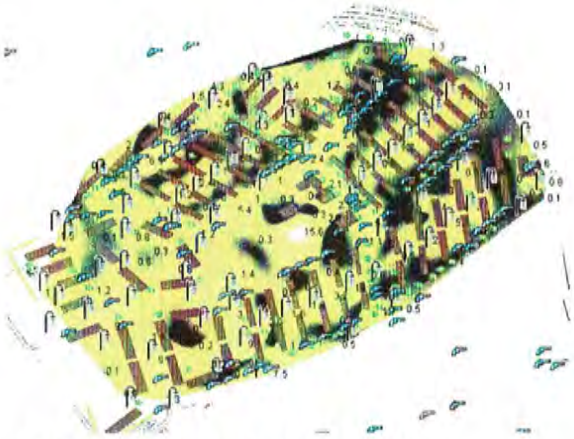

Figure A2. An example of a lighting and crime assessment in and around a multi-family housing complex, using a light map associated with an apartment complex. Locations of light poles and of crime are shown, as well as location of trees. Numbers indicate the location of the light reading, with the value in footcandles. (Image provided courtesy of SPARTA Consulting Corporation)

A.15 Recommendations

Following an analysis of the survey, the next step is to consider the need for change. Recommendations for any changes in lighting patterns or for improved lighting should be detailed and specific, providing a rationale for the change. These recommendations should mention applicable alternatives, and the estimated or quoted cost involved for each. Qualified lighting professionals can provide the necessary data.

Annex B – Taking Security Illumination Measurements: A Working Protocol

B.1 Background

Taking lighting measurements in the field for security purposes is often quite different in practice and purpose from taking measurements for other kinds of lighting applications. Security lighting recordings are often performed by police officers investigating a crime scene. They may also be performed by a security officer or maintenance personnel making

Table 34.2 | Retail Illuminance Recommendations

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65		Vertical (E_v) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	
		Category			Gauge	Category			Gauge
RETAILING, OUTDOOR									
• Automotive Sales	Coordinate lighting with security cameras.								
• Circulation Drives	E_h @pavement; E_v @5' AFF								
◦ High Activity[f]									
▪ LZ4		H	10	20	40	Avg	E	4	8	16	Avg
▪ LZ3 (and LZ4 curfew)		G	7.5	15	30	Avg	D	3	6	12	Avg
▪ LZ2 (and LZ3 curfew)		F	5	10	20	Avg	C	2	4	8	Avg
▪ LZ1 (and LZ2 curfew)		E	4	8	16	Avg	B	1	2	4	Avg
▪ LZ0 (and LZ1 curfew)		-	0	0	0		-	0	0	0	
◦ Medium Activity[f]									
▪ LZ4		G	7.5	15	30	Avg	D	3	6	12	Avg
▪ LZ3 (and LZ4 curfew)		F	5	10	20	Avg	C	2	4	8	Avg
▪ LZ2 (and LZ3 curfew)		E	4	8	16	Avg	B	1	2	4	Avg
▪ LZ1 (and LZ2 curfew)		D	3	6	12	Avg	A	0.5	1	2	Avg
▪ LZ0 (and LZ1 curfew)		-	0	0	0		-	0	0	0	
◦ Low Activity[f]									
▪ LZ4		F	5	10	20	Avg	C	2	4	8	Avg
▪ LZ3 (and LZ4 curfew)		E	4	8	16	Avg	B	1	2	4	Avg
▪ LZ2 (and LZ3 curfew)		D	3	6	12	Avg	A	0.5	1	2	Avg
▪ LZ1 (and LZ2 curfew)		C	2	4	8	Avg	-	0	0	0	
▪ LZ0 (and LZ1 curfew)		-	0	0	0		-	0	0	0	
• Featured Vehicle	Illuminance @respective relevant plane(s) on feature display								
◦ Dazzle	Apply strategically to ≤10% of total vehicle visible from primary viewing direction	E_h and E_v on the featured vehicle ≤10 times E_h of Front Row for respective Activity Level and Lighting Zone			Max				
◦ Highlight	Apply strategically to ≤25% of total vehicle visible from primary viewing direction	E_h and E_v on the featured vehicle ≤5 times E_h of Front Row for respective Activity Level and Lighting Zone			Max				
◦ Total vehicle	IESH/10e proposed values: Apply to total vehicle visible from primary viewing direction	equal to E_h of Front Row for respective Activity Level and Lighting Zone			Avg				
• Front Row	E_h and E_v @4' AFF								
◦ High Activity[f]									
▪ LZ4		P	150	300	600	Avg	P	150	300	600	Avg
▪ LZ3 (and LZ4 curfew)		O	100	200	400	Avg	O	100	200	400	Avg
▪ LZ2 (and LZ3 curfew)		N	75	150	300	Avg	N	75	150	300	Avg
▪ LZ1 (and LZ2 curfew)		M	50	100	200	Avg	M	50	100	200	Avg
▪ LZ0 (and LZ1 curfew)		-	0	0	0		-	0	0	0	
◦ Medium Activity[f]									
▪ LZ4		O	100	200	400	Avg	O	100	200	400	Avg
▪ LZ3 (and LZ4 curfew)		N	75	150	300	Avg	N	75	150	300	Avg
▪ LZ2 (and LZ3 curfew)		M	50	100	200	Avg	M	50	100	200	Avg
▪ LZ1 (and LZ2 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg
▪ LZ0 (and LZ1 curfew)		-	0	0	0		-	0	0	0	

Table 34.2 | Retail Illuminance Recommendations continued next page

Uniformity Targets[e] Over Area of Coverage			[f] [g] Typical Area of Coverage[h]	
1st ratio $E_h/2^{nd}$ ratio E_v if different uniformities apply			Task Proper or Task Area	Room or Designated Area
Max:Avg	Avg:Min	Max:Min		
3:1	3:1			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1				
3:1				
3:1				
3:1	3:1			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			
3:1	3:1 (6:1)			

Notes for Table 34.2

The table column headings are discussed in detail in 34.3 Illuminance Criteria. See 12.5.5 Illuminance for discussion on procedures for establishing illuminance targets for a project. See Table 34.3 | SI Dimensional Conversions.

a. Applications, tasks, or viewing specifics encountered on any given project may be different from these and may warrant different criteria. See 34.3.1 Applications and Tasks. The designer is responsible for making final determinations of applications, tasks, and illuminance criteria. Outdoor tasks are so noted.

b. Values cited are to be maintained over time on the area of coverage.

c. Values cited are consensus and deemed appropriate for respective functional activity. In a few situations, code requirements are within 10% of IES recommendations. This is apparently an artifact of metrication. Footcandle conversions of any values cited in Table 34.2 should be made at 1 fc to 10 lx. Regardless, codes, ordinances, or mandates may supersede any of the IES criteria for any of the applications and tasks and the designer must design accordingly.

d. Targets are intended to apply to the respective plane or planes of the task.

e. Illuminance uniformity targets offer best results when planned in conjunction with luminance ratios and surface reflectances. Any parenthetical uniformity values reference respective parenthetical applications or tasks, such as a curfew situation associated with nighttime outdoor lighting.

f. Applications and tasks cited with sunburst icon are candidates for strategies employing any combination of daylighting and electric lighting to achieve target values during daylight hours. Daylighting may require unconventional approaches.

g. Tasks with specular components, like computers with CSA/ISO Type III screens or printed tasks with glossy ink or glossy paper, are prone to veiling reflections. The likelihood of an application's or task's predisposition to veiling reflections is indicated by the reflected-light icon: black and white signals high likelihood; gray and white signals moderate likelihood; pale gray and white signals some likelihood; and all-white signals little-to-no likelihood.

h. The designer must establish areas of coverage to which targets apply. Green highlight identifies task proper or task area as the typical area of coverage for respective cited targets. Amber highlight identifies room or designated area as the typical area of coverage for respective cited targets.

i. See Table 22.4 | Indoor and Nighttime Outdoor Activity Level Definitions.

j. See Table 26.4 | Nighttime Outdoor Lighting Zone Definitions. Nighttime illuminance targets are intended for application during dark hours of operation where lighting is deemed necessary or desirable. At curfew (client- or jurisdiction-defined), if lighting is still deemed necessary or desirable, then reduce lighting as indicated. See Table 26.5 | Recommended Light Trespass Illuminance Limits for recommended light trespass illuminance limits.

k. Use motion-sensing control to toggle lighting from on/off/dimmed state to recommended curfew state or from recommended curfew state to pre-curfew state as designer and client deem necessary to meet functional needs. Use instant-on lighting equipment.

l. For applications where task position is indefinite, such as some general retail sales, the typical area of coverage is "Room or Designated Area" at the planar elevations noted. For applications where task position is known, such as fixed displays or specific gondola layouts, a more efficient approach is likely achieved when target illuminance is applied to the "Task Proper or Task Area" and which may involve different planar elevations that the designer must accommodate.

Table 34.2 | Retail Illuminance Recommendations

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b, c, d]									
		Horizontal (E_h) Targets					Vertical (E_v) Targets				
		Visual Ages of Observers (years) where **at least half** are					Visual Ages of Observers (years) where **at least half** are				
		Category	<25	25-65	>65	Gauge	Category	<25	25-65	>65	Gauge
RETAILING, OUTDOOR	(Automotive Sales/Front Row continued)										
Low Activity[f]											
LZ4[e]		N	75	150	300	Avg	N	75	150	300	Avg
LZ3[e] (and LZ4 curfew)		M	50	100	200	Avg	M	50	100	200	Avg
LZ2[e] (and LZ3 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg
LZ1[e] (and LZ2 curfew)		K	25	50	100	Avg	K	25	50	100	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Parking	E_h @pavement; E_v @5' AFF										
High Activity[f]											
LZ4[e]		I	15	30	60	Avg	G	7.5	15	30	Avg
LZ3[e] (and LZ4 curfew)		H	10	20	40	Avg	F	5	10	20	Avg
LZ2[e] (and LZ3 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ1[e] (and LZ2 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Medium Activity[f]											
LZ4[e]		H	10	20	40	Avg	F	5	10	20	Avg
LZ3[e] (and LZ4 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ2[e] (and LZ3 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ1[e] (and LZ2 curfew)		E	4	8	16	Avg	C	2	4	8	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Low Activity[f]											
LZ4[e]		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ3[e] (and LZ4 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ2[e] (and LZ3 curfew)		E	4	8	16	Avg	C	2	4	8	Avg
LZ1[e] (and LZ2 curfew)		D	3	6	12	Avg	B	1	2	4	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Preparation and Storage	E_h @pavement; E_v @5' AFF										
High Activity[f]											
LZ4[e]		I	15	30	60	Avg	G	7.5	15	30	Avg
LZ3[e] (and LZ4 curfew)		H	10	20	40	Avg	F	5	10	20	Avg
LZ2[e] (and LZ3 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ1[e] (and LZ2 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Medium Activity[f]											
LZ4[e]		H	10	20	40	Avg	F	5	10	20	Avg
LZ3[e] (and LZ4 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ2[e] (and LZ3 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ1[e] (and LZ2 curfew)		E	4	8	16	Avg	C	2	4	8	Avg
LZ0[e] (and LZ1 curfew)		-	0	0	0		-	0	0	0	

Table 34.2 | Retail Illuminance Recommendations continued next page

Uniformity Targets[e] Over Area of Coverage			[f] [g] Typical Area of Coverage[h]	
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3:1	3:1 (6:1)			
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		Category	<25	25-65	>65	Gauge	Category	<25	25-65	>65	Gauge
RETAILING, OUTDOOR	(Automotive Sales/Preparation and Storage continued)										
Low Activity[f]											
LZ4[e]		G	7.5	15	30	Avg	E	4	8	16	Avg
LZ3[f] (and LZ4 curfew)		F	5	10	20	Avg	D	3	6	12	Avg
LZ2[f] (and LZ3 curfew)		E	4	8	16	Avg	C	2	4	8	Avg
LZ1[f] (and LZ2 curfew)		D	3	6	12	Avg	B	1	2	4	Avg
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Sales	E_h and E_v @4' AFF										
High Activity[f]											
LZ4[e]		N	75	150	300	Avg	L	37.5	75	150	Avg
LZ3[f] (and LZ4 curfew)		M	50	100	200	Avg	K	25	50	100	Avg
LZ2[f] (and LZ3 curfew)		L	37.5	75	150	Avg	J	20	40	80	Avg
LZ1[f] (and LZ2 curfew)		K	25	50	100	Avg	I	15	30	60	Avg
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Medium Activity[f]											
LZ4[e]		M	50	100	200	Avg	K	25	50	100	Avg
LZ3[f] (and LZ4 curfew)		L	37.5	75	150	Avg	J	20	40	80	Avg
LZ2[f] (and LZ3 curfew)		K	25	50	100	Avg	I	15	30	60	Avg
LZ1[f] (and LZ2 curfew)		J	20	40	80	Avg	H	10	20	40	Avg
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Low Activity[f]											
LZ4[e]		L	37.5	75	150	Avg	J	20	40	80	Avg
LZ3[f] (and LZ4 curfew)		K	25	50	100	Avg	I	15	30	60	Avg
LZ2[f] (and LZ3 curfew)		J	20	40	80	Avg	H	10	20	40	Avg
LZ1[f] (and LZ2 curfew)		I	15	30	60	Avg	G	7.5	15	30	Avg
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0	
Seasonal Open-air	Examples include farmers markets, Christmas tree sales, arts festivals, and produce stands typified by open-air or partial-cover situations. Coordinate lighting with security cameras.										
LZ4[f]											
Circulation	E_h @pavement; E_v @5' AFF	H	10	20	40	Avg	E	4	8	16	Avg
Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	N	75	150	300	Avg	N	75	150	300	Avg
Merchandise	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	J	20	40	80	Avg	J	20	40	80	Avg
LZ3[f] (and LZ4 curfew)											
Circulation	E_h @pavement; E_v @5' AFF	G	7.5	15	30	Avg	D	3	6	12	Avg
Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	M	50	100	200	Avg	M	50	100	200	Avg
Merchandise	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	I	15	30	60	Avg	I	15	30	60	Avg

Table 34.2 | Retail Illuminance Recommendations continued next page

Spain, and the Centro de Investigacion en Alimentacion y Desarrollo A.C., Mexico. Meat Science 64. 2003:417-426

7. National Cattlemen's Beef Association News release. Gary C. Smith, Ph.D., from Colorado State University, estimates discoloration and spoilage cost the retail industry $1.1 billion in sales in 1991. 1996. http://www.beefusa.org/NEWSProducerLearnNewWaysToImproveTheirBeefBusiness4843.aspx

8. Food Hazard Analysis Critical Control Points Food. HACCP.com Newsletter. Beef bacteria could hold key to reducing spoilage, food-borne pathogens; and: Spoilage of vacuum-packed meat, which is a $200 million per year problem for the Canadian beef industry. 132; 9/08/2004. http://www.foodhaccp.com/memberonly/newsletter132.html

Excerpts from IES RP-2 Recommended Practice for Retail Lighting

ANNEX C – OUTDOOR LIGHTING

C.1 General

Lighting for the outdoor environment presents opportunities and constraints different from those found indoors. Outdoors, light provides visual interest, safety, and customer security. No attempt should be made to match daylight levels with electric light at night. The nighttime customer decides where to shop based on visual cues often balanced against perceptions of personal security. Outdoor lighting should address this security need as an integral part of the overall lighting plan.

C.2 Visual Considerations

The visual issues involved in outdoor lighting are complex. Evaluations of an outdoor system should consider glare, brightness, visual acuity, and the eye's adaptation ability. This Recommended Practice only brings these key issues to the designer's attention. IES RP-33-14, *Lighting for Exterior Environments*,[1] also an IES Recommended Practice, explores exterior lighting in greater depth from an environmental lighting perspective.

The sensation of glare is produced by stray light entering the eye, which reduces the image contrast on the retina, causes discomfort or annoyance, and defeats the image the retailer seeks to create. Glare can be regulated through controlled light distribution, reduced light intensity, and correct luminaire placement.

The brightness of surfaces and sources contributes to perception. Surface brightness adds depth, interest, and security. Source brightness can (at best) aid orientation or (at worst) create glare.

Visibility operates on three light-dependent levels. There is photopic vision (which operates at the highest light level), scotopic vision (which operates at the lowest level), and mesopic vision (which is occurs where photopic and scotopic vision overlap). Mesopic vision utilizes both rods and cones, allowing color sensation, depth of field, clarity, and peripheral responses to occur. Occasions when the eyes should adapt to varying light levels should be minimized so that the decision process is not impeded by recognition delays or discomfort. For example, when the intense lighting of a gasoline station is next to a brightly illuminated car dealership, viewing is easy and there is no discomfort when passing from one task to the next. However, if drivers leaving this area are looking to

enter an unlighted side street, they might miss the turnout while their eyes adjust to the darkness.

C.3 Imaging

Outdoor lighting creates the "street presence" of retail establishments at night. While often left by default to the parking lot designer, this presence is really made up of signage, facade illumination, landscape lighting, and parking lot lighting. The ability to alter perception gives the lighting designer some responsibility for the store's nighttime success. Using the night sky as background, the store's facade illumination should clearly reinforce the retail concept. Proper execution varies from the clean, bright lighting of a gasoline station to the luxurious drama and warm colors of an exclusive boutique. The role of signage in creating the desired image will determine the nature of the lighting scheme (see **Figure C1**). Bright, self-illuminated signs and their retail message can coexist with bright parking lots, while a poorly illuminated sign can be quickly lost in the same environment. Clear messages are created when the relative brightness and color of the lighting elements are controlled.

Figure C1. A transparent storefront provides nighttime identification without a great deal of exterior lighting. This scheme works well with individual storefronts and smaller retail structures. (©Jim Roof Creative)

C.4 Pedestrian Arcades

For drivers in retail parking lots, the vertical illuminance on pedestrians and other vehicles is of prime importance (see **Figure C2**). An effort to reduce the amount of light emitted horizontally (inhibiting the driver's ability to see signage and other traffic signals) is required. However, for pedestrians to see, they require light on vertical surfaces, such as facades, landscaping, other pedestrians, and changes in elevation, to aid the recognition process. Pedestrians' lighting needs center on personal security and a sense of scale. Therefore, luminaires selected for the pedestrian areas should have light distribution above the horizontal, and perhaps of lower intensity to avoid glare (**Figure C3**). Landscape lighting creates a pedestrian atmosphere whenever the major vertical surfaces of plantings are illuminated.

Figure C2. Exterior illumination should, on occasion, provide lighting for customers arriving by vehicle as well as create a visual identity. (© Dana Hoff.)

