Exhibit B –LEED Light Pollution Reduction

LIGHT POLLUTION REDUCTION

SS CREDIT 8

	NC	SCHOOLS	CS
Credit	SS Credit 8	SS Credit 8	SS Credit 8
Points	1 point	1 point	1 point

Intent

To minimize light trespass from the building and site, reduce sky-glow to increase night sky access, improve nighttime visibility through glare reduction and reduce development impact from lighting on nocturnal environments.

Requirements

NC, SCHOOLS & CS

Project teams must comply with 1 of the 2 options for interior lighting AND the requirement for exterior lighting.

For Interior Lighting

OPTION 1

Reduce the input power (by automatic device of) all nonemergency interior luminaires with a direct line of sight to any openings in the envelope (translucent or transparent) by at least 50% between 11 p.m. and 5 a.m. After-hours override may be provided by a manual or occupant-sensing device provided the override lasts no more than 30 minutes.

OR

OPTION 2

All openings in the envelope (translucent or transparent) with a direct line of sight to any nonemergency luminaires must have shielding (controlled/closed by automatic device for a resultant transmittance of less than 10% between 11 p.m. and 5 a.m.).

For Exterior Lighting

Light areas only as required for safety and comfort. Lighting power densities must not exceed ANSI/ASHRAE/IESNA Standard 90.1-2007 (with errata but without addenda[1]) for the classified zone.

Classify the project under 1 of the following zones, as defined in IESNA RP-33, and follow all the requirements for that zone:

LZ1: Dark (developed areas within national parks, state parks forest land and rural areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 0.01 horizontal and vertical footcandles at the site boundary and beyond. Document that 0% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

1 Project teams wishing to use ASHRAE approved addenda for the purposes of this prerequisite may do so at their discretion. Addenda must be applied consistently across all LEED credits.

NC, SCHOOLS & CS (continued)

LZ2: Low (primarily residential zones, neighborhood business districts, light industrial with limited nighttime use and residential mixed-use areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 0.10 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 10 feet beyond the site boundary. Document that no more than 2% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ3: Medium (all other areas not included in LZ1, LZ2 or LZ4, such as commercial/industrial, and high-density residential)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 0.20 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 5% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ4: High[2] (high-a ctivity commercial districts in major metropolitan areas)

Design exterior lighting so that all site and building-mounted luminaires produce a maximum initial illuminance value no greater than 0.60 horizontal and vertical footcandles at the site boundary and no greater than 0.01 horizontal footcandles 15 feet beyond the site. Document that no more than 10% of the total initial designed fixture lumens (sum total of all fixtures on site) are emitted at an angle of 90 degrees or higher from nadir (straight down).

LZ2, LZ3 and LZ4 - For site boundaries that abut public rights-of-way, light trespass requirements may be met relative to the curb line instead of the site boundary.

For All Zones

Illuminance generated from a single luminaire placed at the intersection of a private vehicular driveway and public roadway accessing the site is allowed to use the centerline of the public roadway as the site boundary for a length of 2 times the driveway width centered at the centerline of the driveway.

SCHOOLS Additional Requirement

Sports Field Lighting (Physical Education Spaces)

Physical education spaces (playing fields) do not need to comply with the lighting power density requirements of this credit, as per ANSI/ASHRAE/IESNA Standard 90.1-2007 section 9.4.5, exception E. Automatic Shutoff: All sports lighting must be automatically controlled to shut off no later than 11 p.m.. Manual override must be provided to avoid disruption of school sponsored sporting events.

2 To be LZ4, the area must be so designated by an organization with local jurisdiction, such as the local zoning authority.

