

DARK SKY ASSESSMENT GUIDE

EVALUATION METHODS, TOOLS, & RESOURCES

WHAT IS LIGHT POLLUTION?

Light pollution is “the inappropriate or excessive use of artificial light,” and consists of four main factors¹:

1. **Glare:** Excessive brightness that causes visual discomfort
2. **Sky glow:** Brightening of the night sky over inhabited areas
3. **Light trespass:** Light falling where it is not intended or needed
4. **Clutter:** Bright, confusing and excessive groupings of light sources

Light pollution caused by the inappropriate or inefficient use of outdoor lighting is costly, and effects people, wildlife, and outdoor environments—most noticeably, it limits our view of the starry night sky.

HOW DO I USE THIS WORKSHEET & GUIDE?

The initial groundwork for a dark sky designation is establishing the current status. This worksheet guides users through several evaluation methods which could be used for a general assessment of dark sky-friendly lighting. While not all of the included methods are required for a quality assessment, it is recommended that those conducting the assessment use as many methods as appropriate to gain a broader perspective. In addition, the various methods may be adapted for public education and engagement on dark sky issues.

After completing your assessment, you will know the current state of lighting in your community or area and will have identified key areas for improvement.

For help with this guide, contact Utah's Community Development Office: (801) 468-0133, info@ruralplanning.org or the Colorado Plateau Dark Sky Cooperative: darkskycooperative@gmail.com

PREPARING FOR YOUR DARK SKY ASSESSMENT

1. Define your purpose

- Who requested the assessment? Who is sponsoring or supporting it?
- What is the goal of your assessment?
- How will you use information gathered during the assessment?
- Will it be the only assessment or will there be more?

2. Identify who should be involved

- List and invite key stakeholders (leaders, active citizens, business owners, etc).
- What do they need to know to support your project and engage in the assessment?
- Who might help you engage with necessary stakeholders and supporters?

3. Design and prepare for the assessment

- Prepare a map of town (can use Google maps, a hand drawn map, or existing city maps).
- Organize where the assessment will begin and end. It may help to divide into different areas, separating commercial districts, residential sectors, or government districts for the purposes of the assessment.
- Walk the route beforehand—are there safety concerns or other considerations that should be acknowledged before conducting an assessment?
- Select areas during the day to take illustrative photos—most SLR cameras can take a good night photo.
- You should try to carry out your assessment on a clear night, with little or no cloud cover. Don't do the assessment when the moon is in the sky.

4. Get the word out

- If not initiated or conducted by the town, notify the town when your assessment will be performed.
- Notify and remind stakeholders.
- Notify the public (fliers, posters, Facebook, etc.); assessments can be helpful and fun for community education (e.g. Our Town Nights, Community Night Connections, etc.).
- Gather maps and other assessment materials.

NOTES

REMEMBER TO TAKE...

- This guide
- Printed map of assessment area
- Pencils / pens / colored markers
- Clipboards
- Measuring tape
- DSLR camera & tripod
- Orange vests / visible clothing / reflective gear
- Comfortable walking shoes
- A friend—work in groups for safety



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GENERAL LIGHTING TERMS

CLUTTER: Bright, confusing and excessive groupings of light sources.

COLOR SPECTRUM: Refers to the portion of the electromagnetic spectrum that is visible to the human eye.

CORRELATED COLOR TEMPERATURE (CCT): Specifies the color appearance of light emitted by a lamp.

DARK SKY: Denoting or located in a place where the darkness of the night sky is relatively free of interference from artificial light.

DSLR CAMERA: “Digital single-lens reflex” or DSLR cameras are versatile cameras with changeable lenses that produce high-quality photos.

FIXTURE: The assembly that holds the lamp in the lighting system and includes elements such as a reflector (mirror) or refractor (lens), the ballast, housing, and the attachment parts.

FOOTCANDLE (fc): Illuminance produced on a surface that is everywhere one foot from a uniform point source of light of one candle and equal to one lumen per square foot.

FULLY SHIELDED: A fixture that allows no emission above a horizontal plane passing through the lowest light-emitting or light-reflecting part of the fixture.