Figure C3. The pedestrian entrance at a large "anchor" store or enclosed mall requires lighting that is sensitive to shoppers arriving and departing while helping provide visual identity. Control of the brightness ratios and glare is important in these applications. (©Jim Roof Creative)

C.5 Outdoor Merchandising

Outdoor merchandising areas are governed by the same concerns as indoor retail spaces. Lighting levels should be determined by the visibility requirements of the space. Energy codes set upper limits for the allowed power density for exterior spaces. Provided that sufficient minimum task and evaluation luminance can be achieved, luminance ratios between the lighted retail area and its surroundings should not exceed 20:1. Increasing the lighting level does not add to merchandise attraction, and may create a hazard to motorists on adjacent roadways or a nuisance for neighbors. A value of ten times the average surrounding task luminance is the maximum that should be utilized for the focus merchandise (see **Figure C4**). This will provide merchandise appeal without producing hazards or creating conflicts with other nighttime events.

Figure C4. While the goals of retail (especially exterior retail) space illumination at night are creating a visual identity and providing light for the customer, care should be exercised to control exterior illumination with respect to the surround. (Image courtesy of LSI Industries)

C.6 Parking Facilities

IES RP-20-14-Revised, *Lighting for Parking Facilities*,[2] discusses parking facility design in detail and gives light level recommendations for various types of facilities and usage conditions. When selecting equipment for lighting parking areas, primary concern should be given to maintainability, distribution, and source type.

C.7 Security

Security of the store's employees, customers, and merchandise should be addressed. Outdoor security lighting is a progression of "layers" that helps provide a sense of personal well-being as well as protecting the store's outdoor assets. The first layer is uniform lighting throughout the parking area. Next comes illuminating the specific paths that pedestrians travel. The third and most overlooked layer is providing light in the untraveled spaces where crime might be committed. The third layer does not need to be excessive. Most often lower light levels that allow observers to see into the fringe spaces are best. Luminaires should not be aimed towards the visitor's approach. This can cause disabling glare that will delay the recognition of potential danger. (See IES G-1-16, *Security Lighting Guidelines for People, Property, and Critical Infrastructure*.[3])

C.8 Safety

For the customer's safe passage from car to store, the stairs, curbs, drop-offs, and other potential hazards should be delineated by a highly visible contrast border. In addition, a clear change in the lighting should exist whenever the change from car to foot travel occurs. This meets the needs of the two different tasks and clearly distinguishes walkways from roads. By using contrasting materials and finishes on curbs, stairs, and other obstructions, the designer can create helpful warnings without adding specific lighting fixtures at every change in pathway elevation. Illumination needs to be maintained at minimum levels (based on the task and age of the clientele) as outlined in IES G-1-16.

C.9 Obtrusiveness

Every outdoor site adjoins another space, be it residential, commercial, or vacant. The designer should refer to local ordinances to determine trespass, distribution, luminance and other limitations placed on exterior lighting. When preparing an outdoor lighting scheme, a nighttime site visit is required so that surrounding luminance levels and the relative level of security can be evaluated. This allows the designer to determine where light trespass might occur, where street lighting deficiencies exist, and what the competition is doing to create its nighttime image. Care should be taken to limit the light spilling onto adjacent properties or radiating skyward. Reduced light trespass and sky glow are important goals. A potential customer who cannot find or read signage because of glare from parking lot floodlighting

may become aggravated and shop elsewhere. Sky glow does not illuminate product and represents a continuous, unnecessary energy cost.

C.10 Automated Setback

Whenever possible, retail properties should take advantage of automated controls by turning off lights or reducing levels after hours. Not only does this save energy, it also improves dark-sky conditions. Even 24-hour operations with lighter late-night customer traffic can reduce potentially obtrusive lighting by limiting parking to set areas around entrances. Of course, security and safety considerations should always be considered. The use of quick-response occupancy sensors can be used with certain instant-on or quick-response lighting systems.

C.11 Outdoor Illumination Levels

When determining outdoor illumination levels, the design team should consider several factors, including the activity occurring in the exterior retail environment, transition experience from the outside to the inside, and the outdoor lighting zone in which the site is located. Refer to **Annex J, Table J.2**, and the columns for *Centers, Outdoor* for guidance with recommended illuminance levels.

REFERENCES FOR ANNEX C

1. Outdoor Environmental Lighting Committee. Lighting for Exterior Environments RP-33-14, Illuminating Engineering Society of North America, New York; 2014.

2. Roadway Lighting Committee. Lighting for Parking Facilities, RP-20-14-Revised, Illuminating Engineering Society of North America, New York; 2016.

3. Security Lighting Committee. Security Lighting Guidelines for People, Property, and Critical Infrastructure, G-1-16, Illuminating Engineering Society, New York; 2016.

ANNEX D – LIGHTING SYSTEM MAINTENANCE

Relamping and Cleaning

The output of all lighting systems depreciates with the passage of time. If the design requirement is for the lighting system to provide reasonable efficiency and a good appearance over time, then the lighting equipment and room surfaces should be well maintained. Wherever access is difficult, special consideration should be given to luminaire accessibility for cleaning and relamping. The overall light loss of any system may be due to several factors in combination:

- **Lamp lumen depreciation (LLD):** The light output of any lamp will decrease to some extent during operation. The actual decrease will depend upon the lamp type and its use. Lamp manufacturers publish the Mean Lumens for their lamps usually at 40 percent or 50 percent of rated life. Mean Lumens divided by Initial Lumens equals the LLD. LLD is recoverable by changing to new lamps.

- **Luminaire dirt depreciation (LDD):** This is attributable to dust and dirt accumulation on any luminaire surfaces that reflect or transmit light. (See *The Lighting Handbook*[1] for LDD calculation procedures.) LDD is recoverable by cleaning the luminaires.

- **Lamp Burnout Factor (LBO):** This is due to burned-out lamps that have not been replaced. This depreciation is recoverable by replacing the burned out lamps.

- **Luminaire Surface Depreciation (LSD):** This is the deterioration of any luminaire surfaces that reflect or transmit light. This depreciation is recoverable by refurbishing or changing parts of the luminaire.

- **Room Surface Dirt Depreciation (RSDD):** This is dust and dirt accumulation on room surfaces. This is depreciation recoverable by cleaning, repainting, or changing the room surfaces.

- **Temperature Factor (TF), Voltage Factor (VF):** Temperature and voltage effects are considered non-recoverable and should be examined at the initial design stage. Fluorescent and LED lamps are particularly affected by changes in temperature. Although all lamps are affected by voltage, filament lamps are particularly affected by changes in voltage.

activity, including the immediate background of the details or objects.

wall washer
A luminaire with an asymmetric distribution, designed to direct a greater portion of its lumen package on a vertical surface such as a wall.

wide flood
Any lamp or luminaire with a focused optical system producing a controlled, wide beam of light, typically between 50 and 60 degrees.

ANNEX J – RETAIL TARGET ILLUMINANCES FOR INTERIORS AND EXTERIORS

Lighting designers utilize illuminance targets measured in lux or footcandles to establish baseline performance measurements in designing successful lighting systems. For retail applications, a wide variety of illuminance targets may be employed and tailored to the type of merchandise and overall brand image of a store.

This annex provides a detailed discussion and tables for target illuminances (light levels) for retail spaces as taken directly from *The Lighting Handbook*, 10th ed.,[1] Chapter 34.

The IES recommends "target" light levels (illuminances) for general lighting (horizontal illuminances) and perimeter lighting (vertical illuminances), as well as contrast ratios for accent lighting. Target light levels are based upon typical "tasks" performed in horizontal and vertical planes. In the retail environment, these "tasks" include browsing, evaluating products, reading labels, and shopping. The IES recommended target illuminances vary with the age of the shoppers (visual age of occupants) and the type of retail space, outdoor or indoor.

The following is a thorough discussion of the IES illuminance target value system and associated tables identifying recommended target illuminances for various retail applications.

J.1 Illuminance Target Value System

Energy considerations and lower lighting power density allowances require more careful tailoring of illuminances to task needs. The target illuminance values in **Table J.1** are considered maintained average illuminances of electric and/or daylight for the designed task area. Target values are not a substitute for careful consideration of all factors relevant to a specific lighting situation. Average illuminance is calculated from an array of points. The accuracy of the resulting average illuminance depends on the density of analysis points in the calculation grid.

When the task involves life safety, human-vehicular proximity and/or personal safety and security as significant concerns, recommendations are considered minimum maintained illuminances at the target area. Additionally, health and life safety code requirements may supersede these recommendations.

Light loss factors, specific room reflectances, and other design considerations should be used to adjust lighting calculations. These considerations may include minimum or maintained lamp lumen output, luminaire output, and ballast factors. LLF's are divided into recoverable and non-recoverable. For a discussion of light loss factors and maintained illuminance, refer to *The Lighting Handbook,* 10th ed. (IES 2011), Section 10.7.1, and IES RP-36-15, *IES/NALMCO Recommended Practice for Lighting Maintenance.*[2]

These target values are design goals, and variation from them is expected and may be found at two stages in the construction process: during design and at the time of occupancy. More-precise values are found in the Application Illumination Recommendation Tables for specific applications.

J.1.1 Recommended Illuminances at Design Time. Quantitative assessments (i.e., "lighting calculations") are usually performed during the design process, using lighting analysis software to predict maintained illuminance. For electric lighting designs, if these calculations predict illuminance values that differ by more than 10% from recommended illuminance targets, the differences require attention and should be addressed during the design process.

If a predicted (calculated) value is more than 15% below the recommended level, then a significant percentage of the users of the system may not find the visibility acceptable. If a predicted (calculated) value exceeds a recommendation by more than 10%, then over-lighting and energy misuse may result. Refer to *The Lighting Handbook,* 10th ed. (IES 2011).

J.1.2 Individual Differences and Uncertainties. As with any lighting design, daylighting should be tailored to the task or application. Lower room surface luminances and daylight levels may be required in spaces with significant computer use, for example. The recommendations provided in the application tables for electric lighting generally apply to daylighting. One exception is the luminance ratio between the task and distant surround, which for daylighting can often be greater than the 1:10 ratio recommended for electric lighting systems. Occupants are likely to tolerate somewhat higher luminance ratios for daylight, particularly when they are associated with a favorable exterior view.

J.1.4 Recommended Illuminances at Occupancy Time. Assessment of illuminance in the field by measurement is more complicated than computation prediction. Non-recoverable light loss factors and measurement equipment performance can seriously affect results. Field measurements of illuminances made soon after lighting equipment installation or occupancy need to differentiate between anticipated recoverable (through regular maintenance, such as cleaning and relamping luminaires) light loss factors and the non-recoverable(attributed to equipment and site conditions and cannot be changed with normal maintenance) light loss factors that were employed in calculations performed during design. Such adjusted values that are within 10% to 30% of the recommended values may be acceptable; however, individual applications may have different criteria tolerances. Refer to *The Lighting Handbook,* 10th ed. (IES 2011), Sections 9.15 Field Measurements and 15.3.2 Field Results.

J.1.5 Localized Tasks. In some applications, task locations are known, such as a desk/reading surface, or non-horizontal machine surface. If task locations are known then the recommended illuminance values apply only to those locations. Local task lighting is recommended and should be controlled locally by the user. As an example, a common task locale is the desktop. In general, the ratio of average to minimum illumination values across the practical task planes, i.e., not including corners or far edges, should not be lower than 1.4:1 unless noted otherwise (see **Table J2 Notes** below).

J.1.6 Area Tasks. In some applications, the task may be performed over a large area, such as the floor of a corridor. If the task is an area, the recommended illuminance is to be achieved over that entire area, including corners.

J.1.7 Tasks at Uncertain Locations within a Large Area. Sometimes the task is localized and performed at specific locations in a large area, but for reasons of space use, planning, or future flexibility, the precise locations are not known at design time. This is the case, for example, with work zones consisting of flexible, modular furniture systems in open office environments.

In these cases, a criterion rating, CR can be determined for the area and used as a performance measure. CR is defined by:

$$CR = \frac{\textit{Number of calculation or measurement points at or above criterion}}{\textit{Number of calculation or measurement points}}$$

It is recommended that the CR of an area of uncertain task locations not be less than 70 percent.[1] See *The Lighting Handbook,* 10th ed. (2011), Section 10.8.3 Criterion Ratings, for details of computing this performance measure.

J.1.8 Multiple Tasks. It is often the case that the illuminance in some areas of an application should support multiple tasks. In these cases, it is usually necessary to rank the tasks by importance, prevalence, or frequency using data that may be available from the client, to determine the commonly occurring task with the highest recommended illuminance. This task should govern the illuminance on the task area. It is not necessary to provide for the highest illuminance level with the general lighting system. Localized task lighting should be employed for the more visually demanding tasks, with the benefits of lower energy use and increased user satisfaction.

J.1.9 Visual Age of Occupants. Age plays a key role in determining satisfaction with lighting levels for different tasks. Older eyes need higher illuminance levels to match the performance of younger eyes. The majority (or a plurality in the case where there is no majority) of occupants expected for a given space should be reviewed and the illuminance criteria selected appropriately. Localized, additional task lighting should be considered for the minority of the occupant population that may require it, before selecting higher illuminance criteria for the entire space or group.

J.1.10 Illuminance Ratios in Large Areas. In applications that present large areas to be lighted, it is usually necessary to assess the variation in illuminance and characterize the uniformity. Average, minimum, and maximum are often used in these assessments to form ratios of Average:Minimum, Maximum:Minimum, and Maximum:Average

J.1.11 Target Lighting Levels. The principal characteristics of this system are as follows:

- All recommendations assume photopic adaptation (refer to *The Lighting Handbook,* 10th ed., Chapter 4, for additional information).
- Each step consists of a central value flanked by an upper and lower value, constituting a range appropriate for a particular task, area, or age.
- The central value of each range is for typical conditions with a majority (or a plurality in the case where there is no majority) of the inhabitants are between 25 and 65 years old.
- The lower value is used for situations where a majority (or a plurality in the case where there is no majority) of the inhabitants are less than 25 years old.
- The higher value is used for situations where a majority (or a plurality in the case where there is no majority) of the inhabitants are at least 65 years old.

Table J.1 Target Illuminance Values

Category	Recommended Illuminance Targets (lux) — Visual Ages of Observers (years) where **at least half** are: <25	25 to 65	>65	Some Typical Application and Task Characteristics	Visual Performance Description
Public and pathway applications	A	0.5	1	2	• Dark adapted situations • Basic convenience situations • Very-low-activity situations	**Orientation, relatively large-scale, physical (less-cognitive) tasks** Visual performance is typically not work-related, but related to dark sedentary social situations, senses of safety and security, and casual circulation based on landscape, hardscape, architecture, and people as visual tasks.
	B	1	2	4		
	C	2	4	8	• Slow-paced situations • Low-density situations	
	D	3	6	12	• Slow-to-moderate-paced situations • Moderate-to-high-density situations	
	E	4	8	16		
	F	5	10	20	• Moderate-to-fast-paced situations • High-density situations • Some indoor very subdued circulaton situations • Some indoor social situations	
	G	7.5	15	30		
	H	10	20	40		
Simple and extensive applications	I	15	30	60	• Congested and significant outdoor intersections, important decision-points, gathering places, and key points of interest • Some indoor social situations • Some indoor commerce situations	
Medium and extensive applications	J	20	40	80		**Common social activity and large and/or high-contrast tasks** Visual performance involves higher-level assessment of landscape, hardscape, architecture, and people and can be work related.
	K	25	50	100		
	L	37.5	75	150	• Some outdoor commerce situations • Some indoor social situations • Some indoor commerce situations	
	M	50	100	200		
	N	75	150	300		
	O	100	200	400		
	P	150	300	600	• Some indoor social situations • Some indoor education situations • Some indoor commerce situations • Some indoor sports situations	**Common, relatively small-scale, more cognitive or fast-performance visual tasks** Visual performance is typically daily life- and work- related, including much reading and writing of hardcopies and electronic media consecutively and/or simultaneously.
	Q	200	400	800	• Some indoor education situations • Some indoor commerce situations • Some indoor sports situations • Some indoor industrial situations	
	R	250	500	1000		
	S	375	750	1500		
	T	500	1000	2000	• Some sports situations • Some indoor commerce situations • Some indoor industrial situations	**Small-scale, cognitive visual tasks** Visual performance is work- or sports-related, close and distant fine inspection, very small detail, high-speed assessment and reaction.
	U	750	1500	3000		
	V	1000	2000	4000		
	W	1500	3000	6000	• Some sports situations • Some indoor industrial situations • Some health care procedural situations	**Unusual, extremely minute and/or life-sustaining cognitive tasks** Visual performance is of the highest order in respective fields of health care, industrial, and sports.
Limited applications	X	2500	5000	10000	• Some health care procedural situations	
	Y	5000	10000	20000		

J.2 Application Illuminance Recommendations

By the time people reach an age of 65 years, four times the amount of light may be required than at 20 years of age. IES recommendations address this wide disparity by assigning three target values to each task or application.

- The central column target value for situations where the visual age of a majority (or a plurality in the case where there is no majority) of the observers is between 25 and 65 years of age.
- A second target value for situations where the visual age of a majority (or a plurality in the case where there is no majority) of the users is less than 25 years old.
- A third target value where the visual age of a majority (or a plurality in the case where there is no majority) of the users is more than 65 years old.

The designer may determine that the age distinction applies to a unique user even where the tasks or application involve many users. Perhaps illuminance targets are based on that unique user's age because, for example, that user is of notable importance or performs tasks of great consequence. In some situations, such a distinction may be accommodated with appropriate task lighting. In other situations, such a distinction may be accommodated with appropriate ambient lighting.

However, if greater luminance and contrast can be achieved with better surface reflectances and contrast techniques, these more sustainable practices should be pursued before increasing illuminance.

While it may expedite the design process and accommodate various tasks at various locations, illuminating whole areas or rooms to address the task with the highest single-value of illuminance can work against energy efficiency and sustainable practices.

Most spaces are used by a variety of occupants. These users might be of significantly varying visual ages and performing a number of tasks, some of which do not demand the same illuminance for satisfactory performance. Where one illuminance design target is quite high for one task relative to the targets for adjacent tasks, or is on a different plane, the designer should consider whether ambient and task lighting systems can be tailored to serve the demands of the higher illuminance task without generating more light than is necessary and avoiding directing unnecessary light on tasks with different demands. If illuminances of the various visual tasks are more than three categories apart, (refer to **Table J.2**) then task and visual age priorities should be used to establish the most frequently performed or most important task or tasks, and the lighting designer should consider the demands of the most important task.

J.2.1 Retail Application Illuminance Recommendations.

Due to the diversity in retailing and the constant evolution to create unique branded environments, recommended Illuminance values may vary between retail store types, or between retailers of similar store classification. The recommended illuminance values provide a basis for determining what illuminance values should be targeted within the design. Choosing desired light levels in the space will set up the decisions for light levels needed to highlight products either in perimeter or freestanding displays.

The next few subsections outline how to use **Table J.1** and **Table J.2.**

Table J.2 provides recommended illuminances for each type of store and retail space and for various visual tasks within the area. It is important to note that illuminance is measured on the plane in which the merchandise is displayed. Quite often, merchandise is displayed on vertical racks or on walls; consequently the vertical plane is the plane of consideration, rather than the horizontal one. Due to the flexible nature of retail environments, a frequent check of illuminance and luminance should be made at display planes to ensure proper emphasis. Computer analysis tools that can include rendered visualizations can be of great value in the evaluation of lighting designs. Refer to **Section 8.0** for additional discussion of computer tools.