SCHOOLS Additional Requirement (continued)

Trespass Calculations

All trespass calculations must be submitted for 2 conditions: (1) with the sports lighting turned off and all other site lighting turned on, the light trespass requirements are as stated above, and (2) with just the sports lighting turned on, the light trespass requirements for horizontal and vertical footcandles (fc) may be increased to the following illuminance levels:

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

1. Benefits and Issues to Consider

Environmental Issues

Outdoor lighting is important for human safety. Illuminating connections between buildings and support facilities such as sidewalks, parking lots, roadways, and community gathering places is necessary for twilight and nighttime use. However, light trespass from poorly designed outdoor lighting systems can affect a site's nocturnal ecosystem, and light pollution limits night sky observations. Through thoughtful design and careful maintenance, outdoor lighting can address night sky visibility issues and site illumination requirements, while minimizing negative impacts on the environment.

Sensitively and creatively designed lighting systems promote a unique appreciation for a place at night. Yet even with the best of luminaries—those designed to reduce light pollution and requiring the lowest wattage—the added light will be reflected off surfaces and into the atmosphere. Using the minimum amount of lighting equipment, limiting or eliminating all landscape lighting, and avoiding light pollution through the careful selection of lighting equipment and controls enables nocturnal life to thrive while still providing for human nighttime activity.

Economic Issues

The initial cost and ongoing operational costs for exterior lighting can be greatly reduced by eliminating luminaries that do not enhance safety. Additionally, using the most efficacious light sources, luminaries, and controls will further reduce the energy costs of these systems. Long-life lamps can further increase operational savings by requiring a less frequent relamping cycle. However, the initial cost per luminaire may be somewhat higher because of increased costs associated with internal reflectors and shielding, more efficient lamp and ballast combinations, and controls.

2. Related Credits

This credit requires adherence to the lighting power densities of ASHRAE 90.1–2007. Any energy savings beyond this baseline, as well as savings stemming from integrated automatic controls, may contribute to achieving the following credit:

- EA Credit 1: Optimize Energy Performance

Automatic occupancy controls to shutoff interior perimeter lighting should be coordinated with occupant controllability objectives, as rewarded under this credit:

- IEQ Credit 6.1: Controllability of Systems—Lighting

3. Summary of Referenced Standard

ANSI/ASHRAE/IESNA Standard 90.1–2007, Energy Standard for Buildings Except Low-Rise Residential Lighting, Section 9 (without amendments)

American Society of Heating Refrigeration, and Air-Conditioning Engineers

http://www.ashrae.org

Standard 90.1–2007 was developed by the American Society of Heating, Refrigerating, and Air-Conditioning Engineers, Inc. (ASHRAE), under an American National Standards Institute (ANSI) consensus process. The Illuminating Engineering Society of North America (IESNA) is a joint sponsor of the standard. Standard 90.1 establishes minimum requirements for the energy-efficient design of buildings, except those that are low-rise residential. The provisions of this standard also do not apply to single-family houses; multifamily structures of 3 habitable stories or fewer above grade; mobile and modular homes; buildings without electricity or fossil fuel consumption; or equipment and portions of building systems that use energy primarily for industrial, manufacturing, or commercial processes. The standard provides criteria in the following general categories: building

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

envelope (Section 5); heating, ventilating, and air-conditioning (Section 6); service water heating (Section 7); power (Section 8); lighting (Section 9); and other equipment (Section 10). Within each section there are mandatory provisions as well as additional prescriptive requirements. Some sections also contain a performance alternate. The energy cost budget option (Section 11) allows the user to exceed some of the prescriptive requirements provided energy cost savings are made in other prescribed areas. However, in all cases, the mandatory provisions must still be met.

Section 9 of the standard provides requirements for the lighting of buildings. Only the exterior lighting requirements apply to this credit. **Table 3** lists the ASHRAE 90.1–2007 allowable building exterior lighting power densities.