GLARE: Excessive brightness that causes visual discomfort.

KELVIN: A measurement unit for light’s “warmness” or “coolness.”

KILOWATT (Kw): A measure equal to 1,000 watts of electrical power.

KILOWATT HOUR (kWh): A measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.

LAMP: A device for giving light which can consist of an electric bulb with its holder and shade or cover, or one burning liquid fuel and consisting of a wick or mantle and a glass shade.

LIGHT TRESPASS: Light falling where it is not intended or needed.

LUMEN: A measurement unit for the brightness from a light source.

LUMINAIRE: A complete lighting unit that usually includes the fixture, ballasts, and lamps.

LUX: One lumen per square meter. Unit of illuminance.

REFLECTION: Light redirected back into the sky off of surfaces that are being illuminated.

SKYGLOW: Brightening of the night sky over inhabited areas.

WATT: The standard unit of power in the International System of Units (SI).

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DARK SKY LIGHTING BASICS: THE “THREE-LEGGED STOOL”

We need lighting for safety at night. However, many city lights are undirected and waste energy while causing light pollution. Proper lighting begins with proper lighting design standards which form a proverbial “three-legged stool”. The legs of the stool are:

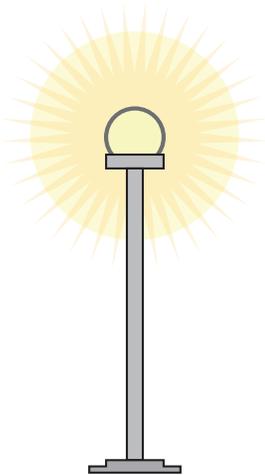
1. **Shielding**
2. **Appropriate lighting levels**
3. **Lighting color**

These three basic design principles form the basis for good lighting design, and when applied correctly, will reduce light pollution.

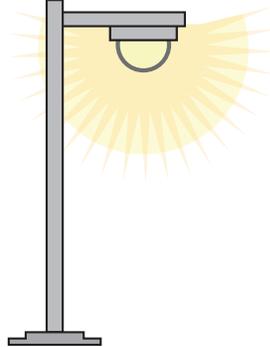


1. LIGHTING SHIELDING

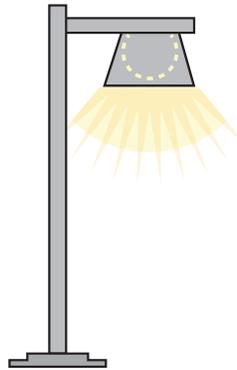
UNSHIELDED



PARTIALLY SHIELDED



FULLY SHIELDED



Outdoor lighting should be “fully shielded,” meaning no light above a 90-degree angle. The goal of fully shielded light fixtures is to prevent:

- **Light trespass** is light falling where it is not wanted or needed. Light trespass can create problems for neighboring and distant properties.
- **Glare** is intense and blinding light that can cause discomfort and temporary blindness.
- **Skyglow** reduces our ability to view celestial objects due to scattered light from sources on the ground.

The more light is directed towards the intended subject, the better. Fully shielded lighting can be purchased or retrofitted.

2. APPROPRIATE LIGHTING LEVELS

Outdoor lighting can easily become excessive or “cluttered.” Appropriate lighting levels means practically managing the amount of outdoor lighting in terms of duration and illuminated area. Ordinances that support appropriate lighting levels will specify the acceptable amount of lumens within an area (such as lumens per acre). Many municipalities use illumination guidelines established by the [Illuminating Engineering Society \(IES\)](#) to set lighting levels in their ordinances. In addition municipalities will remove lights no longer in use or needed. Note that International Dark Sky Association (IDA) standards are more strict than IES standards.

- **Lumens** are a measurement unit of the brightness from a light source.
- **Clutter** is excessive groupings of light sources that create a bright and confusing environment.
- **Reflection** off of what is being illuminated causes light to be redirected back into the sky, contributing to sky glow.

Timers, motion sensors, dimmer switches, and turning lights off when not in use can help improve lighting levels.

Generally, use lighting where it's needed, when it's needed, and only as bright as needed.