The recommended illuminance categories provided in **Table J.1** and **Table J.2** are based on the Society's consensus judgment of best practice for "typical" applications and are extracted directly from *The Lighting Handbook*, 10th ed.,[1] Chapter 34.

J.2.1.1 Target Planes.

Many tasks are performed with the task in roughly

a horizontal orientation or vertical orientation. A dominant orientation should be assigned and the illuminance target determined accordingly. There may be situations where the IES recommended target relating to the typical planar mode of a task should be applied to a different plane. For example, if a home/bath/bedding store's general retail area consists primarily of vertically oriented product displays, then a more exciting rendering of those general retail areas will take place if the horizontal illuminance criteria from **Table J.2** are actually assigned as the vertical illuminance criteria and vice versa. This, however, pressures the designer to attend to glare issues associated with higher vertical illuminances.

Nearly all tasks are expected to have both a horizontal illuminance component (E_h) and a vertical illuminance component (E_v). This allows some degree of task flexibility for off-plane viewing and accommodates various aspects of the task. In many retail applications accommodating a variety of merchandise displays, horizontal-plane and vertical-plane illuminances address the common situation where, simultaneously, some merchandise or some portion of the merchandise is on horizontal planes while other merchandise or portion is on vertical planes.

Where illuminance targets are intended at differing planar elevations, this is indicated under "Notes." For example, for outdoor general merchandise displays (see RETAILING, OUTDOOR/Seasonal Open-air/Merchandise), E_h illuminance targets are intended for 0.76 m (2.5 ft) above finished grade, while E_v illuminance targets are intended for 1.2 m (4 ft). Establishing and tracking task orientations and addressing both horizontal and vertical illuminance are necessary. If orientations in the project under consideration are programmed to be flipped from what might be considered normal viewing, then criteria should be adjusted accordingly. If a task is scheduled to be oriented on some plane off axis from horizontal or vertical by more than 10 degrees, say, then the illuminance criteria should be applied to that off-axis orientation. This is an important distinction for luminaire optical selection and aiming capabilities and for layout, calculations, and field measurements.

For planes related to vertical illuminance targets where the directional orientation of the plane is believed straightforward and easily identified, some guidance is indicated under "Notes." However, the designer may elect to use alternative or multiple vertical planes. In some situations, the vertical planes could be oriented in a number of directions, and the designer should determine which are most appropriate for the situation. For example, feature displays may have a single direction of view or may have multiple directions of view. Lighting three or four sides where only a single-direction view is possible for shoppers is a waste of resources. Lighting one or two sides of a display with a 360-degree view may be a lost opportunity in drawing the attention of a significant number of shoppers. The designer should analyze the situation and determine what best meets the needs of the retailer.

J.2.1.2 Visual Ages of Observers. Illuminance criteria are based on the visual ages of more than half the intended observers. The designer should coordinate with the design team and retailer to establish the age group of the intended observers. The target market may differ from those making the actual purchase, such as parents of shopping children, or from the sales staff. Perhaps transaction areas are illuminated to one age group's criteria while retail areas and feature displays are lighted to another's. The aspects of observers' ages, task sets for age groups, and illuminance targets should be resolved during programming with the client.

J.2.1.3 Daylighting Advancement. Generally, design strategies should embrace combining of daylighting and electric lighting to achieve target values during daylight hours. The preference is for daylighting to provide all or most of the recommended illuminance, presuming that all aspects of daylighting are properly addressed. In **Table J.2,** a sunburst icon depicts those applications and tasks where daylighting is considered a strategic candidate. Photosensor based stepped dimming or continuous dimming should be used to reduce or eliminate electric lighting during daylight hours. For outdoor applications, lamps, ballasts, transformers, and drivers should be selected for ambient

temperature conditions (extremely hot and others extremely cold temperatures). (See **Sections 7.2 Electric Lighting** and **7.3 Daylighting**.) Even for those applications where daylighting is not traditionally a strategic candidate, it may be determined that very careful and coordinated design will offer great sustainability opportunities along with the specific influences associated with daylight and views.

If not properly controlled, the high illuminance and UV content of daylight may cause bleaching and fading..

J.2.1.4 Defining Areas of Coverage. In addition to establishing planes of task orientation, the areas of coverage to which targets apply should be determined. Typical areas of task illuminance coverage are identified in **Table J.2**, but these may not be appropriate to specific project situations. One area of coverage is "task proper or task area." The illuminance criteria are applied to the task itself or to a relatively small area to which the task is confined. In some situations, such as accenting, the "task" area may consist of the entire wall when "feature wall" or "perimeter" accenting is desired. It is important to remember that illuminance is additive; that is, task illuminance can be achieved with some combination of ambient lighting, task lighting, and/or accent lighting, provided the total illuminance on the task proper or task area meets the illuminance criteria outlined in **Table J.2**. With outdoor retail areas, it is most effective to target light to the task proper or task area. General lighting, unless extremely low level over the important shopper-occupied zones, is inappropriate over large areas of the merchandising property.

Another area of coverage is "room or designated area." In this situation, illuminance criteria are applied to the room or an area of fairly substantive size representing the zone in which the applications and tasks are expected to occur. The designated area is typically established by the department or retail layout, for example, but should be scrutinized by the design team and retailer. If, however, the task will be confined to one portion of the department area or if the room or area in which the task is located is itself relatively small, and if the other design goals and criteria outlined are addressed, then a strategy of refining the area or areas of coverage to the task proper or task area has merit. This can result in reduced energy use, more significant visual emphasis of the merchandise, and a more visually interesting and exciting shopping experience.

An assessment and determination should be made as to which area of coverage best satisfies the lighting goals on a particular project.

Table J.2. Retail Application Illuminance Values.

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Category	Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge Category	Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Gauge	Area of Coverage[h] Task Area	Room or Area
CENTERS, OUTDOOR	Vehicular traffic restricted. Open-air malls or centers dedicated to shoppers.															
* Accents	Extinguish at curfew															
* Art	On artwork plane (typically vertical)	see **IES HB 10e Table 15.2** (typically "Moderate" or "Soft")														
* Feature	On wall plane or trees	see **IES HB 10e Table 15.2** (typically "Moderate")														
* Performance Areas	E_h @pavement; E_v @5' AFG	see **IES HB 10e Table 15.2** (typically "Strong" to "Moderate")														
* Perimeter	On wall plane or trees	see **IES HB 10e Table 15.2** (typically "Soft")														
* Significant Focal Point	On focal point plane (typically vertical)	see **IES HB 10e Table 15.2** (typically "Strong" to "Moderate")														
* Plazas and Town Squares	E_h @pavement; E_v @5' AFG in at least the two primary directions of circulation. Coordinate lighting with security cameras.															
* High Activity[i]	Plazas typified by periods of high shopper volume															
* LZ4[j]		E	4	8	16	Avg	C	2	4	8	Avg	4:1	5:1			
* LZ3[j] (and LZ4 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)			
* LZ2[j] (and LZ3 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)			
* LZ1[j] (and LZ2 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)			
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1				
* Medium Activity[i]	Plazas typified by periods of medium shopper volume															
* LZ4[j]		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1			
* LZ3[j] (and LZ4 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)			
* LZ2[j] (and LZ3 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)			
* LZ1[j] (and LZ2 curfew)		A	0.5	1	2	Avg	-	0	0	0		4:1	5:1 (10:1)			
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1				
* Low Activity[i]	Plazas typified by periods of low shopper volume															
* LZ4[j]		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1			
* LZ3[j] (and LZ4 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)			
* LZ2[j] (and LZ3 curfew)		A	0.5	1	2	Avg	-	0	0	0		4:1	5:1 (10:1)			
* LZ1[j] (and LZ2 curfew)		A	0.5	1	2	Avg	-	0	0	0		4:1	5:1 (10:1)			
* LZ0[j] (and LZ1 curfew)		-	0	0	0		-	0	0	0						
* Ramps, Stairs, and Steps	E_h @treads/landings; E_v @5' AFG in at least the two primary directions of circulation. Coordinate lighting with security cameras. Lighting should address the area of the ramps, steps, and															
* High Activity[i]	Ramps, stairs, and steps typified by periods of high shopper volume															
* LZ4[j]		F	5	10	20	Avg	D	3	6	12	Avg	4:1	5:1			
* LZ3[j] (and LZ4 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	4:1	5:1 (10:1)			
* LZ2[j] (and LZ3 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)			
* LZ1[j] (and LZ2 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)			
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	B	1	2	4	Avg	A	0.5	1	2	Avg	4:1				

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Area of Coverage[h] Task Area	Room or Area
		Category				Category									
CENTERS, OUTDOOR	(continued)														
* Medium Activity[j]	Ramps, stairs, and steps typified by periods of medium shopper volume														
* LZ4[j]		E	4	8	16	Avg	C	2	4	8	Avg	4:1	5:1		
* LZ3[j] (and LZ4 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ2[j] (and LZ3 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ1[j] (and LZ2 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1			
* Low Activity[j]	Ramps, stairs, and steps typified by periods of low shopper volume														
* LZ4[j]		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1		
* LZ3[j] (and LZ4 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ2[j] (and LZ3 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ1[j] (and LZ2 curfew)		A	0.5	1	2	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1			
* Shopping Promenades	E_h @grade; E_v @5' AFG in at least the two primary directions of circulation. Coordinate lighting with security cameras.														
* High Activity[j]	Shopping promenades typified by periods of high shopper volume														
* LZ4[j]		F	5	10	20	Avg	D	3	6	12	Avg	4:1	5:1		
* LZ3[j] (and LZ4 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	4:1	5:1 (10:1)		
* LZ2[j] (and LZ3 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ1[j] (and LZ2 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	B	1	2	4	Avg	A	0.5	1	2	Avg	4:1			
* Medium Activity[j]	Shopping promenades typified by periods of medium shopper volume														
* LZ4[j]		E	4	8	16	Avg	C	2	4	8	Avg	4:1	5:1		
* LZ3[j] (and LZ4 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ2[j] (and LZ3 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ1[j] (and LZ2 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1			
* Low Activity[j]	Shopping promenades typified by periods of low shopper volume														
* LZ4[j]		D	3	6	12	Avg	B	1	2	4	Avg	4:1	5:1		
* LZ3[j] (and LZ4 curfew)		C	2	4	8	Avg	B	1	2	4	Avg	4:1	5:1 (10:1)		
* LZ2[j] (and LZ3 curfew)		B	1	2	4	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ1[j] (and LZ2 curfew)		A	0.5	1	2	Avg	A	0.5	1	2	Avg	4:1	5:1 (10:1)		
* LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	A	0.5	1	2	Avg	-	0	0	0		4:1			

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]									Uniformity Targets[e]			Area of Coverage[h]	
		Horizontal (E_h) Targets				Vertical (E_v) Targets					Over Area			Task Area	Room or Area
		Visual Ages of Observers (years) where at least half are				Visual Ages of Observers (years) where at least half are					1st ratio $E_h/2^{nd}$ ratio E_v if different uniformities apply				
		<25	25-65	>65		<25	25-65	>65			Max:Avg	Avg:Min	Max:Min		
		Category			Gauge	Category			Gauge						
MALLS, INDOOR															
Accenting		Accenting influences observers' overall brightness perceptions and provides visual relief. Accenting is also used for visual attraction and wayfinding.													
- Art		On artwork plane (typically vertical).				see **IES HB 10e Table 15.2** (typically "Moderate" or "Soft")									
Displays		On plane(s) of display				see **IES HB 10e Table 15.2** (typically "Moderate")									
Feature Displays		On plane(s) of display				see **IES HB 10e Table 15.2** (typically "Dramatic")									
Feature Wall		On wall plane				see **IES HB 10e Table 15.2** (typically "Soft" or "Subtle")									
Services		E_h @floor; E_v @5' AFF	P	150	300	600	Avg	M	50	100	200	Avg	2:1		
Concourses		E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
Directories		E_v @3'-5' AFF						P	150	300	600	Avg			
Entertainment Areas		See **IES HB 10e Ch 24** | LIGHTING FOR EDUCATION/AUDITORIA/Performance													
Information Desks		E_h @3' AFF	P	150	300	600	Avg	M	50	100	200	Avg			
Retail Kiosks															
Displays															
- Horizontal		E_h @3' AFF	P	150	300	600	Avg						1.2:1	1.2:1	
- Vertical		E_v @3'-5' AFF						P	150	300	600	Avg	1.5:1	1.5:1	
General		E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
Transaction Counters		E_h @3' AFF	P	150	300	600	Avg						2:1		
Service Corridors		E_h @floor; E_v @5' AFF	P	150	300	600	Avg	M	50	100	200	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
RETAILING, INDOOR															
Feature Displays		E_h and E_v @respective relevant plane(s) on feature display													
- Bazaar		Apply strategically to ≤10% of display				10 times general E_h of adjacent retail area; may affect fading, bleaching, and shelf life					Max	2:1			
- Highlight		Apply strategically to ≤25% of display				5 times general E_h of adjacent retail area; may affect fading, bleaching, and shelf life					Max	2:1			
- Focal Display		Apply to entire display				Equal to general E_h of adjacent retail area					Avg	1.2:1	1.2:1		
Fitting Rooms		Primary plane of interest is vertical oriented toward mirror.													
Dressing Areas															
- Typical		E_h @floor; E_v @3'-5' AFF	P	150	300	600	Avg	P	150	300	600	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
- Upscale		E_h @floor; E_v @3'-5' AFF	P	150	300	600	Avg	R	250	500	1000	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
Fitting Areas		E_h @floor; E_v @3'-5' AFF	P	150	300	600	Avg	R	250	500	1000	Avg	1.2:1/1.5:1	1.2:1/1.5:1	
Retail by Classification		Classified by type of store or department. Coordinate lighting with security cameras.													
Automotive Sales/Service															
- Circulation		E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg	1.2:1	1.2:1	

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[1]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]												Uniformity Targets[e]					
		Horizontal (E_h) Targets						Vertical (E_v) Targets						Over Area					
		Visual Ages of Observers (years) where at least half are						Visual Ages of Observers (years) where at least half are						1st ratio $E_h/2^{nd}$ ratio E_h if different uniformities apply					
		<25	25-65	>65				<25	25-65	>65				MaxcAvg	Avg:Min	MaxcMin			
		Category			Gauge	Category					Gauge								
RETAILING, INDOOR																			
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	M	50	100	200	Avg	3:1/6:1	3:1/6:1						
- Perimeter[f]	E_v @5' AFF						P	150	300	600	Avg	4:1	4:1						
- Service																			
(General)	E_h @floor; E_v @5' AFF	R	250	500	1000	Avg	P	150	300	600	Avg	1.5:1	1.5:1						
Provisional	Provide for portable worklights as needed																		
- Circulation	E_h and E_v @3' 6" AFF	T	500	1000	2000	Avg	R	250	500	1000	Avg	1.5:1	1.5:1						
- Work order write-up	E_h and E_v @3' 6" AFF	Q	200	400	800	Avg	N	75	150	300	Avg	1.5:1	1.5:1						
* Department Store																			
- Circulation	E_h @floor; E_v @5' AFF	N	75	150	300	Avg	K	25	50	100	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	Q	200	400	800	Avg	N	75	150	300	Avg	1.5:1/3:1	1.5:1/3:1						
- Perimeter[f]	E_v @5' AFF						S	375	750	1500	Avg	2:1	2:1						
* Designer Shop/Boutique																			
- Circulation	E_h @floor; E_v @5' AFF	L	37.5	75	150	Avg	H	10	20	40	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	3:1/6:1	3:1/6:1						
- Perimeter[f]	E_v @5' AFF						O	100	200	400	Avg	4:1	4:1						
* Discount																			
- Circulation	E_h @floor; E_v @5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	O	100	200	400	Avg	1.5:1/3:1	1.5:1/3:1						
- Perimeter[f]	E_v @5' AFF						R	250	500	1000	Avg	2:1	2:1						
* Drug and Convenience																			
- Circulation	E_h @floor; E_v @5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	O	100	200	400	Avg	1.5:1/3:1	1.5:1/3:1						
- Perimeter[f]	E_v @5' AFF						R	250	500	1000	Avg	2:1	2:1						
* Fine/Precious Jewelry																			
- Circulation	E_h @floor; E_v @5' AFF	N	75	150	300	Avg	K	25	50	100	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	Q	200	400	800	Avg	N	75	150	300	Avg	3:1/6:1	3:1/6:1						
- Perimeter[f]	E_v @5' AFF						Q	200	400	800	Avg	4:1	4:1						
* Furniture																			
- Circulation	E_h @floor; E_v @5' AFF	L	37.5	75	150	Avg	H	10	20	40	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	3:1/6:1	3:1/6:1						
- Perimeter[f]	E_v @5' AFF						O	100	200	400	Avg	4:1	4:1						
* Grocery/Supermarket																			
- Circulation	E_h @floor; E_v @5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	1.2:1	1.2:1						
- General retail[f]	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	O	100	200	400	Avg	1.5:1/3:1	1.5:1/3:1						
- Perimeter[f]	E_v @5' AFF						R	250	500	1000	Avg	2:1	2:1						

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]												Uniformity Targets[e]					Area of Coverage[h]	
		Horizontal (E_h) Targets						Vertical (E_v) Targets						Over Area					Task Area	Room or Area
		Visual Ages of Observers (years) where at least half are						Visual Ages of Observers (years) where at least half are						1st ratio E_h/2nd ratio E_v if different uniformities apply						
		<25		25-65		>65		<25		25-65		>65		Max:Avg		Avg:Min		Max:Min		
		Category					Gauge	Gauge	Category				Gauge							
RETAILING: INDOOR	(continued)																			
• Home/Bath Bedding																				
– Circulation	E_h @floor; E_v @5' AFF	N	75	150	300	Avg	K	25	50	100	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	Q	200	400	800	Avg	N	75	150	300	Avg	3:1/6:1	3:1/6:1							
– Perimeter	E_v @5' AFF						Q	200	400	800	Avg	4:1	4:1							
• Mass Merchant																				
– Circulation	E_h @floor; E_v @5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	O	100	200	400	Avg	1.5:1/3:1	1.5:1/3:1							
– Perimeter	E_v @5' AFF						R	250	500	1000	Avg	2:1	2:1							
• Specialty Retailer																				
– Circulation	E_h @floor; E_v @5' AFF	N	75	150	300	Avg	K	25	50	100	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	Q	200	400	800	Avg	N	75	150	300	Avg	3:1/6:1	3:1/6:1							
– Perimeter	E_v @5' AFF						S	375	750	1500	Avg	4:1	4:1							
• Upscale Crystal – China – Silver																				
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	Q	200	400	800	Avg	N	75	150	300	Avg	3:1/6:1	3:1/6:1							
– Perimeter	E_v @5' AFF						Q	200	400	800	Avg	4:1	4:1							
• Upscale Department																				
– Circulation	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	P	150	300	600	Avg	O	100	200	400	Avg	3:1/6:1	3:1/6:1							
– Perimeter	E_v @5' AFF						R	250	500	1000	Avg	4:1	4:1							
• Upscale Specialty																				
– Circulation	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	P	150	300	600	Avg	M	50	100	200	Avg	3:1/6:1	3:1/6:1							
– Perimeter	E_v @5' AFF						P	150	300	600	Avg	4:1	4:1							
• Warehouse Store																				
– Circulation	E_h @floor; E_v @5' AFF	O	100	200	400	Avg	L	37.5	75	150	Avg	1.2:1	1.2:1							
– General retail	E_h @2' 6" AFF; E_v @3'-5' AFF	R	250	500	1000	Avg	O	100	200	400	Avg	1.5:1/3:1	1.5:1/3:1							
– Perimeter	E_v @5' AFF						R	250	500	1000	Avg	2:1	2:1							
• Sales Transaction Areas	E_h @3' 6" AFF; E_v @5' AFF	P	150	300	600	Avg	M	50	100	200	Avg	1.2:1/1.5:1	1.2:1/1.5:1							
• Show Windows	E_v on relevant areas of displays in windows																			
• Exterior Facing Windows																				
• Day																				
– Display	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life						Y	5000	10000	20000	Max									