Table 3. Lighting Power Densities for Building Exteriors

	Applications	Lighting Power Densities
Tradable Surfaces (Lighting power densities for uncovered parking areas, building grounds, building entrances and exits, canopies and overhangs and outdoor sales areas may be traded.)	**Uncovered Parking Areas**	
	Parking Lots and drives	0.15W/ft²
	Building Grounds	
	Walkways less than 10 feet wide	1.0W/linear foot
	Walkways 10 feet wide or greater Plaza areas Special Feature Areas	0.2W/ft²
	Stairways	1.0W/ft²
	Building Entrances and Exits	
	Main entries	30W/linear foot of door width
	Other doors	20W/linear foot of door width
	Canopies and Overhangs	
	Canopies (free standing and attached and overhangs)	1.25W/ft²
	Outdoor Sales	
	Open areas (including vehicle sales lots)	.5W/ft²
	Street frontage for vehicle sales lots in addition to "open area" allowance	20W/linear foot
Non-Tradable Surfaces (Lighting power density calculations for the following applications can be used only for the specific application and cannot be traded between surfaces or with other exterior lighting. The following allowances are in addition to any allowance otherwise permitted in the "Tradable Surfaces" section of this table.)	Building Facades	0.2W/ft² for each illuminated wall or surface or 5.0W/linear foot for each illuminated wall or surface length
	Automated teller machines and night depositories	270W per location plus 90W per additional ATM per location
	Entrances and gatehouse inspection stations at guarded facilities	1.25W/ft² of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Loading areas for law enforcement, fire, ambulance and other emergency service vehicles	0.5W/ft² of uncovered area (covered areas are included in the "Canopies and Overhangs" section of "Tradable Surfaces")
	Drive-up windows at fast food restaurants	400W per drive-through
	Parking near 24-hour retail entrances	800W per main entry

Source: Table 9.4.5, ANSI/ASHRAE/IESNA 90.1–2007.

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

4. Implementation

Interior Building Lighting

OPTION 1

All nonemergency interior lighting fixtures must be automatically controlled and programmed to turn off or have their input power reduced by at least 50% following regular business hours. Controls can be automatic sweep timers, occupancy sensors, or programmed master lighting control panels. The design can also include manual or occupancy based override capabilities that enable lights to be turned on after hours.

Twenty-four-hour operation projects are exempt from the after-hours override automatic shutoff, and thus must follow Option 2.

OPTION 2

All exterior openings, such as windows, must have shielding that can be automatically controlled and programmed to close from 11:00 p.m. to 5:00 a.m. Shielding options include automatic shades that have less than 10% transmittance.

An example is a timer-controlled automated rolling shade with the appropriate light transmittance.

CS In core and shell buildings, these requirements are limited to the core and shell lighting. This typically includes lobby and core circulation spaces. If no light is provided to tenant spaces as part of the core and shell development, those spaces are exempt from these requirements. Core and shell projects that do not install any interior lighting as part of the project scope have met this requirement.

Exterior Lighting Power Density

Design the project's exterior lighting to meet lighting power densities that are equal to or less than the requirements set forth in SS Credit 8, Figure 1, ASHRAE 90.1–2007, Section 9, Table 9.4.5., Lighting for Exterior Areas.

Projects should light areas only as required for safety and comfort, provide only the light levels necessary to meet the design intent, and select efficient fixtures using efficacious sources to meet the lighting requirements of the site while minimizing light pollution.

Exterior Light Distribution

Design the project's exterior lighting to comply with the light pollution requirements for the project's zone. The lighting requirements address the site illumination level at and beyond the site boundary and the luminaire distribution relative to up-lighting. The exterior lighting must meet the light pollution requirements under both precurfew and postcurfew conditions. Curfew timers and controls can be effective parts of the overall lighting strategy, but controls cannot be used to make otherwise noncompliant exterior areas comply with the credit.

SCHOOLS School projects must include curfew timers and controls in the design of sports field lighting, providing automatic shutoff no later than 11 p.m. The lighting designer should provide manual overrides to avoid disrupting evening sporting events that may run beyond the normal curfew.

Consider using low-intensity shielded fixtures and curfew controllers to turn off nonessential site lighting after 10:00 p.m. or immediately after closing (whichever is later) to further reduce the effects

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

of light pollution. Minimize the lighting of architectural and landscape features. Where lighting is required for safety, security, egress, or identification, utilize down-lighting techniques rather than up-lighting.