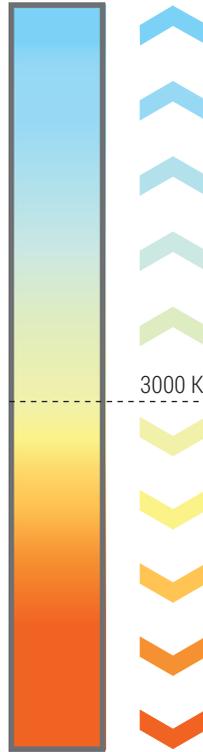
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3. LIGHTING COLOR

The color of the light is important as well. Cool, blue spectrum lights brighten the night sky more than amber colored light and researchers are beginning to connect blue light spectrum to negative health effects in people and greater problems for wildlife. IDA recommends using long-wavelength lighting with a color temperature of < 3000 Kelvin.

- **Kelvin** refers to a temperature scale used to measure light's warmth or coolness.
- **Color Spectrum** refers to the portion of the electromagnetic spectrum that is visible to the human eye.

WARM SPECTRUM **COOL SPECTRUM**



NOTES

ESSENTIAL TAKEAWAYS

- ❑ **LIGHT ONLY WHAT YOU NEED:** Use fully shielded fixtures. Shine lights down, not up. Direct lighting at desired areas. Be strategic with lighting and only use it where needed.
- ❑ **LIGHT ONLY WHEN YOU NEED:** Install timers, motion sensors, and dimmer switches, and turn off lights when not in use.
- ❑ **LIGHT ONLY HOW MUCH YOU NEED:** Use the right amount of light. Save electricity by using the lowest adequate wattage bulbs. Too much light is wasteful, impairs vision, and can be costly.
- ❑ **LIGHT ONLY HOW YOU NEED:** Use long-wavelength lights with a red or yellow tint to minimize negative health effects. Use warmer colored bulbs, like yellow or amber instead of white. Avoid bluish light, which is known to have a variety of negative effects.

ADAPTED FROM THE INTERNATIONAL DARK-SKY ASSOCIATION, DARKSKY.ORG

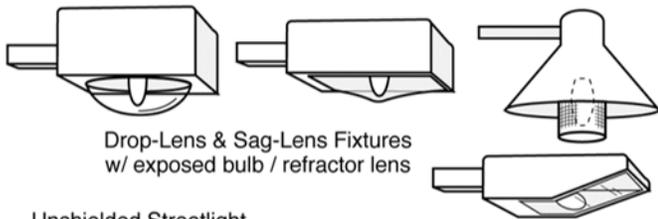
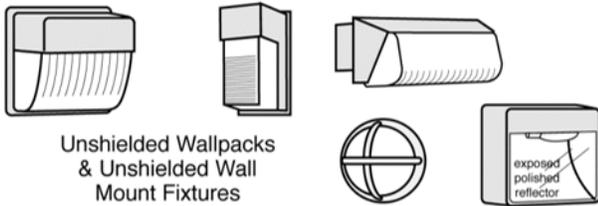
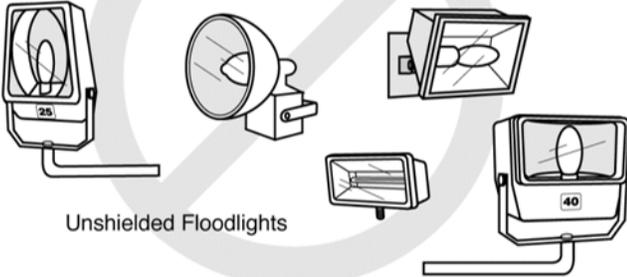
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ACCEPTABLE LIGHTING TYPES

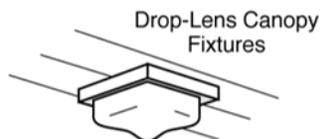
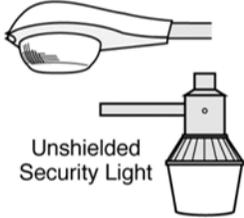
The images below illustrate various acceptable lighting forms. For more informations, visit <http://www.darksky.org/fsa/fsa-products/>.