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Vertical (E_v) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Uniformity Targets[e] Over Area — 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	[f]	[g]	Area of Coverage[h] Task Area	Room or Area
		Category			Gauge Category			Gauge						
RETAILING, INDOOR	(continued)													
Highlight	Apply strategically to ≤25% of total display or displays visible from primary				X	2500	5000	10000	Max					
Total display	Apply to total display or displays visible from primary viewing direction				T	500	1000	2000	Avg	5:1				
Night														
High Activity[i]	Show windows in areas typified by high nighttime pedestrian or vehicular activity													
L24[j]														
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				W	1500	3000	6000	Max					
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				U	750	1500	3000	Max					
Total display	Apply to total display or displays visible from primary viewing direction				P	150	300	600	Avg	5:1				
L23[j] (and L24 curfew)														
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				V	1000	2000	4000	Max					
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				T	500	1000	2000	Max					
Total display	Apply to total display or displays visible from primary viewing direction				O	100	200	400	Avg	5:1				
L22[j] (and L23 curfew)														
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				T	500	1000	2000	Max					
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				R	250	500	1000	Max					
Total display	Apply to total display or displays visible from primary viewing direction				M	50	100	200	Avg	5:1				
L21[j] (and L22 curfew)														
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				R	250	500	1000	Max					
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				P	150	300	600	Max					

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[e] Over Area — 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	[f]	[g]	Area of Coverage[h] Task Area	Room or Area
		Category				Category											
RETAILING, INDOOR	(continued)																
Total display	Apply to total display or displays visible from primary viewing direction					K	25	50	100	Avg	5:1						
LZ0[i] (and LZ1 curfew)		-	0	0	0	-	0	0	0								
Medium Activity[j]	Show windows in areas typified by medium nighttime pedestrian or vehicular activity																
LZ4[j]																	
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					V	1000	2000	4000	Max							
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					T	500	1000	2000	Max							
Total display	Apply to total display or displays visible from primary viewing direction					O	100	200	400	Avg	5:1						
LZ3[j] (and LZ4 curfew)																	
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					T	500	1000	2000	Max							
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					R	250	500	1000	Max							
Total display	Apply to total display or displays visible from primary viewing direction					M	50	100	200	Avg	5:1						
LZ2[j] (and LZ3 curfew)																	
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					R	250	500	1000	Max							
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					P	150	300	600	Max							
Total display	Apply to total display or displays visible from primary viewing direction					K	25	50	100	Avg	5:1						
LZ1[j] (and LZ2 curfew)																	
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					P	150	300	600	Max							
Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life					N	75	150	300	Max							
Total display	Apply to total display or displays visible from primary viewing direction					I	15	30	60	Avg	5:1						
LZ0[i] (and LZ1 curfew)		-	0	0	0	-	0	0	0								

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]									Uniformity Targets[e]			Area of Coverage[h]	
		Horizontal (E_h) Targets				Vertical (E_v) Targets					Over Area			Task Area	Room or Area
		Visual Ages of Observers (years) where at least half are				Visual Ages of Observers (years) where at least half are					1st ratio $E_h/2^{nd}$ ratio E_h if different uniformities apply				
		<25	25-65	>65	Gauge Category	<25	25-65	>65	Gauge		Max:Avg	Avg:Min	Max:Min		
RETAILING: INDOOR	(continued)														
Food Activity	Show windows in areas typified by low nighttime pedestrian or vehicular activity														
LZ4															
Dazzle					T	500	1000	2000	Max						
Highlight	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				R	250	500	1000	Max						
Total display	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				M	50	100	200	Avg		5:1				
LZ3 (and LZ4 curfew)	Apply to total display or displays visible from primary viewing direction														
Dazzle					R	250	500	1000	Max						
Highlight	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				P	150	300	600	Max						
Total display	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				K	25	50	100	Avg		5:1				
LZ2 (and LZ3 curfew)	Apply to total display or displays visible from primary viewing direction														
Dazzle					P	150	300	600	Max						
Highlight	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				N	75	150	300	Max						
Total display	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				I	15	30	60	Avg		5:1				
LZ1 (and LZ2 curfew)	Apply to total display or displays visible from primary viewing direction														
Dazzle					N	75	150	300	Max						
Highlight	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				L	37.5	75	150	Max						
Total display	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				G	7.5	15	30	Avg		5:1				
LZ0 (and LZ1 curfew)	Apply to total display or displays visible from primary viewing direction														
Interior Facing Windows		-	0	0	0	-	0	0	0						
Dazzle	Apply strategically to ≤10% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life				U	750	1500	3000	Max						

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are					Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are				Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply			[f]	[g]	Area of Coverage[h]	
			<25	25-65	>65			<25	25-65	>65		Max:Avg	Avg:Min	Max:Min			Task Area	Room or Area
		Category				Gauge	Category				Gauge							
RETAILING, OUTDOOR	(continued)																	
• Highlight	Apply strategically to ≤25% of total display or displays visible from primary viewing direction; may affect fading, bleaching, and shelf life						S	375	750	1500	Max							
• Total display	Apply to total display or displays visible from primary viewing direction						N	75	150	300	Avg	5:1						
• Wrapping and Packaging	E_h @3' 6" AFF; E_v @5' AFF	P	150	300	600	Avg	M	50	100	200	Avg	1.2:1/1.5:1	1.2:1/1.5:1					
• Automotive Sales	Coordinate lighting with security cameras.																	
• Circulation Drives	E_h @pavement; E_v @5' AFF																	
• High Activity[i]																		
• LZ4[j]		H	10	20	40	Avg	E	4	8	16	Avg	3:1	3:1					
• LZ3[j] (and LZ4 curfew)		G	7.5	15	30	Avg	D	3	6	12	Avg	3:1	3:1 (6:1)					
• LZ2[j] (and LZ3 curfew)		F	5	10	20	Avg	C	2	4	8	Avg	3:1	3:1 (6:1)					
• LZ1[j] (and LZ2 curfew)		E	4	8	16	Avg	B	1	2	4	Avg	3:1	3:1 (6:1)					
• LZ0[j] (and LZ1 curfew)		-	0	0	0		-	0	0	0								
• Medium Activity[i]																		
• LZ4[j]		G	7.5	15	30	Avg	D	3	6	12	Avg	3:1	3:1					
• LZ3[j] (and LZ4 curfew)		F	5	10	20	Avg	C	2	4	8	Avg	3:1	3:1 (6:1)					
• LZ2[j] (and LZ3 curfew)		E	4	8	16	Avg	B	1	2	4	Avg	3:1	3:1 (6:1)					
• LZ1[j] (and LZ2 curfew)		D	3	6	12	Avg	A	0.5	1	2	Avg	3:1	3:1 (6:1)					
• LZ0[j] (and LZ1 curfew)		-	0	0	0		-	0	0	0								
• Low Activity[i]																		
• LZ4[j]		F	5	10	20	Avg	C	2	4	8	Avg	3:1	3:1					
• LZ3[j] (and LZ4 curfew)		E	4	8	16	Avg	B	1	2	4	Avg	3:1	3:1 (6:1)					
• LZ2[j] (and LZ3 curfew)		D	3	6	12	Avg	A	0.5	1	2	Avg	3:1	3:1 (6:1)					
• LZ1[j] (and LZ2 curfew)		C	2	4	8	Avg	-	0	0	0		3:1	3:1 (6:1)					
• LZ0[j] (and LZ1 curfew)		-	0	0	0		-	0	0	0								
• Featured Vehicle	Illuminance @respective relevant plane(s) on feature display																	
• Dazzle	Apply strategically to ≤10% of total vehicle visible from primary viewing direction						E_h and E_v on the featured vehicle ≤10 times E_h of Front Row for respective Activity Level and Lighting Zone				Max	3:1						
• Highlight	Apply strategically to ≤25% of total vehicle visible from primary viewing direction						E_h and E_v on the featured vehicle ≤5 times E_h of Front Row for respective Activity Level and Lighting Zone				Max	3:1						
• Total vehicle	IESH/10e proposed values: Apply to total vehicle visible from primary viewing direction						Equal to E_h of Front Row for respective Activity Level and Lighting Zone				Avg	3:1						

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]												Uniformity Targets[e]			Area of Coverage[h]	
		Horizontal (E_h) Targets						Vertical (E_v) Targets						Over Area				
		Visual Ages of Observers (years) where at least half are						Visual Ages of Observers (years) where at least half are						1st ratio E_h/2nd ratio E_h if different uniformities apply			Task Area	Room or Area
		<25		25-65		>65		<25		25-65		>65		MaxcAvg	AvgcMin	MaxcMin		
		Category			Gauge	Category			Gauge		Category		Gauge					
RETAILING, OUTDOOR	(continued)																	
• Front Row	E_h and E_v @4' AFF																	
– High Activity[f]																		
– L24[f]		P	150	300	600	Avg	P	150	300	600	Avg			3:1	3:1			
– L25 (and L24 curfew)		O	100	200	400	Avg	O	100	200	400	Avg			3:1	3:1 (6:1)			
– L22 (and L24 curfew)		N	75	150	300	Avg	N	75	150	300	Avg			3:1	3:1 (6:1)			
– L21 (and L23 curfew)		M	50	100	200	Avg	M	50	100	200	Avg			3:1	3:1 (6:1)			
– L20 (and L21 curfew)		-	0	0	0		-	0	0	0								
– Medium Activity[f]																		
– L24[f]		O	100	200	400	Avg	O	100	200	400	Avg			3:1	3:1			
– L23 (and L24 curfew)		N	75	150	300	Avg	N	75	150	300	Avg			3:1	3:1 (6:1)			
– L22 (and L23 curfew)		M	50	100	200	Avg	M	50	100	200	Avg			3:1	3:1 (6:1)			
– L21 (and L22 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg			3:1	3:1 (6:1)			
– L20 (and L21 curfew)		-	0	0	0		-	0	0	0								
– Low Activity[f]																		
– L24[f]		N	75	150	300	Avg	N	75	150	300	Avg			3:1	3:1			
– L23 (and L24 curfew)		M	50	100	200	Avg	M	50	100	200	Avg			3:1	3:1 (6:1)			
– L22 (and L23 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg			3:1	3:1 (6:1)			
– L21 (and L22 curfew)		K	25	50	100	Avg	K	25	50	100	Avg			3:1	3:1 (6:1)			
– L20 (and L21 curfew)		-	0	0	0		-	0	0	0								
• Parking	E_h @pavement; E_v @5' AFF																	
– High Activity[f]																		
– L24[f]		I	15	30	60	Avg	G	7.5	15	30	Avg			3:1	3:1			
– L23 (and L24 curfew)		H	10	20	40	Avg	F	5	10	20	Avg			3:1	3:1 (6:1)			
– L22 (and L23 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg			3:1	3:1 (6:1)			
– L21 (and L22 curfew)		F	5	10	20	Avg	D	3	6	12	Avg			3:1	3:1 (6:1)			
– L20 (and L21 curfew)		-	0	0	0		-	0	0	0								
– Medium Activity[f]																		
– L24[f]		H	10	20	40	Avg	F	5	10	20	Avg			3:1	3:1			
– L23 (and L24 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg			3:1	3:1 (6:1)			
– L22 (and L23 curfew)		F	5	10	20	Avg	D	3	6	12	Avg			3:1	3:1 (6:1)			
– L21 (and L22 curfew)		E	4	8	16	Avg	C	2	4	8	Avg			3:1	3:1 (6:1)			
– L20 (and L21 curfew)		-	0	0	0		-	0	0	0								
– Low Activity[f]																		

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets — Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[e] Over Area — 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Area of Coverage[h] Task Area	Room or Area
		Category				Category									
RETAILING, OUTDOOR	(continued)														
LZ4[f]		G	7.5	15	30	Avg	E	4	8	16	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	3:1	3:1 (6:1)		
LZ2[f] (and LZ3 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	3:1	3:1 (6:1)		
LZ1[f] (and LZ2 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	3:1	3:1 (6:1)		
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0					
+ Preparation and Storage	E_h @pavement; E_v @5' AFF														
+ High Activity[f]															
LZ4[f]		I	15	30	60	Avg	G	7.5	15	30	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		H	10	20	40	Avg	F	5	10	20	Avg	3:1	3:1 (6:1)		
LZ2[f] (and LZ3 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg	3:1	3:1 (6:1)		
LZ1[f] (and LZ2 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	3:1	3:1 (6:1)		
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0					
+ Medium Activity[f]															
LZ4[f]		H	10	20	40	Avg	F	5	10	20	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg	3:1	3:1 (6:1)		
LZ2[f] (and LZ3 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	3:1	3:1 (6:1)		
LZ1[f] (and LZ2 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	3:1	3:1 (6:1)		
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0					
+ Low Activity[f]															
LZ4[f]		G	7.5	15	30	Avg	E	4	8	16	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	3:1	3:1 (6:1)		
LZ2[f] (and LZ3 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	3:1	3:1 (6:1)		
LZ1[f] (and LZ2 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	3:1	3:1 (6:1)		
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0					
+ Sales	E_h and E_v @4' AFF														
+ High Activity[f]															
LZ4[f]		N	75	150	300	Avg	L	37.5	75	150	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		M	50	100	200	Avg	K	25	50	100	Avg	3:1	3:1 (6:1)		
LZ2[f] (and LZ3 curfew)		L	37.5	75	150	Avg	J	20	40	80	Avg	3:1	3:1 (6:1)		
LZ1[f] (and LZ2 curfew)		K	25	50	100	Avg	I	15	30	60	Avg	3:1	3:1 (6:1)		
LZ0[f] (and LZ1 curfew)		-	0	0	0		-	0	0	0					
+ Medium Activity[f]															
LZ4[f]		M	50	100	200	Avg	K	25	50	100	Avg	3:1	3:1		
LZ3[f] (and LZ4 curfew)		L	37.5	75	150	Avg	J	20	40	80	Avg	3:1	3:1 (6:1)		

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are					Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are				Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply			Area of Coverage[h]	
		Category	<25	25-65	>65	Gauge	Category	<25	25-65	>65	Gauge	Max:Avg	Avg:Min	Max:Min	Task Area	Room or Area
RETAILING, OUTDOOR	(continued)															
· LZ2[i] (and LZ3 curfew)		K	25	50	100	Avg	I	15	30	60	Avg	3:1	3:1 (6:1)			
· LZ1[i] (and LZ2 curfew)		J	20	40	80	Avg	H	10	20	40	Avg	3:1	3:1 (6:1)			
· LZ0[i] (and LZ1 curfew)		-	0	0	0		-	0	0	0						
· Low Activity																
· LZ4[i]		L	37.5	75	150	Avg	J	20	40	80	Avg	3:1	3:1			
· LZ3[i] (and LZ4 curfew)		K	25	50	100	Avg	I	15	30	60	Avg	3:1	3:1 (6:1)			
· LZ2[i] (and LZ3 curfew)		J	20	40	80	Avg	H	10	20	40	Avg	3:1	3:1 (6:1)			
· LZ1[i] (and LZ2 curfew)		I	15	30	60	Avg	G	7.5	15	30	Avg	3:1	3:1 (6:1)			
· LZ0[i] (and LZ1 curfew)		-	0	0	0		-	0	0	0						
*Seasonal Open-air	Examples include farmers markets, Christmas tree sales, arts festivals, and produce stands typified by open-air or partial-cover situations. Coordinate lighting with security cameras.															
*LZ4[i]																
· Circulation	E_h @pavement; E_v @5' AFF	H	10	20	40	Avg	E	4	8	16	Avg	2:1	2:1			
· Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	N	75	150	300	Avg	N	75	150	300	Avg	2:1				
· Merchandise[j]	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	J	20	40	80	Avg	J	20	40	80	Avg	2:1	2:1 (4:1)			!
*LZ3[i] (and LZ4 curfew)																
· Circulation	E_h @pavement; E_v @5' AFF	G	7.5	15	30	Avg	D	3	6	12	Avg	2:1	2:1 (4:1)			
· Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	M	50	100	200	Avg	M	50	100	200	Avg	2:1				
· Merchandise[j]	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	I	15	30	60	Avg	I	15	30	60	Avg	2:1	2:1 (4:1)			!
*LZ2[i] (and LZ3 curfew)																
· Circulation	E_h @pavement; E_v @5' AFF	F	5	10	20	Avg	C	2	4	8	Avg	2:1	2:1 (4:1)			
· Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	K	25	50	100	Avg	K	25	50	100	Avg	2:1				
	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known															

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are					Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are					Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply			Area of Coverage[h]	
		Category	<25	25-65	>65	Gauge	Category	<25	25-65	>65	Gauge	Max:Avg	Avg:Min	Max:Min	Task Area	Room or Area
RETAILING, OUTDOOR	(continued)															
• Merchandise[f]		H	10	20	40	Avg	H	10	20	40	Avg	2:1	2:1 (4:1)			
• LZ1[i] (and LZ2 curfew)																
◦ Circulation	E_h @pavement; E_v @5' AFF	D	3	6	12	Avg	B	1	2	4	Avg	2:1	2:1 (4:1)			
◦ Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	J	20	40	80	Avg	J	20	40	80	Avg	2:1				
◦ Merchandise[f]	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	G	7.5	15	30	Avg	G	7.5	15	30	Avg	2:1	2:1 (4:1)			
• LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]															
◦ Circulation	E_h @pavement; E_v @5' AFF	C	2	4	8	Avg	A	0.5	1	2	Avg	2:1				
◦ Feature displays	Apply strategically to ≤25 ft² or 25% of feature whichever covers more area of feature	I	15	30	60	Avg	I	15	30	60	Avg	2:1				
◦ Merchandise[f]	E_h @2' 6" AFF; Ev @4' AFF or at actual display elevations and orientations when known	F	5	10	20	Avg	F	5	10	20	Avg	2:1				
• Service Stations	Coordinate lighting with security cameras.															
• Approaches/Drives/Parking	Areas not associated with dispensing or service functions.															
• High Activity[l]	E_h @pavement; E_v @5' AFF															
◦ LZ4[i]		H	10	20	40	Avg	F	5	10	20	Avg	2:1	3:1			
◦ LZ3[i] (and LZ4 curfew)		G	7.5	15	30	Avg	E	4	8	16	Avg	2:1	3:1 (6:1)			
◦ LZ2[i] (and LZ3 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	2:1	3:1 (6:1)			
◦ LZ1[i] (and LZ2 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	2:1	3:1 (6:1)			
◦ LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	D	3	6	12	Avg	B	1	2	4	Avg	2:1				
• Medium Activity[l]	E_h @pavement; E_v @5' AFF															
◦ LZ4[i]		G	7.5	15	30	Avg	E	4	8	16	Avg	2:1	3:1			
◦ LZ3[i] (and LZ4 curfew)		F	5	10	20	Avg	D	3	6	12	Avg	2:1	3:1 (6:1)			
◦ LZ2[i] (and LZ3 curfew)		E	4	8	16	Avg	C	2	4	8	Avg	2:1	3:1 (6:1)			
◦ LZ1[i] (and LZ2 curfew)		D	3	6	12	Avg	B	1	2	4	Avg	2:1	3:1 (6:1)			
◦ LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	C	2	4	8	Avg	A	0.5	1	2	Avg	2:1				
• Low Activity[l]	E_h @pavement; E_v @5' AFF															