For example, in environments that are primarily dark (LZ1), no landscape features should be illuminated and architectural lighting should be designed only when other strategies cannot provide the minimum amount of required lighting. In places with medium or high ambient brightness (LZ3 and LZ4), some low-level lighting of features, facades, or landscape areas may be appropriate in pedestrian areas, or for identifying and marking pedestrian paths in areas where light trespass is not likely to be an issue. However, even in areas of high ambient brightness, all nonessential lighting (including landscape and architectural lighting) should be minimized or turned off after hours. All adjustable luminaires should be properly aimed so that light from the luminaires does not cross project boundaries. Use controls wherever possible to turn off nonessential lighting after normal operating hours or after curfew.

At a minimum, consider the following strategies when designing the exterior lighted environment:

- Employ a lighting professional to assess the project's lighting needs and provide recommendations based specifically on lighting for a sustainable built environment.
- Carefully review and respond to any applicable lighting ordinances or bylaws that might affect the lighting design for the project site.
- Determine the environmental zone that the project falls under from Dark (LZ1) to High Ambient Brightness (LZ4). Understand the design implications of the environmental zone that is determined and study neighboring areas to identify potential light trespass problems.
- In most cases, it is better to have 2 luminaires with lower light output and good glare control than 1 higher-output luminaire.
- Select all lighting equipment carefully. Any type of luminaire, whether it is full cutoff, semi-cutoff or non-cutoff, can produce excessive brightness in the form of glare. For example, horizontal lamp positions in full cutoff luminaires tend to produce much less glare than vertical lamps.
- Design exterior lighting to produce minimal upward illumination from the luminaire and reflected light off of adjacent surfaces. Select luminaire locations carefully to control glare and contain light within the design area. Pay special attention to luminaires that are located near the property line to ensure that minimal measurable light from these luminaires crosses the LEED project boundary.
- Use the minimum amount of light necessary. Design and develop a control scheme to minimize or turn lighting off after hours or during post-curfew periods.
- Create a computer model of the proposed electric lighting design and simulate system performance. Use this model to calculate the specified illuminances demonstrating that illuminance values are as required at the project site boundary and at the required distance beyond the site boundary. Calculate the vertical light levels along and above the site boundary to a height of at least the highest luminaire on the site.
- After the lighting system is constructed, commission it to make sure that it is installed and operating properly. Perform maintenance on the system on a regular basis to make sure that it continues to operate properly and that light pollution is minimized.

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

5. Timeline and Team

Once the environmental zone is determined by the lighting designer, often in the schematic design phase, the design can move forward. Consider local light level requirements and the unique aspects of the site in relation to the light pollution thresholds of this credit.

As the exterior lighting is designed, a photometric analysis of the site should be performed at intervals to verify the project's continued compliance with the credit requirements. During the construction documents phase, the landscape architect, civil engineer, lighting designer, architect, electrical engineer, and others as appropriate should coordinate to verify the layout and compliance of the exterior fixtures.

6. Calculations

Interior Building Lighting

There are no calculations associated with this portion of the credit.

Exterior Lighting Power Density

Calculate the exterior lighting power density in accordance with ANSI/ASHRAE/IESNA 90.1–2007 Section 9 (see Table 1) and determine whether it is less than the allowable densities for the project site. Note that individual luminaire wattages must be input watts (not just lamp watts), including all ballast losses.

Exterior Sky Glow and Light Trespass

To measure compliance with the light trespass requirements, use lighting design software and develop a site illumination model (i.e., photometric site plan). The model should show the full extent of the site and all installed exterior lighting fixtures. Set up a horizontal calculation grid to measure the site illumination at the ground plane (the grid should extend to the property line and 10 feet beyond the site boundary for LZ2, and 15 feet beyond the site boundary for LZ3 and LZ4). Set a vertical calculation grid at the property boundary and at the extents of the LZ requirements (10 feet beyond the site boundary for LZ2, and 15 feet beyond the site boundary for LZ3 and LZ4) to measure vertical illumination. The calculation grid spacing should be a maximum of 10 feet x 10 feet and should exclude building interior areas.