Unacceptable / Discouraged

Fixtures that produce glare and light trespass

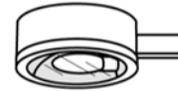
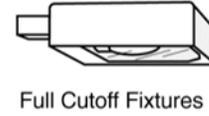
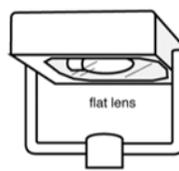


Unshielded Streetlight

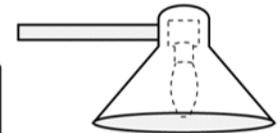
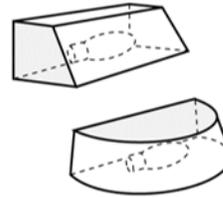
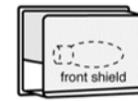
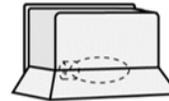


Acceptable

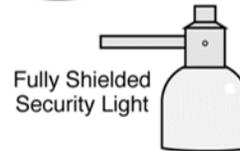
Fixtures that shield the light source to minimize glare and light trespass and to facilitate better vision at night



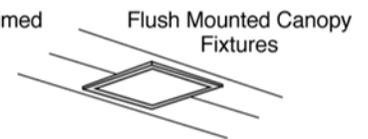
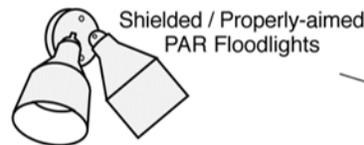
Fully Shielded Wallpack & Wall Mount Fixtures



Fully Shielded Fixtures



Fully Shielded 'Period' Style Fixtures
bulb shielded in opaque top



ILLUSTRATIONS BY BOB CRELIN©. RENDERED FOR THE TOWN OF SOUTHAMPTON, NY. COURTESY OF INTERNATIONAL DARK-SKY ASSOCIATION.

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CONDUCTING A FORMAL LIGHTING AUDIT

The IDA requires formally designated Dark Sky Communities (DSC) to adopt a quality and comprehensive lighting code which includes a commitment to a brightness measurement program. The brightness measurement program can be maintained either by the community or by another public or private organization. The measurement program is meant to monitor success in reducing light pollution. A formal lighting audit should be performed to establish a baseline for monitoring success.

A formal audit may require outside help from organizations such as a university, research center, IDA chapter, astronomy club, or other qualified entities since determining the electrical, physical, and operational characteristics of lighting can be difficult or technical. The process for lighting audits vary depending on the organization; however, the Federal Department of Energy (DOE) recommends several basic guidelines.

BASIC LIGHTING AUDIT GUIDELINES

THE FOLLOWING ITEMS ARE RECOMMENDED FOR CONSIDERATION:

- The age, condition, quality, and location of existing light fixtures.
- Model and manufacturer of lighting system to obtain existing photometrics (perceived brightness).
- Lamp wattage and ballast type (if appropriate).
- Take note of the environment, is there the possibility of particulate, moisture, or dirt buildup in or around the lighting fixture?
- Take note of what kinds of activities, or uses are being performed in the space. Are there are special visual requirements?
- Observe how the lighting system is controlled and how often it is used.
- Note the perceived color of the lighting, e.g. blue, white, or amber light.
- Measure the physical layout of the existing lighting system and take note of height and spacing.
- If possible, use an illuminance meter to measure light intensity. Readings should be taken on the ground and at even intervals to create a "grid" of measurements.

ADAPTED FROM THE FEDERAL DEPARTMENT OF ENERGY EXTERIOR LIGHTING AUDIT GUIDELINES

A lighting audit provides benchmarks for determining the effectiveness of lighting improvements and energy savings.

USEFUL MEASUREMENT EQUIPMENT



ON HAND

- TAPE MEASURE
- DSLR CAMERA
(see pg. 15)
- SMART PHONE
(see pg. 13)

OPTIONAL EQUIPMENT

- LIGHT METER
- COLOR TEMPERATURE METER
- SKY QUALITY METER
- LASER DISTANCE METER

EQUIPMENT RENTAL

The Colorado Plateau Dark Sky Cooperative has some equipment available to rent for free! Contact darkskycooperative@gmail.com for more information.