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]												Uniformity Targets[e]			Area of Coverage[h]	
		Horizontal (E_h) Targets					Vertical (E_v) Targets							Over Area			Task Area	Room or Area
		Visual Ages of Observers (years) where at least half are					Visual Ages of Observers (years) where at least half are							1st ratio E_v/2nd ratio E_v if different uniformities apply				
		<25	25-65	>65	Gauge	Category	<25	25-65	>65	Gauge				Max:Avg	Avg:Min	Max:Min		
RETAILING: OUTDOOR	(continued)																	
• [12]						F	5	10	20	Avg	D	3	6	12	Avg	2:1	3:1	
[12] (and [11] curfew)						E	4	8	16	Avg	C	2	4	8	Avg	2:1	3:1 (6:1)	
[12] (and [13] curfew)						D	3	6	12	Avg	B	1	2	4	Avg	2:1	3:1 (6:1)	
[12] (and [12] curfew)						C	2	4	8	Avg	A	0.5	1	2	Avg	2:1	3:1 (6:1)	
[20] (and [13] curfew)		Control with motion sensors[k]				B	1	2	4	Avg	-	0	0	0		2:1		
• Building Facades		Key vertical facade surfaces to define place and attract attention. Apply strategically to ≤25% of area of building facade visible from primary viewing directions																
• High Activity[f]																		
[24]											K	25	50	100	Avg	4:1	4:1	
[24] (and [12] curfew)											J	20	40	80	Avg	4:1	4:1 (8:1)	
[22] (and [12] curfew)											I	15	30	60	Avg	4:1	4:1 (8:1)	
[21] (and [12] curfew)											H	10	20	40	Avg	4:1	4:1 (8:1)	
[21] curfew											G	7.5	15	30	Avg	4:1	8:1	
[20]											-	0	0	0				
• Medium Activity[f]																		
[24]											J	20	40	80	Avg	4:1	4:1	
[23] (and [12] curfew)											I	15	30	60	Avg	4:1	4:1 (8:1)	
[22] (and [12] curfew)											H	10	20	40	Avg	4:1	4:1 (8:1)	
[21] (and [12] curfew)											G	7.5	15	30	Avg	4:1	4:1 (8:1)	
[21] curfew											F	5	10	20	Avg	4:1	8:1	
[20]											-	0	0	0				
• Low Activity[f]																		
[24]											I	15	30	60	Avg	4:1	4:1	
[23] (and [12] curfew)											H	10	20	40	Avg	4:1	4:1 (8:1)	
[22] (and [12] curfew)											G	7.5	15	30	Avg	4:1	4:1 (8:1)	
[21] (and [12] curfew)											F	5	10	20	Avg	4:1	4:1 (8:1)	
[21] curfew											E	4	8	16	Avg	4:1	8:1	
[20]											-	0	0	0				
• Dispensing Islands		Fuel pumps or short-time (Level III) charging stations																
• High Activity[f]		E_h @pavement in area defined by 9' radius from center of each dispensing pump or charging station face; E_v @face of dispensing pump or charging station including transaction device. Control with motion sensors.[k]																
[12][f]						O	100	200	400	Avg	O	100	200	400	Avg	2:1	4:1	
[12] (and [12] curfew)						N	75	150	300	Avg	N	75	150	300	Avg	2:1	4:1 (8:1)	

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[e] Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Area of Coverage[h] Task Area	Room or Area
		Category				Category									
RETAILING, OUTDOOR	(continued)														
LZ2[j] (and LZ3 curfew)		M	50	100	200	Avg	M	50	100	200	Avg	2:1	4:1 (8:1)		
LZ1[j] (and LZ2 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg	2:1	4:1 (8:1)		
LZ0[j] (and LZ1 curfew)		K	25	50	100	Avg	K	25	50	100	Avg	2:1			
Medium Activity[j]	E_h @pavement in area defined by 9' radius from center of each dispensing pump or charging station face; E_v @face of dispensing pump or charging station including transaction device. Control with motion sensors.[k]														
LZ4[j]		N	75	150	300	Avg	N	75	150	300	Avg	2:1	4:1		
LZ3[j] (and LZ4 curfew)		M	50	100	200	Avg	M	50	100	200	Avg	2:1	4:1 (8:1)		
LZ2[j] (and LZ3 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg	2:1	4:1 (8:1)		
LZ1[j] (and LZ2 curfew)		K	25	50	100	Avg	K	25	50	100	Avg	2:1	4:1 (8:1)		
LZ0[j] (and LZ1 curfew)		J	20	40	80	Avg	J	20	40	80	Avg	2:1			
Low Activity[j]	E_h @pavement in area defined by 9' radius from center of each dispensing pump or charging station face; E_v @face of dispensing pump or charging station including transaction device. Control with motion sensors.[k]														
LZ4[j]		M	50	100	200	Avg	M	50	100	200	Avg	2:1	4:1		
LZ3[j] (and LZ4 curfew)		L	37.5	75	150	Avg	L	37.5	75	150	Avg	2:1	4:1 (8:1)		
LZ2[j] (and LZ3 curfew)		K	25	50	100	Avg	K	25	50	100	Avg	2:1	4:1 (8:1)		
LZ1[j] (and LZ2 curfew)		J	20	40	80	Avg	J	20	40	80	Avg	2:1	4:1 (8:1)		
LZ0[j] (and LZ1 curfew)		I	15	30	60	Avg	I	15	30	60	Avg	2:1			
Landscape Highlights	Key vertical foliage surfaces to define place and attract attention. Apply strategically to ≤25% of area of select foliage visible from primary viewing direction.														
High Activity[j]															
LZ4[j]						J	20	40	80	Avg	3:1	3:1			
LZ3[j] (and LZ4 curfew)						I	15	30	60	Avg	3:1	3:1 (6:1)			
LZ2[j] (and LZ3 curfew)						H	10	20	40	Avg	3:1	3:1 (6:1)			
LZ1[j] (and LZ2 curfew)						G	7.5	15	30	Avg	3:1	3:1 (6:1)			
LZ1[j] curfew						F	5	10	20	Avg	3:1	3:1 (6:1)			
LZ0[j]						-	0	0	0						
Medium Activity[j]															
LZ4[j]						I	15	30	60	Avg	3:1	3:1			
LZ3[j] (and LZ4 curfew)						H	10	20	40	Avg	3:1	3:1 (6:1)			
LZ2[j] (and LZ3 curfew)						G	7.5	15	30	Avg	3:1	3:1 (6:1)			
LZ1[j] (and LZ2 curfew)						F	5	10	20	Avg	3:1	3:1 (6:1)			
LZ1[j] curfew						E	4	8	16	Avg	3:1	3:1 (6:1)			
LZ0[j]						-	0	0	0						

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] — Horizontal (E_h) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets: Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[a] — Over Area: 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Area of Coverage[h]: Task Area	Room or Area
		Category				Category									
RETAILING, OUTDOOR	(continued)														
Low Activity[i]															
LZ4[j]						H	10	20	40	Avg	3:1	3:1			
LZ3[j] (and LZ4 curfew)						G	7.5	15	30	Avg	3:1	3:1 (6:1)			
LZ2[j] (and LZ3 curfew)						F	5	10	20	Avg	3:1	3:1 (6:1)			
LZ1[j] (and LZ2 curfew)						E	4	8	16	Avg	3:1	3:1 (6:1)			
LZ1[j] curfew						D	3	6	12	Avg	3:1	3:1 (6:1)			
LZ0[j]						-	0	0	0						
Outdoor Service	For nighttime performance of non-mechanical services such as fluids and air pressure checks and fills or use of long-time (Type II) charging stations.														
High Activity[i]	E_h @3' 6° AFG at designated service or charging area defined by 9' radius from center of each charging station face; E_v @face of charging station including transaction device.														
LZ4[j]		K	25	50	100	Avg	K	25	50	100	Avg	2:1	2:1		
LZ3[j] (and LZ4 curfew)		J	20	40	80	Avg	J	20	40	80	Avg	2:1	2:1 (4:1)		
LZ2[j] (and LZ3 curfew)		I	15	30	60	Avg	I	15	30	60	Avg	2:1	2:1 (4:1)		
LZ1[j] (and LZ2 curfew)		H	10	20	40	Avg	H	10	20	40	Avg	2:1	2:1 (4:1)		
LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	G	7.5	15	30	Avg	G	7.5	15	30	Avg	2:1			
Medium Activity[i]	E_h @3' 6° AFG at designated service or charging area defined by 9' radius from center of each charging station face; E_v @face of charging station including transaction device.														
LZ4[j]		J	20	40	80	Avg	J	20	40	80	Avg	2:1	2:1		
LZ3[j] (and LZ4 curfew)		I	15	30	60	Avg	I	15	30	60	Avg	2:1	2:1 (4:1)		
LZ2[j] (and LZ3 curfew)		H	10	20	40	Avg	H	10	20	40	Avg	2:1	2:1 (4:1)		
LZ1[j] (and LZ2 curfew)		G	7.5	15	30	Avg	G	7.5	15	30	Avg	2:1	2:1 (4:1)		
LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	F	5	10	20	Avg	F	5	10	20	Avg	2:1			
Low Activity[i]	E_h @3' 6° AFG at designated service or charging area defined by 9' radius from center of each charging station face; E_v @face of charging station including transaction device.														
LZ4[j]		I	15	30	60	Avg	I	15	30	60	Avg	2:1	2:1		
LZ3[j] (and LZ4 curfew)		H	10	20	40	Avg	H	10	20	40	Avg	2:1	2:1 (4:1)		
LZ2[j] (and LZ3 curfew)		G	7.5	15	30	Avg	G	7.5	15	30	Avg	2:1	2:1 (4:1)		
LZ1[j] (and LZ2 curfew)		F	5	10	20	Avg	F	5	10	20	Avg	2:1	2:1 (4:1)		
LZ0[j] (and LZ1 curfew)	Control with motion sensors[k]	E	4	8	16	Avg	E	4	8	16	Avg	2:1			

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Category	Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Vertical (E_v) Targets: Category	Visual Ages of Observers (years) where at least half are <25	25-65	>65	Gauge	Uniformity Targets[e] Over Area (1st ratio E_h/2nd ratio E_v if different uniformities apply) Max:Avg	Avg:Min	Max:Min	⊙[f] II[g]	Area of Coverage[h] Task Area	Room or Area
SUPPORT SPACES																	
• Alterations Rooms																	
• General	E_h @2' 6"; E_v @4' AFF	R	250	500	1000	Avg	N	75	150	300	Avg	1.2:1/1.5:1	1.2:1/1.5:1		⊙		■
• Task Areas	E_h @2' 6"; E_v @4' AFF	T	500	1000	2000	Avg	P	150	300	600	Avg	1.2:1/1.5:1	1.2:1/1.5:1		⊙	■	
• Coat Check or Coat Rooms	E_h @3' 0"; E_v @5' AFF	P	150	300	600	Avg	M	50	100	200	Avg		3:1		⊙		■
• Copy/Print Rooms																	
• General	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	I	15	30	60	Avg		3:1		⊙		■
• Machines	E_h and E_v @3' 6" AFF	P	150	300	600	Avg	M	50	100	200	Avg		3:1		⊙	■	
• Janitor's Closet	E_h @floor; E_v @4' AFF	M	50	100	200	Avg	I	15	30	60	Avg		3:1		⊙		■
• Receiving/Shipping																	
• Dock	E_h @floor; E_v @4' AFF	M	50	100	200	Avg	I	15	30	60	Avg		2:1		⊙		■
• Receiving/Staging	E_h @floor; E_v @4' AFF	P	150	300	600	Avg	M	50	100	200	Avg		2:1		⊙		■
• Stock Rooms	E_h @floor; E_v @4' AFF	P	150	300	600	Avg	M	50	100	200	Avg		2:1		⊙		■
• Storage																	
• Frequent Use	E_h @floor; E_v @4' AFF	M	50	100	200	Avg	I	15	30	60	Avg		3:1		⊙		■
• Infrequent Use	E_h @floor; E_v @4' AFF	K	25	50	100	Avg	H	10	20	40	Avg		3:1		⊙		■
• Valet	E_h @3' 0"; E_v @5' AFF	M	50	100	200	Avg	K	25	50	100	Avg		3:1		⊙		■
TRANSITION SPACES	(continued)																
• Elevators																	
• Freight																	
• Cab interior	E_h @floor; E_v @3' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙		■
• Threshold																	
Cab exterior	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙	■	
Cab interior	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙	■	
• Passenger																	
• Cab interior	E_h @floor; E_v @3' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙		■
• Threshold																	
Cab exterior	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙	■	
Cab interior	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙	■	
• Escalators/Moving Walkways	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg		2:1		⊙	■	
• Lobbies	As the architect coordinates contrast markings with steps, curbs, and ramps, localized lighting may be deemed appropriate.																
• Circulation, Elevator Lobbies																	
• At building entries	Close proximity to exterior. Lighting should assist with adaptation when passing to/from exterior.																
Day	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	K	25	50	100	Avg		3:1		⊙		■

Table J.2. Retail Application Illuminance Values. (continued)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d]												Uniformity Targets[e]			Area of Coverage[h]	
		Horizontal (E_h) Targets						Vertical (E_v) Targets						Over Area				
		Visual Ages of Observers (years) where at least half are						Visual Ages of Observers (years) where at least half are						1st ratio $E_h/2^{nd}$ ratio E_v if different uniformities apply			Task Area	Room or Area
		<25	25-65	>65				<25	25-65	>65				MaxcAvg	AvgcMin	MaxcMin		
		Category			Gauge	Category					Gauge							
TRANSITION SPACES																		
(continued)																		
Night	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	H	10	20	40	Avg			3:1				
Distant from entries	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	K	25	50	100	Avg			3:1				
Security Screening	E_h @3' AFF; E_v @5' AFF	O	100	200	400	Avg	M	50	100	200	Avg			2:1				
Elevators																		
Break		M	50	100	200	Avg	K	25	50	100	Avg			3:1				
Reception/Waiting Areas																		
Reception Desk		Q	200	400	800	Avg	N	75	150	300	Avg							
Waiting Areas		O	100	200	400	Avg	M	50	100	200	Avg			3:1				
Stairs	As the architect coordinates contrast markings with steps, curbs, and ramps, localized lighting may be deemed appropriate.																	
High activity	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	K	25	50	100	Avg			2:1				
Live surveillance	E_h @floor; E_v @5' AFF	M	50	100	200	Avg	K	25	50	100	Avg			2:1				
Typical	E_h @floor; E_v @5' AFF	K	25	50	100	Avg	I	15	30	60	Avg			2:1				

Table J.2 Notes:

a. Applications, tasks, or viewing specifics encountered on any given project may be different from these and may warrant different criteria. Refer to *The Lighting Handbook*, 10th ed. (IES 2011), Section 29.3.1 Applications and Tasks. The designer is responsible for making final determinations of applications, tasks, and illuminance criteria. Outdoor tasks are so noted.

b. Values cited are to be maintained over time on the area of coverage.

c. Values cited are consensus and deemed appropriate for respective functional activity. In a few situations, code requirements do not match IES recommendations but are within 10 percent. This is apparently an artifact of metrification. Footcandle conversions of any values cited in this table should be made at 1 fc to 10 lx. Regardless, codes, ordinances, or mandates may supersede any of the IES criteria for any of the applications and tasks, and the designer should design accordingly.

d. Targets are intended to apply to the respective plane or planes of the task.

e. Illuminance uniformity targets offer best results when planned in conjunction with luminance ratios and surface reflectances. Any parenthetical uniformity values apply to the respective parenthetical applications or tasks, such as a curfew situation associated with nighttime outdoor lighting.

f. Applications and tasks cited with a sunburst icon are candidates for strategies employing any combination of daylighting and electric lighting to achieve target values during daylight hours. Daylighting may require unconventional approaches.

g. Tasks with specular components, such as computers with CSA/ISO Type III screens or printed tasks with glossy ink or glossy paper, are prone to veiling reflections. The likelihood of an application's or task's predisposition to veiling reflections is indicated by the reflected-light icon: *black and white* signals high likelihood; *gray and white* signals moderate likelihood; *pale gray and white* signals some likelihood; and *all white* signals little to no likelihood.

h. The designer should establish areas of coverage to which targets apply. Green highlight identifies *task proper* or *task area* as the typical area of coverage for the respective cited targets. Amber highlight identifies *room* or *designated areas* as the typical area of coverage for the respective cited targets.

i. Nighttime illuminance targets are intended for application during dark hours of operations where lighting is deemed necessary or desirable. At curfew (client or jurisdiction defined), if lighting is still deemed necessary or desirable, then the lighting should be reduced as indicated.

j. Alternatively, the lighting designer may design to specific tasks, if known, from the *READING AND WRITING* part of the table.

k. For applications where the task position is indefinite, such as some types of flexible meeting rooms, the typical area of coverage is *Room or Designated Area*. For applications where the task position is known, such as an office desk or a reading chair, a more efficient approach is likely achieved when target illuminance is applied to the *task proper* or *task area*.

l. E_h and E_v elevations are based on conventional work surface and seated eye height. Where other elevations are programmed, the designer should adjust the planes of interest for the illuminance criteria accordingly.

REFERENCES FOR ANNEX J

1. DiLaura D et al. (editors). The Lighting Handbook, 10th ed. New York: Illuminating Engineering Society of North America; 2011.

2. Maintenance Committee. Recommended Practice for Lighting Maintenance, RP-36-15. New York: Illuminating Engineering Society of North America; 2015.

For IES documents not currently listed in the IES publication catalog, please contact ies@ies.org.