Using manufacturers' fixture data, determine the initial lamp lumens for each luminaire. Additionally, from photometric data, determine the number of initial lamp lumens that are emitted at or above 90 degrees from nadir. Use these data to determine the percentage of lumens at or above 90 degrees.

Luminaires without photometric distribution data must be assumed to have 100% of their initial lamp lumens at or above 90 degrees. Luminaires with limited field adjustability must be assumed to have maximum tilt applied, and lumens at or above 90 degrees must be calculated from maximum tilted orientation. Luminaires with full range of field adjustability (those that can be aimed above 90 degrees from nadir) must be assumed to have 100% of the emitted fixture lumens at or above 90 degrees.

SCHOOLS For LEED for Schools projects with sports field lighting, perform this calculation with sports lighting turned off. The result must be less than or equal to the value referenced for the site's LZ.

For schools with sports field lighting, perform a second calculation with just the sports lighting turned on. Confirm that the light trespass requirements for horizontal and vertical footcandles do not exceed the following illuminance levels:

LZ1 = 0.10 fc at the site boundary, dropping to 0.01 fc within 10 feet of the boundary
LZ2 = 0.30 fc at the site boundary, dropping to 0.01 fc within 10 feet of the boundary
LZ3 = 0.80 fc at the site boundary, dropping to 0.01 fc within 15 feet of the boundary
LZ4 = 1.50 fc at the site boundary, dropping to 0.01 fc within 15 feet of the boundary

	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

7. Documentation Guidance

As a first step in preparing to complete the LEED-Online documentation requirements, work through the following measures. Refer to LEED-Online for the complete descriptions of all required documentation.

Interior Lighting

- If automatic controls are used for interior lighting, prepare drawings showing their locations. Incorporate the sequence of operation for lighting into drawings and specifications or the building operation plan.
- If automatic shading devices are used to control interior lighting, prepare drawings of the devices, assembly specifications, or product data showing that they block at least 90% of the light, and incorporate the sequence of operation for automatic shading devices into drawings and specifications, or the building operation plan.

Exterior Lighting

- Determine the zone classification for a project site.
- Acquire manufacturer's data for lamps used on a project site.
- Prepare a description of the light trespass analysis procedure conducted to determine credit compliance.
- Develop a photometric site plan of parking areas that includes footcandle summary tables for light ratio.

SCHOOLS

- For sports field lighting on school grounds, develop a photometric site plan showing adherence to allowable light level limits, prepare drawings showing automatic controls for sports field lighting, and incorporate the sequence of operation for sports field lighting into drawings and specifications or the building operation plan.

8. Examples

EXAMPLE 1. Exterior Lighting Power Density and Trespass Assessment

Table 2 shows an example of how exterior lighting power density calculations are performed, and Table 15 demonstrates the data required to calculate the percentage of lumens emitted at or above 90 degrees from nadir.