2.3.6.1 Illuminance Target Value System Energy considerations and lower lighting power density allowances require more careful tailoring of illuminances to task needs. The target illuminance values in **Table 1** are considered average, maintained illuminances of electric and/or daylight for the designed task area. Target values are not a substitute for careful consideration of all factors relevant to a specific lighting situation.

When the task involves life safety, human-vehicular proximity and/or personal safety and security as significant concerns, recommendations are considered minimum, maintained illuminances at the target area. Additionally, health and life safety code requirements may supersede these recommendations.

Light loss factors, specific surface reflectances, and other design criteria should be used to adjust lighting calculations. Other criteria may include differences in minimum/maintained lamp lumen output, luminaire output, surface reflectances and ballast factors, between the two conditions. LLFs are divided into recoverable and non-recoverable. See **Section 13.2**, and the *IES Lighting Handbook, 10th Edition, 2011- Chapter 10.7.1 | Light Loss Factors*, for a discussion of light loss factors and maintained illuminance.

These values are design goals and variation from them is expected and may be found at two stages in the construction process: during design and at the time of occupancy. More precise values are found in **Table 2** for specific applications.

2.3.6.1.1 Recommended illuminances at design time Quantitative assessments (i.e., "lighting calculations") are usually performed during the design process, using lighting analysis software to predict maintained illuminance. For electric lighting designs, if these calculations predict illuminance values that differ by more than 10% from recommended illuminance targets, the differences require attention and should be addressed during the design process.

If a predicted (calculated) value is more than 15% below the recommended level then a significant percentage of the users of the system may not find the visibility acceptable. If a predicted (calculated) value exceeds a recommendation by more than 10% then over-lighting and energy misuse may result. Refer to *IES Lighting Handbook, 10th Edition, 2011 - Chapter 4.12.4.1 | Individual Differences and Uncertainties.*

2.3.6.1.2 Recommended illuminances at occupancy time Assessment of illuminance in the field by measurement is more complicated than computation prediction. Non-recoverable light loss factors and measurement equipment performance can seriously affect results. Field measurements of illuminances made soon after lighting equipment installation or occupancy need to differentiate between anticipated recoverable (through regular maintenance, such as cleaning and relamping luminaires) light loss factors and the non-recoverable(attributed to equipment and site conditions and cannot be changed with normal maintenance) light loss factors that were employed in calculations performed during design. Such adjusted values that are within 10-30% of the recommended values may be acceptable; however, individual applications may have different criteria tolerances. Refer to the *IES Lighting Handbook, 10th Edition, 2011 - Chapter 9.15 | Field Measurements and 15.3.2 Field Results.*

2.3.6.1.3 Localized tasks In some applications when task locations are known, such as building entries, then the recommended illuminance values apply only to those locations. Local task lighting is recommended and should be controlled locally by the user.

2.3.6.1.4 Area tasks In some applications the task may be performed over a large area, such as a parking area. If the task is an area, the recommended illuminance is to be achieved over that entire area, including corners.

2.3.6.1.5 Tasks at uncertain locations over a large area Sometimes the task is localized and performed at specific locations in a large area, but for reasons of space use, planning, or future flexibility, the precise locations are not known at design time. This is the case, for example, with work zones such as vehicle inspection at a gated entry. In these cases, a criterion rating (CR), can be determined for the area and used as a performance measure. CR is defined by

$$CR = \frac{\text{(Number of calculation or measurement points at or above the criterion)}}{\text{(Number of calculation or measurement points)}} * 100\%$$

It is recommended that the CR of an area of uncertain task locations not be less than 70 per cent. (See the *IES Lighting Handbook, 10th Edition, 2011 - Chapter 10. 8.3 | Criterion Ratings* for details of computing this performance measure.)

2.3.6.1.6 Multiple tasks It is often the case that the illuminance in some areas of an application should support multiple tasks. In these cases it is usually necessary to rank the tasks by importance, prevalence, or frequency using data that may be available from the client, to determine the commonly occurring task with the highest recommended illuminance. This task should govern the illuminance on the task area. It is not necessary to provide for the highest illuminance level with the general lighting system. Localized task lighting should be employed for the more visually demanding tasks, with the corresponding benefits of lower energy use and increased user satisfaction.

Table 1 – Target Illumination Values.

Category		Recommended Illuminance Targets (lux) Visual Ages of Observers (years) where **at least half** are			Some Typical Application and Task Characteristics	Visual Performance Description
		<25	25 to 65	>65		
Outdoor Applications	A	0.5	1	2	• Dark adapted situations • Basic convenience situations • Very-low-activity situations	**Orientation, relatively large-scale, physical (less-cognitive) tasks** Visual performance is typically not work-related, but related to dark sedentary social situations, senses of safety and security, and casual circulation based on landscape, hardscape, architecture, and people as visual tasks.
	B	1	2	4		
	C	2	4	8	• Slow-paced situations • Low-density situations	
	D	3	6	12	• Slow-to-moderate-paced situations • Moderate-to-high-density situations	
	E	4	8	16		
	F	5	10	20	• Moderate-to-fast-paced situations • High-density situations • Some indoor very subdued circulaton situations • Some indoor social situations	
	G	7.5	15	30		
	H	10	20	40		
Interior Applications	I	15	30	60	• Congested and significant outdoor intersections, important decision-points, gathering places, and key points of interest • Some indoor social situations • Some indoor commerce situations	
Interior Applications	J	20	40	80		**Common social activity and large and/or high-contrast tasks** Visual performance involves higher-level assessment of landscape, hardscape, architecture, and people and can be work related.
	K	25	50	100		
	L	37.5	75	150	• Some outdoor commerce situations • Some indoor social situations • Some indoor commerce situations	
	M	50	100	200		
	N	75	150	300		
	O	100	200	400		
	P	150	300	600	• Some indoor social situations • Some indoor education situations • Some indoor commerce situations • Some indoor sports situations	**Common, relatively small-scale, more cognitive or fast-performance visual tasks** Visual performance is typically daily life- and work- related, including much reading and writing of hardcopies and electronic media consecutively and/or simultaneously.
	Q	200	400	800	• Some indoor education situations • Some indoor commerce situations • Some indoor sports situations • Some indoor industrial situations	
	R	250	500	1000		
	S	375	750	1500		
	T	500	1000	2000	• Some sports situations • Some indoor commerce situations • Some indoor industrial situations	**Small-scale, cognitive visual tasks** Visual performance is work- or sports-related, close and distant fine inspection, very small detail, high-speed assessment and reaction.
	U	750	1500	3000		
	V	1000	2000	4000		
	W	1500	3000	6000	• Some sports situations • Some indoor industrial situations • Some health care procedural situations	**Unusual, extremely minute and/or life-sustaining cognitive tasks** Visual performance is of the highest order in respective fields of health care, industrial, and sports.
Interior Applications	X	2500	5000	10000	• Some health care procedural situations	
	Y	5000	10000	20000		

Notes for Table 2.

Notes

The table column headings are discussed in detail in the Illuminance Criteria Section. Refer to the discussion on procedures for establishing illuminance targets for a project.

a. Applications, tasks, or viewing specifics encountered on any given project may be different from these and may warrant different criteria. Refer to IES Lighting Handbook, Section 29.3.1 Applications and Tasks. The designer is responsible for making final determinations of applications, tasks, and illuminance criteria. Outdoor tasks are so noted.

b. Values cited are to be maintained over time on the area of coverage.

c. Values cited are consensus and deemed appropriate for respective functional activity. In a few situations, code requirements are within 10% of IES recommendations. This is apparently an artifact of metrification. Footcandle conversions of any values cited in this table should be made at 1 fc to 10 lx. Regardless, codes, ordinances, or mandates may supersede any of the IES criteria for any of the applications and tasks and the designer must design accordingly.

d. Targets are intended to apply to the respective plane or planes of the task.

e. Illuminance uniformity targets offer best results when planned in conjunction with luminance ratios and surface reflectances. Any parenthetical uniformity values reference respective parenthetical applications or tasks, such as a curfew situation associated with nighttime outdoor lighting.

f. Applications and tasks cited with a sunburst icon are candidates for strategies employing any combination of daylighting and electric lighting to achieve target values during daylight hours. Daylighting may require unconventional approaches.

g. The designer must establish areas of coverage to which targets apply. Green highlight identifies task proper or task area as the typical area of coverage for respective cited targets. Amber highlight identifies room or designated areas as the typical area of coverage for respective cited targets.

h. Nighttime illuminance targets are intended for application during dark hours of operations where lighting is deemed necessary or desirable. At curfew (client-or-jurisdiction-defined), if lighting is still deemed necessary or desirable, then reduce lighting as indicated.

i. See IES Lighting Handbook, 10th Edition, Table 22.4 - Indoor and Nighttime Outdoor Activity Level Definitions.

j. See IES Lighting Handbook, 10th Edition, Table 26.4 Nighttime Outdoor Lighting Zone Definitions. Nighttime illuminance targets are intended for application during dark hours of operation where lighting is deemed necessary or desirable. At curfew (client or jurisdiction defined), if lighting is still deemed necessary or desirable, then reduce lighting as indicated. See IES Lighting Handbook, 10th Edition, Table 26.5 Recommended Light Trespass Illuminance Limits.

Table 3: Notes for Parking Decks. (Refer to *IES RP-20-14 Lighting for Parking Facilities*)

Applications and Tasks[a]	Notes	Recommended Maintained Illuminance Targets (lux)[b,c,d] Horizontal (E_h) Targets: Visual Ages of Observers (years) where **at least half** are <25	25-65	>65	Vertical (E_v) Targets: Visual Ages of Observers (years) where **at least half** are <25	25-65	>65	Uniformity Targets[e] Over Area of Coverage[f]: 1st ratio E_h/2nd ratio E_v if different uniformities apply Max:Avg	Avg:Min	Max:Min	Typical Area of Coverage[g]: Task Area	Area
		Category			Gauge Category			Gauge				
FOUNTAINS	See IES HB 10e Chapter 26 for discussion											
PARKING DECKS	Covered parking facilities. See *IES HB Chapter 26* and *IES RP-20-14* for discussion. A checklist of probable application tasks and areas follows for which illuminance criteria should be established.											
• Dedicated Corners/Ramps	Lighting should address corners and ramps dedicated primarily, if not exclusively, to vehicular activity with no adjoining parking. E_h @finished floor; E_v @5' AFF in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Drive Aisles/Parking Areas	Lighting should address drive aisles and adjacent parking with mixed pedestrian and vehicular activity. E_h @finished floor; E_v @5' AFF in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Drop-off/Pickup Areas, Interior Vehicle Transaction Areas and Valets	Lighting should address courtesy drop-off and pickup areas and valets with mixed pedestrian and vehicular activity. Lighting should address vehicle transaction areas distant from covered entry/exit portals. E_h @finished floor; E_v @5' AFF in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Elevator Lobbies, Pedestrian Transaction Areas, and Stairways	Lighting should address the lobby proper and pedestrian parking-fee transaction areas. E_h @finished floor; E_v @5' AFF in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Vehicular Entries and Exits	Lighting should address vehicular entries and exits and adjacent parking and pedestrian areas. E_h @finished floor; E_v @5' AFF in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
PARKING LOTS	Open parking facilities, including tops of parking decks. See *IES HB Ch. 26* and *IES RP-20-14* for discussion. A checklist of probable application tasks and areas follows for which illuminance criteria should be established.											
• Drive Aisles/Parking Areas	Lighting should address drive aisles and adjacent parking with mixed pedestrian and vehicular activity. E_h @grade; E_v @5' AFG in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Pedestrian Transaction Areas	Lighting should address pedestrian parking-fee transaction areas. E_h @grade; E_v @5' AFG in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
• Vehicle Transaction Areas and Vehicular Entries/Exits	Lighting should address vehicle transaction areas and vehicular entries and exits.. E_h @grade; E_v @5' AFG in at least the two primary directions of travel. The face is defined by an imaginary vertical plane oriented perpendicular to the primary direction of travel. Illuminances on both sides of the plane are assessed. Coordinate illuminance criteria with observers' ages and high, medium, or low activity level.[f]											
PEDESTRIAN MALLS	See **IES HB 10e Table 34.2 | Retail Illuminance Recommendations/CENTERS, OUTDOOR**											

a. Applications, tasks or viewing specifics encountered on any given project may be different from these and may warrant different criteria (refer to the *IES Lighting Handbook, 10th Edition, Chapter 26*). The designer is responsible for making final determinations of applications, tasks, and illuminance criteria. Outdoor tasks are so noted.

b. Any values cited are to be maintained over time over the area of coverage.

c. Value cited are consensus and deemed appropriate for respective functional activity. In a few situations, code requirements are within 10% of IES recommendations. This is apparently an artifact of metrification. Footcandle conversions of any values cited should be made at 1 fc to 10 lx. Regardless, codes, ordinances, or mandates may supersede any of the IES criteria for any of the applications and tasks and the designer must design accordingly.

d. Targets are intended to apply to the respective plane or planes of the task.

e. Illuminance uniformity targets offer best results when planned in conjunction with luminance ratios and surface reflectances. Any parenthetical uniformity values reference respective parenthetical applications or tasks, such as a curfew situation associated with nighttime outdoor lighting.

f. See *IES Lighting Handbook, 10th Edition, Table 22.4 Indoor and Nighttime Outdoor Activity Level Activities.*

g. See **Section 2.5 Lighting Zones Definitions**. Nighttime illuminance targets are intended for application during dark hours of operation where lighting is deemed necessary or desirable. At curfew (client or jurisdiction defined), if lighting is still deemed necessary or desirable, then reduce lighting as indicated (see **Section 2.4.2 Light Trespass** *and IES Lighting Handbook, 10th Edition Table 26.5*).

h. Use motion-sensing control to toggle lighting from on/off/dimmed state to recommended curfew state or from recommended curfew state to pre-curfew state as designer and client deem necessary to meet functional needs. Use instant-on lighting equipment.

i. For applications where task position is indefinite, the typical area of coverage is at the planar elevations noted. For applications where task position is known, a more efficient approach is likely achieved when target illuminance is applied to the "Task Proper or Task Area" and which may involve different planar elevations that the designer must accommodate.

2.4 Dealing with Stray Light

Light pollution, sky glow, and obtrusive light are terms used to describe the excess or nuisance light created by humans. Light pollution and light trespass have become extremely important considerations whenever a new outdoor lighting design is being prepared. As people increasingly appreciate the beauty and benefits of the night, they become less tolerant of unnecessary and intrusive lighting. Refer to *IES DG-22-12 Sustainable Lighting* for a further discussion of Light Pollution and Light Trespass issues and design considerations.

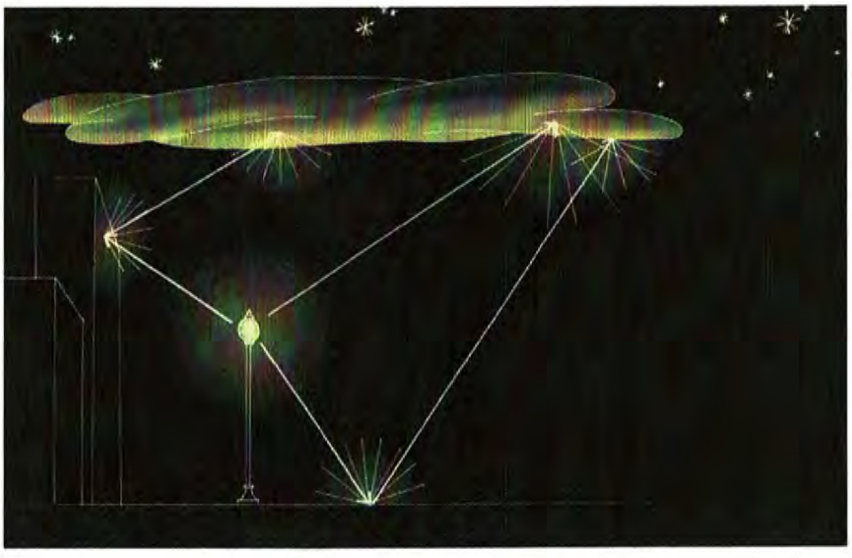

Figure 9: Light pollution and light trespass impacts from a non-shielded luminaire. (Image courtesy of Clanton & Associates.)

2.4.1 Light Pollution Light pollution is the combination of all the adverse or obtrusive effects of electric light that produces artificial sky glow.

- Unnecessary, unwanted or wasted light
- Light that damages or degrades the nighttime luminous environment
- Light that negatively impacts humans, and other species

Sky glow is visible light reflected by particles in the atmosphere. It deprives urban residents of the opportunity to see the night sky as their ancestors did, stargaze, and relax under a beautiful natural night sky. It can hamper professional and amateur astronomers' attempts to view the night sky through telescopes. Skyglow is increased by electric lighting at night.

› Natural Phenonema

Natural sources of skyglow exist, mostly due to the energy reradiated by atmospheric chemicals during nighttime cooling (known as airglow). The spectral composition of these natural phenomena is well documented and is typically addressed by professional astronomers through the use of specialized filters and processing techniques.

Two light scattering processes that contribute to sky glow (i.e., there would be airglow emission scattering or not) are scattering of light that is emitted into the atmosphere from molecules such as N_2 and O_2 (called Rayleigh scattering), and that from aerosols (called Mie scattering). Rayleigh scattering is stronger for short-wavelength (blue) light than longer-wavelength light, while scattering from aerosols is little affected by wavelength. Atmospheric aerosols are more concentrated over urban environments, increasing the impact of electric lighting on perceived and measurable skyglow compared to more rural environments.

› Effect of Electric Lighting

Electric lighting increases skyglow above the natural background through a combination of direct and reflected light. Any light emitted above the horizontal contributes directly to sky glow. Light reflected from the ground or from vertical surfaces can contribute to skyglow, depending on the ground cover conditions (snow is highly reflective, for example).

Mesopic and Scotopic vision are dominant at lower levels of illumination, and at these times, the eye perceives short-wavelength (blue) light more easily than long-wavelength (red). Historically, outdoor lighting for roadways and large areas has primarily utilized high pressure sodium, which has minimal short wavelength (blue) light. Low pressure sodium is used occasionally, which has no short wavelength (blue) light. Blue-rich light sources (such as high CCT LED, Mercury Vapor and Metal Halide) provide broader spectral content, but the increase in short-wavelength (blue) light increases the relative impact of Rayleigh scattering and thus can lead to relatively higher skyglow. Lower CCT LED and metal halide light sources have less short wavelength light.

› Skyglow Models

In an urban center at night it may be that only a handful of stars are visible to the naked eye. At a truly dark site a thousand times as many stars can be seen as well as the Milky Way. An excellent older summary of the problem of light pollution has been published by Fitch.[19]

Skyglow levels may be measured with suitable photometers, or estimated in a variety of ways. Fred Schaaf[20] has suggested a seven-level sky quality scale based on the faintest stars visible to the naked eye in the zenith. Less subjective estimates can be obtained by numerical models. A simple model that gives skyglow in proportion to the population of a city was developed by Merle Walker.[21] This gives values of skyglow observed at a 45° zenith angle and can be determined for any distance (in km) outside the urban center.