SS	
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

Table 2. Sample Exterior Lighting Power Density Calculation

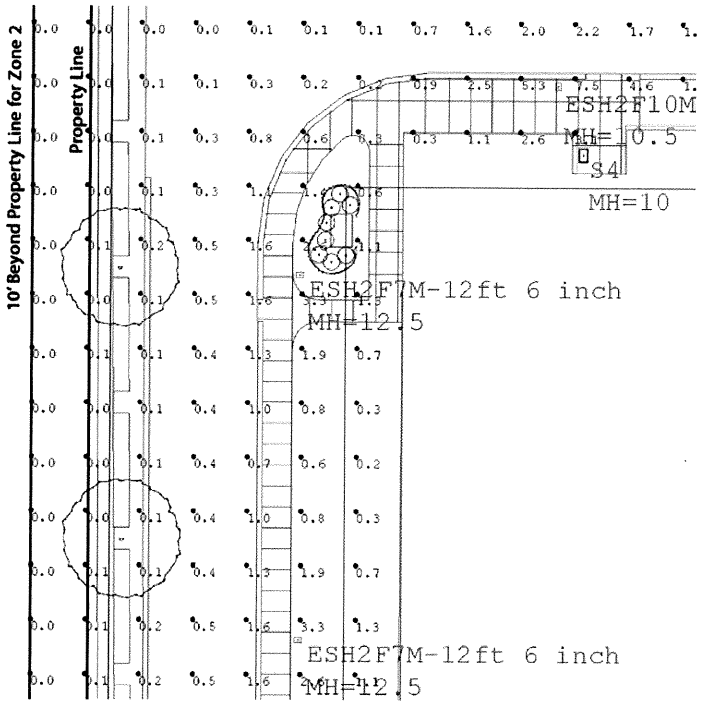
Site Lighting Power Density Calculation						
Site Lighting Fixture	**Fixture Power (watts)**	**Total Fixtures (qty)**	**Total Fixture Power (watts)**	**Site Location**	**Site Area (sf)**	**LPD (w/sf)**
Pole Fixture 1	250	14	3,500	Parking 1	32,000	0.11
Pole Fixture 1	250	8	2,000	Parking 2	18,000	0.11
Pole Fixture 2	115	1	115	Walkways 1	875	0.13
Bollard Fixture 1	40	4	160	Walkways 1	875	0.18
Bollard Fixture 1	40	6	240	Courtyard 1	1,500	0.16
Wall Washer 1	50	5	250	Building Façade N	2,500	0.10
Site Areas						
Identification	Area (sf)	ASHRAE 90.1.2004 Allowable LPD (w/sf)	Actual LPD (From Site Lighting Table)	Actual LPD Reduction (%)	Required LPD Reduction (%)	Complies (Yes/No)
Parking 1	32,000	0.25	0.11	27%	20%	YES
Parking 2	18,000	0.15	0.11	26%	20%	YES
Walkways 1 (10' wide)	875	0.2	0.16	21%	20%	YES
Courtyard 1	1,500	0.2	0.16	20%	20%	YES
Building Façade N	2,500	0.2	0.10	50%	50%	YES

Table 3. Lamp Lumen Calculation

Luminaire Type	Quantity of Installed Luminaires	Initial Fixture Lumens per Luminaire	Total Fixture Lumens (column 2 x column 3)	Initial Fixture Lumens from Luminaire above 90 Degrees (from nadir-straight down)	Total Fixture Lumens above 90 Degrees (column 2 x column 5)
A	10	4,600	46,000	100	1,000
B	20	11,900	238,000	0	0
C	5	2,000	10,000	2,000	10,000
Total			294,000		11,000

Figure 1 shows the photometric site plan generated by an illumination model. The example is in compliance with the credit requirements for a project located in LZ2: The light level at the property line does not exceed 0.1 footcandles, and the light level 10 feet beyond the property line does not exceed 0 footcandles.

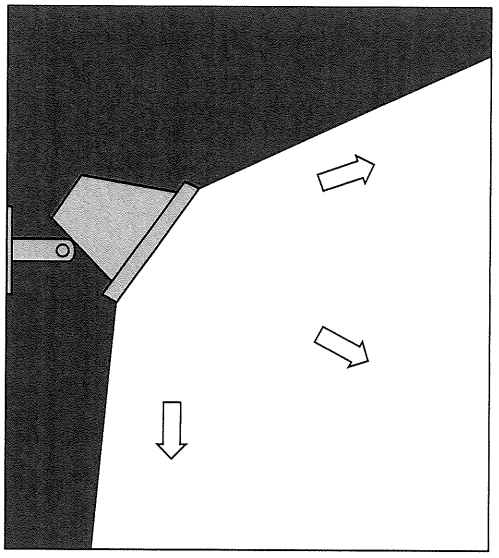
Figure 1. Sample Illumination Model



	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

Figures 2–5 show how a shielded light can prevent light trespass and light pollution of the night sky.