Two standard models used to calculate sky glow have been developed by R.H. Garstang[22,23,24] and Merle Walker.

The first model, developed by Garstang, considers direct light from luminaires, ground reflectance, cloud depth and reflectance, particles in the atmosphere, the curvature of the earth, distance, city population, and city radius. The comprehensive analysis method by Garstang provides a detailed understanding of the effect that sky glow has on locations such as mountain observatories where the urban center is below the line of site but sky glow still hinders astronomic observation.

The second model, Walker's Law, is a simplistic model that relates sky glow to the population of a city. The decay of sky glow observed at a 45° zenith angle can be determined from any distance (in km) outside the urban center.

Although these modeling methods are readily available, additional research models are needed for more complete analysis of skyglow measurements.

› Special Considerations

In areas near astronomical observatories and in areas of endangered species or special conditions such as turtle nesting areas, protection from sky glow is a primary concern. Fully shielded luminaires with no uplight should be specified with designs to the minimum possible lighting levels. Such features as red path lights work well to preserve dark adaptation. Reflectorized markings rather than electric lighting should be used on roadways whenever possible. Nearly monochromatic light sources (such as low pressure sodium or amber LEDs) are advantageous for outdoor areas because any unwanted light that enters observatory instruments often can be filtered out. The use of sources with limited spectral composition does not completely eliminate atmospheric light pollution from the telescope's view but it helps greatly and is highly recommended for such locales.

› Controlling Light Pollution

The methods that best control light pollution are:

Minimize upward emissions. Exterior lighting systems, including lighting for sports activities, parking lots, buildings, landscape, storage areas, vehicle sales lots, and other outdoor retail or drive-up windows should be designed to minimize or eliminate direct upward emission. Note also that near-horizontal emissions, either direct or reflected, have a much higher impact on the astronomical observatories than does light output at lower angles (below 80 degrees) below the horizontal

Minimize non-target lighting. Lighting systems that project light upward, such as architectural and sign lighting, should be designed to minimize light that does not illuminate the target area.

Do not over light. Use no higher a lighting level than is needed for the task.

Turn off or dim outdoor lighting during low or no use. All outdoor lighting, including advertising sign lighting and interior high-rise office building lighting, should be turned off after use unless necessary for safety and security. Usually, safety and security illuminance can be at levels much lower than those needed when the area is in use.

Refer to the *Joint IDA-IES Model Lighting Ordinance (MLO)*[3] for limitations on skyglow.

2.4.2 Light Trespass The topic of light trespass relates to light which is obtrusive off-site. A typical example is the "light shining in my window" complaint. Light trespass limits can be defined by using the backlight (B) rating limits outlined in the *Joint IDA-IES Model Lighting Ordinance (MLO).* Solutions include shielding the offending luminaire so its brightness is not directly visible to the complainant, turning off the light after curfew, or in some cases, eliminating the light source if not required. The offending illumination is called *obtrusive light.*

Light trespass is usually defined by the adjacent property receiving unwanted light (high illuminance levels)

The following general suggestions will help control light trespass problems:

- Inspect areas adjacent to the lighting design location to identify and consider any potential problems involving residences and other places of sleep, roadways, airports, and topographical challenges such as a light higher on a hillside from the bedroom window.
- Select luminaires with tightly controlled candela distributions that meet the "BUG" (Backlight, Uplight, and Glare – refer to *IES TM-15-11 Luminaire Classification System for Outdoor Luminaires and Addendum A*[25]) rating for specific lighting zones.
- For non-shielded luminaires, use low lumen light sources to minimize brightness.
- Contain light within the design area by carefully selecting, locating, and mounting the luminaires.
- Keep façade lighting aiming angles low so that the entire beam always falls within the intended lighted area during (and after) the design and installation process. Aim luminaires away from impacted areas.
- Meet the prescriptive and/or performance methods in the Model Lighting Ordinance (see **Section 3.0**).

Efforts have been made in numerous jurisdictions to write ordinances or bylaws controlling light trespass. These ordinances have met with a range of success, depending on practical enforcement. One method to control light trespass is based on using specific lighting zone descriptions (see **Section 2.5.1**) that then

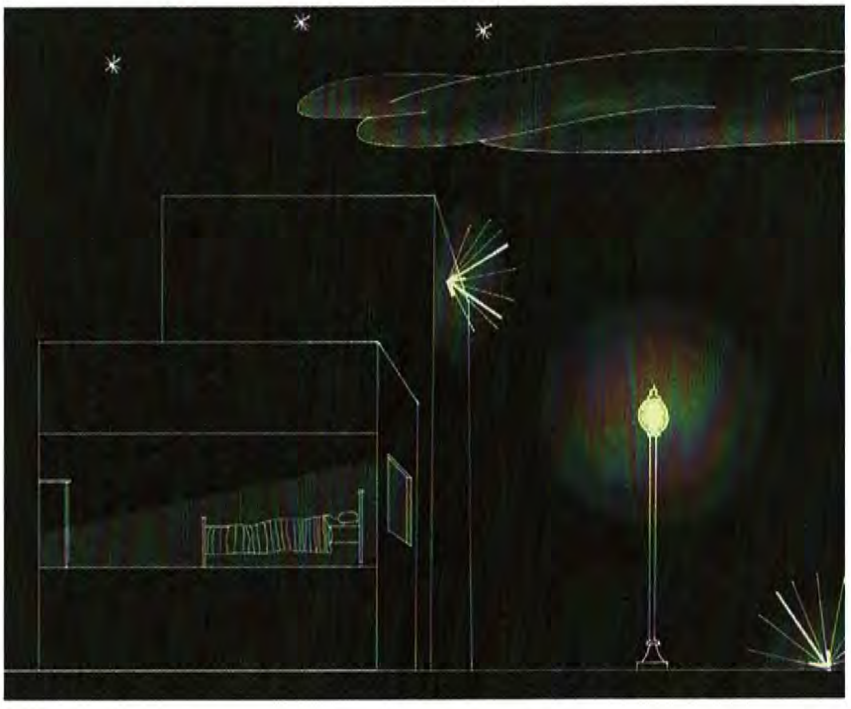

Figure 10: Light Trespass. Decorative globe allows light to spill onto the façade and also into residential windows. (Image courtesy of Clanton & Associates)

underlie any restrictions. Refer to the *Joint IDA-IES Model Lighting Ordinance (MLO)* and *TM-15-11* for limits on luminaire BUG ratings, property line maximum illuminance, and lumen density per lighting zone. Lighting zones and the BUG rating system can provide the basis for restricting the brightness that should be tolerated in a specific environment. Within any category, a curfew time may be established, allowing higher lighting levels during those hours when the curfew is not in effect.

Since light trespass is extremely subjective, there is no single set of values or limits that will work in every situation. The report *IES TM-11-00/R11 Light Trespass: Research, Results and Recommendations*[26] suggests that light trespass can be evaluated by illuminance values measured at the eye in a plane perpendicular to the line-of-sight when looking at the brightest source in the field of view. This report also stresses the subjectivity of the research and how it may be affected by the personalities and desires of different individuals.

While these recommendations serve to reduce serious light trespass, their implementation is not a guarantee against objections. In some situations, such as a sports field in a small park closely surrounded by residences, no methods and combinations of lighting design, aiming, or control can provide for both safe play and satisfy some neighbors' desires for limited light trespass. Consensus solutions involving field locations, curfews to restrict the hours of nighttime use, glare abatement, or landscape screens should be reached by all the parties involved. Refer to **Table 5** below.

Table 5 : Maximum Vertical Illuminance at any point in the vertical plane of the property line. (From Table F *Joint IDA-IES MLO*)

Lighting Zone 0	Lighting Zone 1	Lighting Zone 2	Lighting Zone 3	Lighting Zone 4
0.05 FC or 0.5 LUX	0.1 FC or 1.0 LUX	0.3 FC or 3.0 LUX	0.8 FC or 8.0 LUX	1.5 FC or 15.0 LUX

2.5 Lighting Zones

Zoning is a well–established practice in community planning. The fundamental idea behind zoning is that it allows a community to determine and regulate appropriate types of use in different areas within its jurisdiction, for example to define acceptable land uses in different areas. Lighting zones, which reflect the base (or ambient) light levels desired by a community, work well with land use zones in setting limits on the type and amount of lighting that can be used in different areas. Using lighting zones allows a great deal of flexibility and customization without the burden of excessive regulation.

The choice of an appropriate lighting zone is a matter of judgment based on community priorities for any given area. It is recommended that the lowest reasonable lighting zone(s) be adopted. Selection of lighting zone or zones should be based not on existing conditions but rather on the type of lighting environments the jurisdiction seeks to achieve. For instance, new development on previously rural or undeveloped land may be zoned as LZ-1.

Lighting zones are best implemented as an overlay to the established zoning especially in communities where a variety of zone districts exist within a defined area or along an arterial street. Where zone districts are cohesive, it may be possible to assign lighting zones to established land use zoning. It is recommended that the lighting zone includes churches, schools, parks, and other uses embedded within residential communities.

Lighting zones help communities minimize the contrast (and conflict) between extremes in lighting such as a brightly lighted car dealership adjacent to or within line of sight to a residential neighborhood, or a lighted sports facility in the middle of a residential neighborhood. Lighting zones may also determine restrictions on outdoor lighting that impact "places of sleep" such as residential areas, hospitals, and long term care facilities. Lighting zones may also employ vertical distinctions such as in mixed use facilities where the commercial aspects are on the street with residential units on the higher levels. Zones also encourage minimal changes in visual adaptation when traveling from site to site.

However, if an adjacent use could be adversely impacted by allowable lighting, the adopting authority may require that a particular site meet the requirements for a lower lighting zone. For example, the authority could specify Lighting Zone 1 or 2 requirements if a commercial development were adjacent to a residence, hospital or open space, or to any land assigned to a lower zone.

Community involvement is important in determining lighting zone issues, such as whether and how to light churches, schools, ice rinks, or playing fields. Among the factors that should be considered are neighborhood ambient conditions, lighting expectations, special environmental concerns, and how interior lighting may affect the exterior environment. Curfews and controls are appropriate for all lighting zones, and should be specified.

2.5.1 Lighting Zone Definitions Because identifying the appropriate outdoor lighting zone is a matter of judgment and consensus, there is no means of determining which zone is appropriate for a given area. The same type of lighting application may fall into different lighting zones in different jurisdictions or using different standards. As used in the *Joint IDA-IES Model Lighting Ordinance (MLO)*, the lighting zones are defined with suggested uses as follows:

- **LZ0:** No ambient light
  Areas where the natural environment could be seriously and adversely affected by small amounts of electric lighting at night. This includes biological cycles of flora and fauna, and human enjoyment and appreciation of the natural environment. The vision of human residents and users is adapted to the total darkness, and they do not expect to see electric lighting. Human activity is sparse and is subordinate in importance to the natural environment. There is no expectation for electric lighting. Although some lighting is allowed, it is required to be controlled.

LZ-0	Lighting Zone 0 should be applied to areas in which permanent lighting is not expected and when used, is limited in the amount of lighting and the period of operation. LZ-0 typically includes undeveloped areas of open space, wilderness parks and preserves, areas near astronomical observatories, or any other area where the protection of a dark environment is critical. Special review should be required for any permanent lighting in this zone. Some rural communities may choose to adopt LZ-0 for residential areas.	Recommended default zone for wilderness areas, parks and preserves, and undeveloped rural areas Includes protected wildlife areas and corridors

- **LZ1:** Low ambient light
  Developed areas within a natural environment and areas of human activity that are inherently dark at night. Electric lighting at night could adversely affect the biological cycles of flora and fauna, or could interrupt the quiet, dark character of the area. The vision of human residents and users is adapted to the low light levels, and they do not expect to see electric lighting except where absolutely necessary to improve visibility and safety. In these limited areas, low light levels are appropriate. Lighting is expected to be non-continuous (i.e., pools of light rather than uniform lighting along a path or roadway). After curfew, both light levels and uniformity may be reduced in some areas.

LZ-1	Lighting Zone 1 pertains to areas that desire low ambient lighting levels. These typically include single and two family residential communities, rural town centers, business parks, and other commercial or industrial/storage areas typically with limited nighttime activity. May also include the developed areas in parks and other natural settings	Recommended default zone for rural and low density residential areas Includes residential single or two family, agricultural zone districts, rural residential zone districts, business parks, open space include primarily undeveloped areas

Figure 11: Parking Lot located in a Lighting Zone 1 community. Aspen, CO. (Image courtesy of N. Clanton)

› **LZ2:** Moderate ambient light
Areas of human activity (i.e., habitation, recreation and/or work) where electric lighting may be required for safety and convenience at night. The vision of human residents and users is adapted to moderate light levels, and they have moderate expectations of electric lighting. Lighting is expected to be non-continuous (e.g., pools of light at crosswalks or intersections, rather than uniform lighting along a path or street). After curfew, both light levels and uniformity may be reduced in some areas as activity levels decline.

LZ-2	Lighting Zone 2 pertains to areas with moderate ambient lighting levels. These typically include multifamily residential uses, institutional residential uses, schools, churches, hospitals, hotels/motels, commercial and/or businesses areas with evening activities embedded in predominately residential areas, neighborhood serving recreational and playing fields and/or mixed use development with a predominance of residential uses. Can be used to accommodate a district of outdoor sales or industry in an area otherwise zoned LZ-3.	Recommended default zone for light commercial business districts and high density or mixed use residentialdistricts. Includes neighborhood business districts, churches, schools and neighborhood recreation facilities; and light industrial zoning with modest nighttime uses or lighting requirements.

Figure 12: Parking Lot in LZ 2 - Fully shielded, uniform distribution. Anchorage, AK (Image courtesy of N. Clanton)

› **LZ3:** Moderately high ambient light
Areas of human activity (i.e., habitation, recreation and/or work) where electric lighting may be continuous and is required for safety and convenience at night. The vision of human residents and users is adapted to moderately high light levels, and they have moderate to high expectations of electric lighting. Lighting is expected to be continuous (e.g. lighting delivered fairly evenly along the length of a path or street). After curfew, both light levels and uniformity may be reduced in some areas as activity levels decline.

LZ-3	Lighting Zone 3 pertains to areas with moderately high lighting levels. These typically include commercial corridors, high intensity suburban commercial areas, town centers, mixed use areas, industrial uses and shipping and rail yards with high night time activity, high use recreational and playing fields, regional shopping malls, car dealerships, gas stations, and other nighttime active exterior retail areas.	Recommended default zone for large cities' business district. Includes business zone districts, commercial mixed use, and heavy industrial and/or manufacturing zone districts.

Figure 13: A Long Term Care Facility in LZ 3 with well-shielded lighting – no uplight. (Image courtesy of David Roederer)

› **LZ4:** High ambient light
Areas of high levels of human activity at night including significant interaction among pedestrians and/or vehicles. The vision of humans when outside is typically adapted to moderate light levels. Lighting is continuous and is required for safety and convenience. Expectations for man-made lighting are high, both in terms of light levels and uniformity along pathways or streets. However, both light levels and uniformity may be reduced after curfew hours in some areas as activity levels decline.

LZ-4	Lighting zone 4 pertains to areas of very high ambient lighting levels. LZ-4 should only be used for special cases and is not appropriate for most cities. LZ-4 may be used for extremely unusual installations such as high density entertainment districts, and heavy industrial uses.	Not a default zone Includes high intensity business or industrial zone districts.

Figure 14: Entertainment district in urban area in LZ 4. (Image courtesy of N. Clanton)

2.5.2 How to Use Lighting Zones The following questions need to be addressed whenever the use of lighting zones is proposed.

1. *What is the purpose behind the adoption of a lighting zone to regulate outdoor lighting?* Is it to preserve or to improve the present state of outdoor lighting in the area? If it is the former, then selecting the appropriate lighting zone is a matter of matching the zone to the prevailing lighting. If it is the latter, some care is necessary in selecting the lighting zone to be sure that the hoped-for result can be achieved. This means paying attention to the arrangements for exemptions, waivers, relaxations, and "grandfathering".

2. *Is it intended to adopt one lighting zone for the whole jurisdiction or to match the lighting zones to the land-use zones?* The approach to adopt will depend upon the diversity of land use in the jurisdiction. Adopting the same outdoor lighting zone for the whole jurisdiction is appropriate where there is little diversity of land-use or nighttime activity. Where there is a wide diversity of land-use and nighttime activity, matching the lighting zones to the land-use zones is a more sensible approach.

3. *What is the desired activity level of the area covered by the proposed zone?* Selection of lighting zone or zones should be tailored to the type of lighting environments the jurisdiction seeks to achieve. In general, the lowest level of lighting appropriate for the activity level is best, rather than allowing for the occasional or extreme use. For example, a school playing field adjacent to residential areas could be zoned the same as the residential area, with provision for occasional exceptions for night games. Façade lighting on sporting facilities, churches, and other buildings that may have occasional nighttime use can be allowed to be energized at all times, but required to be dimmed after curfew.

4. *What are the relative priorities for light pollution, public safety, developing the local economy, or preserving local wildlife?* Community priorities will suggest different lighting zones. For example, LZ0 can be assigned to areas where there is no expectation for nighttime lighting. It should also be applied to areas sensitive to wildlife, such as shore areas for sea turtles during breeding and hatching time. Lower lighting zones should be applied to places of sleep. In a rural or suburban area where there are fewer late nighttime activities, and decrease in late nighttime traffic, priority can easily be given to reducing the light pollution impact on a natural preserve by adopting lighting zones LZ1 or LZ2, and by adopting curfews. Communities that value the nighttime sky as an asset may choose LZ0 or LZ1. Conversely, in an urban area where traffic density is high, there is more late nighttime activity, or where crime is a problem, higher levels of lighting may be very appropriate for applying lighting zone LZ3. Lighting zone LZ4 should be reserved for continuous nighttime activity, such as an urban entertainment district.

5. *What are the relative priorities to be given to reducing sky glow, limiting glare, diminishing light trespass, and conserving energy?* The answer to this question is related to the size of the lighting zone. Giving priority to reducing sky glow implies that the lighting zone or zones should be low and cover as large an area as possible, because all lighting installations over a large area contribute to sky glow. Giving priority to reducing glare and light trespass means that the lighting zone or zones should be tailored to the zoning code, because glare and light trespass are local phenomena, specific to the topography of the situation. Lighting should also be reduced during periods of low activity or seasonal conditions such as snow covered terrain. This is referred to as adaptive lighting and allows for lighting level reductions. Also, any reduction in exterior lighting will conserve energy.

6. *Are there any special circumstances about the area covered by the proposed outdoor lighting zone?* Special circumstances come in three forms: those that imply a high priority to one of the objectives listed above, those that are exempt from local regulations, and those that are lighted to a much higher level than most of the area but only for a limited time. An example of the first is a professional observatory. The presence of such an observatory nearby demands that priority be given to minimizing light pollution. An example of both the first and the second is a prison. State and federal prisons are exempt from local regulations and their function requires that the lighting priority be providing good visibility. An example of the third is a façade-lighted outdoor sports stadium. Such sports stadiums are usually lighted to a very high illuminance to facilitate play and television transmission but may only be lighted for a short time, so these can be dealt with by means of a curfew.