Figure 2. Unshielded Floodlight



SS	
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

Figure 3. Task Area from Unshielded Floodlight

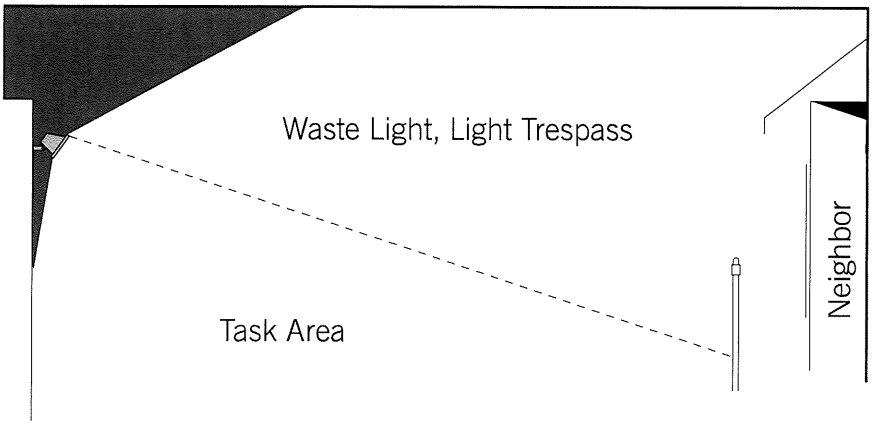


Figure 4. Shielded Floodlight

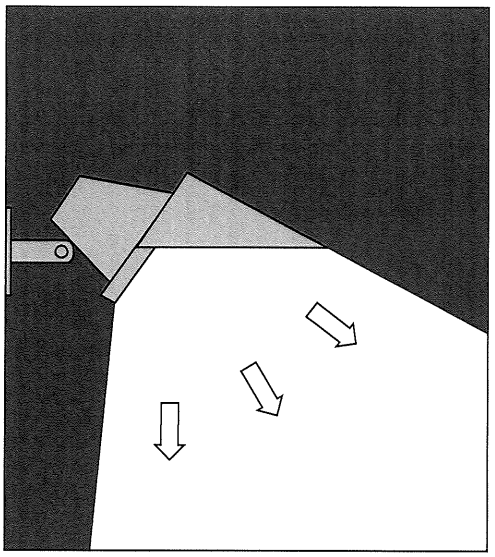
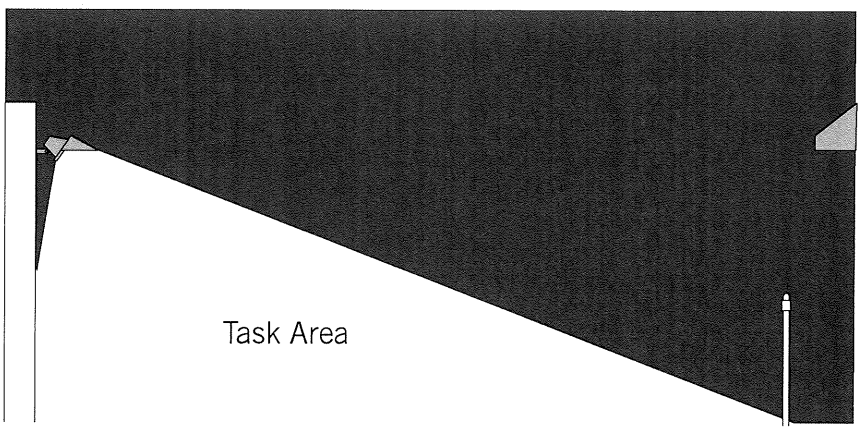


Figure 5. Task Area from Shielded Floodlight



	SS
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

9. Exemplary Performance

This credit is not eligible for exemplary performance under the Innovation in Design section.

10. Regional Variations

There are no regional variations associated with this credit.

11. Operations and Maintenance Considerations

Exterior luminaires must be periodically cleaned and relamped to maintain optimal light levels. Depending on the number of exterior luminaires, it may be beneficial to implement a schedule and policy for group relamping to help avoid lamp burnouts and to minimize the labor costs associated with spot relamping. Additionally, if group relamping is identified as an operational strategy during the design phase, the initial light levels can often be reduced while still maintaining the design illuminance. A rule of thumb to determine whether group relamping is likely to be economically feasible is if the labor cost to change a lamp exceeds the cost per lamp.

12. Resources

Please see USGBC's LEED Registered Project Tools (http://www.usgbc.org/projecttools) for additional resources and technical information.

Websites

American Society of Heating, Refrigeration, and Air-Conditioning Engineers
http://www.ashrae.org
ASHRAE advances the science of heating, ventilation, air conditioning, and refrigeration for the public's benefit through research, standards writing, continuing education, and publications. To purchase ASHRAE standards and guidelines, visit the bookstore on the ASHRAE website.

California Energy Commission (CEC)–2005, California Energy Efficiency Building Standards: Lighting Zones
http://www.energy.ca.gov/title24/2005standards/outdoor_lighting/2004-09-30_LIGHTING_ZONES.PDF
This site describes the outdoor lighting zones developed for use in the California Energy Efficiency Building Standards (Title 24), effective 2005.

Illuminating Engineering Society of North America
http://www.iesna.org
The mission of IESNA is to benefit society by promoting knowledge and disseminating information for the improvement of the lighted environment..

International Dark-Sky Association
http://www.darksky.org
This nonprofit agency is dedicated to educating about and providing solutions to light pollution.

Sky and Telescope
http://skytonight.com/resources/darksky
This site includes facts on light pollution and its impact on astronomy and information about purchasing light pollution-minimizing light fixtures.

Print Media

The IESNA Lighting Handbook, ninth edition, by Illuminating Engineering Society of North America (IESNA, 2000).

Lighting for Exterior Environments RP-33-99, by IESNA Outdoor Environment Lighting Committee (IESNA, 1999).

SS	
NC	Credit 8
SCHOOLS	Credit 8
CS	Credit 8

Concepts in Practice Lighting: Lighting Design in Architecture, by Torquil Barker (B.T. Batsford Ltd., 1997).

The Design of Lighting, by Peter Tregenza and David Loe (E & FN Spon, 1998).

ASNI/ASHRAE/IESNA Standard 90.1–2007 User's Manual, effective 2008.

13. Definitions

Curfew hours are locally determined times when lighting restrictions are imposed. When no local or regional restrictions are in place, 10:00 p.m. is regarded as a default curfew time.

A footcandle (fc) is a measure of light falling on a given surface. One footcandle is defined as the quantity of light falling on a 1-square-foot area from a 1 candela light source at a distance of 1 foot (which equals 1 lumen per square foot). Footcandles can be measured both horizontally and vertically by a footcandle meter or light meter.

A **full-cutoff luminaire** has zero candela intensity at an angle of 90 degrees above the vertical axis (nadir or straight down) and at all angles greater than 90 degrees from straight down. Additionally, the candela per 1,000 lamp lumens does not numerically exceed 100 (10%) at an angle of 80 degrees above nadir. This applies to all lateral angles around the luminaire.

Horizontal footcandles occur on a horizontal surface. They can be added together arithmetically when more than 1 source provides light to the same surface.

Light pollution is waste light from building sites that produces glare, is directed upward to the sky, or is directed off the site. Waste light does not increase nighttime safety, utility, or security and needlessly consumes energy.

Light trespass is obtrusive light that is unwanted because of quantitative, directional, or spectral attributes. Light trespass can cause annoyance, discomfort, distraction, or loss of visibility.

Safety and comfort light levels meet local code requirements and must be adequate to provide a safe path for egress without overlighting the area.

Shielding is a nontechnical term that describes devices or techniques that are used as part of a luminaire or lamp to limit glare, light trespass, or sky glow.

Sky glow is caused by stray light from unshielded light sources and light reflecting off surfaces that then enter the atmosphere and illuminate and reflect off dust, debris, and water vapor. Sky glow can substantially limit observation of the night sky, compromise astronomical research, and adversely affect nocturnal environments.

Vertical footcandles occur on a vertical surface. They can be added together arithmetically when more than 1 source provides light to the same surface.