7. *Will a curfew be adopted?* A curfew changes the lighting criteria for the lighting zone at a particular time of night, representing a change in priorities. A curfew should always be considered because most of the benefits of outdoor lighting are only felt when there are people present. For example, the lighting of a supermarket parking lot is often changed at midnight. Before midnight, there are many people and vehicles about, so public safety has priority. After midnight, there are significantly fewer people about and vehicles are parked closer to the buildings, so the risk to public safety is reduced and priority can be given to reducing light pollution and trespass on surrounding neighborhoods. Parking lots not normally used at night, such as business parks or commercial buildings, may allow significantly reduced lighting levels. Motion sensors and intelligent control systems can increase and decrease lighting levels as activity varies. A preferred option is to dim the lighting instead of turning off every other light in order to preserve lighting uniformity

8. *Will exemptions from the requirements be allowed in the lighting zone and will exceptions be available for special events or installations?* It is up to the jurisdictions to establish exceptions for events and installations that can be brought within the spirit of the outdoor lighting zone and are appropriate for the area.

9. *Will the criteria associated with a lighting zone be relaxed where special visual needs are evident, such as the entrance at a senior housing facility?* The entrance and drop-off area may require higher lighting levels, yet glare is still undesirable for seniors. Sleeping areas still need very low lighting levels in order to minimize circadian cycle issues.

10. *What will be done about lighting that contributes to light pollution, visual clutter, or reduced visual acuity, but is not normally considered a general lighting installation?* This includes illuminated signs or façade-lighted buildings. These installations can still be regulated and controlled within the lighting zones.

11. *Are adjacent outdoor lighting zones compatible?* "Compatible" means that there is not more than one change in outdoor lighting zone class between adjacent zones, i.e., the adjacent zones to a LZ2 zone should be either LZ1 or LZ3 but not LZ4. This restriction is necessary because light from one zone will overlap into the adjacent zone. If the difference between adjacent zones is too great, the zone with the stricter criteria should regulate.

12. *What outdoor lighting zone is appropriate for mixed use type areas?* Lighting zones should be applied to the use type. For example, if the street level is all commerce, but the upper floors are residential units, then a separate lighting zone classification may be applied to both. Lighting zone from the commerce level may be higher but should avoid extraneous light from entering the residential units.

13. *Should restrictions on spectral distribution be required in a lighting ordinance?* Currently, the MLO does not address spectral distribution, but a community may want to add restrictions such as monochromatic or amber lighting, especially if located near an observatory or for wildlife concerns such as turtle nesting areas. Some communities may want to provide guidance on spectral distribution and color rendering in order to provide a cohesive community theme and provide better security lighting.

14. *Should sign lighting be regulated?* Communities can regulate sign lighting and changing copy duration. Intensity, movement, luminaire locations for externally lighted signs are methods in which regulations occur. For internally lighted signs, daylight hours intensity may also be regulated.

3.0 DEVELOPING A LIGHTING ORDINANCE

An effective method to control the quality of outdoor lighting at the community level is to use a lighting ordinance. Depending upon the locale, authority for the creation and/or implementation of such an ordinance may or may not rest at the local level. Unless mandated otherwise by a higher political jurisdiction, municipalities, e.g., cities, boroughs, townships, towns, are well advised to take responsibility for developing and maintaining such an ordinance. Without it, the municipality will have little or no authority to guard against lighting that is excessive, insufficient, abusive, unsafe, or inconsistent with the accepted lighting practices and the best interests of the community.

Such an ordinance performs several important functions. It sets a community standard. By its existence, it educates the community and all its components about the value of quality night lighting. It adds value to the community and its citizens. By having minimum acceptable standards, the municipality can evaluate proposed lighting installations against the standards and require compliance, thus protecting against unpleasant surprises. The ordinance will also accord the community the authority to require remedial action to correct non-

conforming lighting installations. In addition, such regulations will be very useful for establishing and maintaining community or neighborhood aesthetic themes.

3.1 Getting Started

Preparing an effective lighting ordinance requires forethought and planning. To address the relevant issues, it is helpful to convene a group of interested citizens, business owners, elected/appointed officials, the municipal engineer, the code enforcement officer, representatives from the local police and other stakeholders. Because lighting may not necessarily be on every elected official's priority list, having representation from the governing body can be helpful in spreading the word. Field trips to experience existing examples of good and bad lighting and to become familiar with local situations and needs are appropriate. Using the *Joint IES-IDA MLO* as a template will help municipalities develop accepted lighting ordinance language and methods of compliance. The municipality's legal representative will be well advised to be involved in the process.

Getting an ordinance approved can be a daunting task and is often a compromise between those who insist upon ironclad control and those who resist any form of regulation. The reality is that if the ordinance language does not meet the needs of the community, it will not likely be enacted. On the other hand, if the ordinance is enacted but does not meet the needs of those who are responsible for enforcing it, e.g., the municipal engineer and the code enforcement officer, it will likely not get applied. For those reasons, it is prudent to have broad involvement and buy-in by the right stakeholders.

3.2 Model Lighting Ordinance Details

Once the issues have been fully explored, use the *Joint IDA-IES MLO* as the technical basis for an ordinance. The following sections describe basic considerations that should be incorporated into a new lighting ordinance.

3.2.1 Purpose, Intent, and Preamble The document should first establish the purpose for the ordinance. This can be modified to suit specific community issues. The MLO has a suggested preamble statement that reads:

- The purpose of this Ordinance is to provide regulations for outdoor lighting that will:
- Permit reasonable uses of outdoor lighting for night-time safety, utility, security, productivity, enjoyment and commerce
- Conserve energy and resources to the greatest extent possible
- Minimize adverse offsite impacts including glare and obtrusive light
- Curtail light pollution and preserve the nighttime environment
- Help preserve the dark night sky for astronomy and enjoyment
- Help protect the natural environment from the adverse effects of night lighting from electric sources

3.2.2 General Regulations for All Outdoor Lighting The ordinance needs to establish what outdoor lighting is regulated, exempt, and what exceptions are allowed. Communities have a choice to regulate lighting on private commercial and/or residential property, and lighting in the public right of way such as street lighting. Governmental properties can be regulated through state or federal regulations. The MLO addresses lighting regulations for private properties, both commercial and residential applications. The MLO has an optional street lighting ordinance which only addresses uplighting. Issues such as amortization, grandfathering, or size of property that is to be regulated are left up to the community. The MLO lists suggested areas of applicability, exemptions, and exceptions that communities can adopt or modify.

Regardless of regulations, the lighting installation must meet local electrical, energy, and applicable sections of the building codes.

3.2.3 Establish Lighting Zones Establishing lighting zones is a means to establish different limitations for lighting within a community. The lighting zones vary from an area or district with no ambient light (LZ0), to one of high ambient light (LZ4). Similar to land use zoning, the lighting zones help define the desired ambient lighting conditions and community expectations. Some smaller communities may assign only one or two zones to the entire community in order to simplify the regulations. Default zones will typically be LZ1 – LZ3. Refer to **Section 2.5.1 Lighting Zones** for lighting zone descriptions and suggested lighting zones land use areas.

3.2.4 Establish Curfews Curfews are a means of reducing lighting impacts on the community later in the evening or night. Curfews are very important in residential and other areas of sleep, or in areas where environmental impacts are potentially high. Street and pedestrian lighting can also be reduced when vehicle and pedestrian activity is reduced. Reduction in street lighting is referred to as "Adaptive Lighting Controls".

appears. As the background luminance of the scene increases, the apparent brightness of a luminaire becomes lower. Viewing car headlights during the daytime is a good example of a situation involving high luminance but low brightness perception. At night on a dark road, those same headlights may be perceived as overly bright.

Human vision factors also affect the perception of brightness. Blue LEDs are often judged as brighter than red or green ones, and also cause more discomfort and disability glare[15,16] than other longer wavelengths. While red or green light is focused precisely onto the retina, blue light is focused slightly in front of it, which causes a distracting halo around bright blue lights. In addition, blue scatters more widely than other colors as it passes through the eyeball. Also, human vision becomes far more sensitive to blue when ambient light levels are low, a phenomenon known as the Purkinje shift. So a blue light that is merely eye-catching in a brightly lighted area can become dazzling when the lights are dim.

Because of its subjective nature, brightness is difficult (if not impossible) to measure. However, luminaire luminance and luminous intensity are two photometric quantities correlated with brightness that can be used to specify luminaires. By considering one (or both) of these quantities, a designer can specify a high-quality lighting installation without excessive brightness. Using the BUG rating system will help select the appropriate luminaires (see **Annex B – Luminaire Classification**). Also, careful selection of the appropriate CCT will help minimize apparent brightness.

Any type of luminaire, whether it is fully shielded or non-shielded, can yield excessive brightness. Factors such as the luminaire optics (size of the luminous area/opening, direct visibility of the light source (clear or diffuse), and the concentration and viewing angle of a luminaire's main light output), the mounting height of the luminaire, the proximity and reflectance characteristics of adjacent objects or surfaces, and the overall luminance of the surrounding scene will all have an effect on how bright a luminaire will appear.

The design of a luminaire will have an effect on its luminance. The higher the luminance, the greater the potential for excessive brightness perception. Poorly-designed high angle light producing luminaires can yield excessive luminance, while well-designed, partially shielded luminaires can be comfortable to view. However (assuming equivalent lumen packages), as designers move from specifying shielded to non-shielded luminaires, increasing attention should be paid to the luminaire luminance and potential for excessive brightness perception. For diffuse sources, average luminance can be calculated from an *ANSI/IES LM-63-02/R2008 IESNA Standard File Format for the Electronic Transfer of Photometric Data and Related Information* data file. For directional sources, sample luminaires should be evaluated for brightness appropriateness. Care should be given to limit upward light transmission to minimize light pollution. Ideally, a mock-up of the scene or direct examination of an already-installed site will yield valuable information about the brightness of a specific luminaire.

4.6 Safety and Security Lighting

Providing a sense of safety and security are critical functions for exterior lighting. Lighting for safety involves ensuring proper level of illumination to identify hazards or obstructions with low glare light to allow for better adaptation, to provide safe working conditions and safe passage. Lighting for *security* is installed to enhance the perception of safety and to protect people and property from criminal activity. Refer to *IES G-1-03 Security Lighting for People, Property and Public Spaces.*[27] However, because the security of people and property involves psychology, perception, and other issues, it is a much more difficult task for an exterior lighting system to satisfy.

4.6.1 Safety Lighting Effective safety lighting is unobtrusive. It provides comfortable visibility of activity areas and possible hazards, while avoiding unnecessary glare, light pollution, or light trespass.

Too often, people associate brighter light and glare with "safer" surrounds. In reality, more light and glare do not necessarily equate to better lighting. It can be easily demonstrated that too much light, or poorly directed light, actually causes a *loss* of visibility. For example, if a light produces disability glare, it prevents a person from discerning important detail because of the high brightness contrast (or glare which causes a silhouette effect). Another example would be a small area where overly high luminance and illumination levels may prevent a person from discerning or recognizing any objects or activity beyond the area being illuminated. Higher light levels can also result in luminance adaptation issues as a person moves from the area of high luminance to the darker surroundings.

Successful exterior lighting designs consist of layers of light. Layered lighting involves providing a minimal amount of ambient lighting with accents or highlights on a few key features. This approach begins with street and pedestrian lighting. In addition to lighting the street, safety is increased by providing adequate vertical light at crosswalks and intersections. The light poles may need to be located so as to light a pedestrian's face and body rather than the top of the head. This lighting gives motorists and pedestrians the

Walkways not adjoining roadways and having minimal non-pedestrian traffic need not be lighted continuously. Only hazards along the walkway such as stairs, abrupt changes in elevation, bridges, and curves may be lighted. Alternatively, lighting the walkway surroundings is an acceptable method. Lighting on the termination or resting points along the walkway is another useful technique. This approach gives pedestrians a visual clue about where important destinations are located.

Walkways located in the middle of a park or large landscaped area require a unique blend of lighting that covers key landscape features, selected buildings or shelters, resting points and any walkway hazards (e.g., stairs, abrupt changes in elevation, bridges, and curves). However, park walkways need not be lighted continuously or at all if the walkways are not encouraged to be used at night.

It is important to consider the adjacent surroundings for walkways and bikeways. Lighting Zones and lighting levels should be developed during the Community Responsive Design process and as described in **Section 4**.

8.0 PEDESTRIAN MALL AND PLAZA LIGHTING

Pedestrian malls have often been described as outdoor living rooms. The first step in creating this illusion is to provide soft vertical and horizontal surface brightness. This fill light provides boundary definition for the mall. Cornerstone building features, like a clock tower or steeple, will add depth to the mall when illuminated.

Next, provide luminaires that put light on people's faces, using pedestrian–scale poles. The glow from these luminaires should add visual variations and contextual detail rather than substantial additional brightness to the overall visual scene. Finally, add subtle highlights by softly lighting statues and key landscape features.

The success of the three–step layered design process ultimately depends on careful coordination of all lighting in the plaza area to create a cohesive design. Awareness of lighting zones and correct luminaire selection will provide the desired effect without adding nuisance light (see **Section 2.3**).

Dynamic lighting systems that blink, flash, or frequently change can sometimes be effective in creating an active environment. But bright sources and blinking lights may also destroy a peaceful setting and create visual hazards for motorists. These systems are only successful when coordinated with adjacent property owners and the street lighting authorities.

Walkways within a pedestrian mall should be lighted according to the recommendations in **Section 2.3.6.1.10**.

9.0 PARKING LOT LIGHTING

The first step in determining Lighting Zone classifications and light level ranges for parking areas comes during the Community Responsive Design process of **Section 4**. Minimizing nuisance glare to homes in residential communities and other places of sleep from adjacent parking lots should be a prime concern. Fully shielded luminaires should be used in essentially all applications and comply with BUG ratings, or a lighting design meeting the performance requirements per lighting zone. (See **Annex B**.)Poles should usually be no higher than nearby buildings. House–side shields may be necessary in glare sensitive areas.

Lighting parking lots with building-mounted equipment should also be done with care. Fully shielded luminaires should be used in essentially all applications and comply with BUG ratings, or a lighting design meeting the performance requirements per lighting zone.

Refer to *ANSI/IES RP–8-14* and *IES RP–20-14 Lighting for Parking Facilities*[29] for specific design guidance and criteria.

10.0 OUTDOOR SPORTS LIGHTING

The first step in determining area classifications and light level ranges for outdoor sports lighting comes during the Community Responsive Design process of **Section 4**. When sports fields are adjacent to roadways, the sports lighting should not create an unsafe glare condition on the roadways. When sports fields are located adjacent to residential communities, the overall brightness should be carefully controlled. Poles should be at least 70 ft. (21.3 meters) high for aerial sports such a baseball or softball. Lights should not be aimed above 62 degrees (approximately two times the mounting height) from nadir, and should use internal louvers and external shields to help minimize light pollution. All outdoor sports fields should take into account surrounding community brightness and nuisance glare and be designed to minimize sky glow. Curfews may require lights to be turned off or reduced between

certain hours, but may also provide for occasional exceptions. Refer to the latest version of *IES RP–6-01(R2009) Recommend Practice for Sports and Recreational Area Lighting*[30] for specific design guidance and criteria.

11.0 OUTDOOR RETAIL LIGHTING

Exterior areas where customers view and select merchandise such as car dealerships, automobile service stations, and lumber yards require outdoor retail lighting. This lighting is used to attract shoppers, for customers to comfortably review the merchandise, and for safe pedestrian passage. Security is also an issue, especially when the merchandise is left outside continuously. Typically, the first step in determining lighting zones and lighting levels for outdoor retail should come from the Community Responsive Design process of **Section 4.0**.

Care should be taken that outdoor retail areas are only appropriately brighter than their surrounds. If the adjacent properties and roadways are lighted to a base level, the restaurant's drive–up and parking areas should be no more than five times that level. Additional brightness will not attract more attention, and may present a hazard to motorists on adjacent roadways. The adaptation level of customers leaving the retail property may also be an issue as they leave the bright zone surrounding the establishment for the relatively dark public zones surrounding it. See **Section 2.5** for information on using lighting zones.

Refer to *The IES Lighting Handbook, 10th Edition*, for merchandise lighting guidelines.

11.1 Automobile Dealership Lighting

The merchandise located on lots surrounding an automobile showroom usually consists of a front row of cars or trucks adjacent to a primary road. Attracting customers to these vehicles can be artfully accomplished. The lighting should fill the area without producing excessive brightness. Luminaires should be selected and located to provide minimal luminance as seen by motorists from normal viewing angles on adjacent roadways, and from potential customers examining merchandise close up. This can be accomplished by locating certain luminaire support poles between the roadway and the front row merchandise, and careful aiming of well-shielded, low glare luminaires directly at the front row. Glare reflected off of the merchandise at normal viewing angles should be avoided. Select a light source that renders colors well to enhance merchandise appearance.

Other luminaires should be located on poles throughout the lot. Luminance produced by these luminaires should not cause disability glare for motorists or customers. In all cases, luminaires should be selected and located to avoid nuisance glare for homeowners in surrounding neighborhoods.

For lighting feature displays, see *The IES Lighting Handbook, 10th Edition.*

11.2 Service Station Lighting

The key to quality service station lighting is providing sufficient illuminance to safely and effectively perform the visual tasks required while providing only the luminance needed to create a sense of welcome and security. Too often, these sites simply use more and brighter lights. Many facilities combine automobile fueling with convenience stores or fast-food facilities on the same sites. This suggests the need for a more holistic approach to the lighting design, taking into account not only the various visual tasks but also the building interior, roadway, and adjacent area lighting levels. Adaptation from inside the store to the exterior is an issue for the dispenser manager, who should monitor the interior activities, and also the dispenser conditions.

Safety can be enhanced by using low-brightness sources that do not project glare into pedestrians' and drivers' eyes and also by maintaining proper maximum to minimum uniformity ratios among the important areas of the site. For example, a store clerk may need to monitor activity at the dispensers, which will affect the lighting design levels of at the dispenser island and the inside the store. Service stations canopy areas lighted to high illuminance levels may pose adaptation problems for customers leaving the station and re–entering the much darker street or roadway nearby. While entering the dispenser island area, minimizing glare from the luminaires will help avoid similar adaptation problems as well.

Service stations can be lighted very effectively with glow from indirectly lighting the dispenser island canopy as opposed to direct illumination from bright sources that may also create glare for those on the adjacent roadway. By lighting service station surfaces (like the dispenser island canopy and the station's facade), customers can be drawn to a retail area that is comfortable and attractive, yet free of the negative impacts associated with very bright lighting conditions. It is recommended that U0 luminaires be used (for example, use a flat lens instead of dropped lenses or refractors). This will reduce the direct glare from the luminaires within the driver's field of view and generally lower light trespass problem concerns.