Available:

- Sky Quality Meter (SQM) - 1 available
- Laser Distance Meter - 2 available

OPTIONAL EQUIPMENT?

- **Light Meter** an instrument used to measure the intensity of light.
- **Color Temperature Meter** a device used to measure color temperature in degrees Kelvin.
- **Sky Quality Meter (SQM-L with lens)** an instrument used to measure the luminance of the night sky.
- **Laster Distance Meter** a portable device designed to measure distance from the device to a remote target.

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LIGHTING INVENTORY TEMPLATE: DOWNLOAD AN EXAMPLE SPREADSHEET [HERE](#)

There are different ways to log lighting inventory information. One simple way is to record the information on a spreadsheet. The following example spreadsheet was adapted from the [Anza-Borrego Desert State Park IDA Nomination](#) with supplemental information from *John Barentine, International Dark Sky Association Director of Conservation*. Accompanying the template are descriptions of the content found in the columns of the sample Lighting Inventory worksheet below. The template can be adapted by parks, communities, and other entities performing a lighting inventory. **Some data points can be captured during the day while other data points will require a nighttime visit.**

A detailed description of each item and examples of fixture and lamp types follows.

EXAMPLE LIGHTING INVENTORY TEMPLATE #1

| ID | FUNCTION | | | FIXTURE/ LAMP | | | | | | | | | | PHOTOS | |
|----|--|-------------------|----------------|---------------|--------------------|-------------------|--|-----------|----------------|------------|-----------------------------|--|--------------------|---|---|
| | FIXTURE ID | LOCATION | FUNCTION | HAZARDS | NUMBER OF FIXTURES | LAMPS PER FIXTURE | FIXTURE TYPE | LAMP TYPE | COLOR TEMP (K) | LUMENS | SHIELDING STATE | OPERABLE? | ADAPTIVE CONTROLS? | LIGHT MANAGEMENT PLAN (LMP) COMPLIANT? | CLOSEUP |
| 1 | Restroom building at parking lot in Visitor Center | Building egress | None | 8 | 1 | Can | Par 16 Amber Lamp, 3W | 1800 | 120 | Fully | Yes | None | Yes |  |  |
| 2 | Path near Visitor Center | Wayfinding | Uneven Surface | 22 | 1 | Post | 8 5W Amber A-lamp, 4 yellow LED or CFL "bug lites" | <2700 | 200 | Partially | Yes | None | 8 Yes / 14 No |  |  |
| 3 | Admin Building | Building approach | Steps | 1 | 2 | Spot | 8W Par30 Amber LED | 1800 | 320 | Eave | Yes, only one socket in use | Motion sensor, 4 min duration/ 15 sec. delay/ Programed 10%-60%10% | Yes |  |  |
| 4 | Lab Building | Building egress | None | 1 | 1 | Jelly Jar | 3W Par 16 Amber LED | 1800 | 320 | Unshielded | No | None | No |  |  |
| 5 | Staff Housing | Building egress | Step | 1 | 1 | Wallpack | 7W Amber LED | 1800 | 280 | Fully | Yes | None | Yes |  |  |
| 6 | | | | | | | | | | | | | | | |
| 7 | | | | | | | | | | | | | | | |
| 8 | | | | | | | | | | | | | | | |
| 9 | | | | | | | | | | | | | | | |

TEMPLATE ADAPTED FROM THE ANZA-BORREGO DESERT STATE PARK IDA NOMINATION & JOHN BARENTINE

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TEMPLATE OVERVIEW

FIXTURE ID: Any unique identifier for the fixture or group of fixtures. This usually takes the form of some running number (e.g., 1, 2, 3, ...) but could include letters or other location-specific information. For example, a set of fixtures at a visitor center could be identified as VC1, VC2, ..., etc. Ideally the Fixture ID is sufficiently specific to identify individual fixtures among a group.

LOCATION: A short description of where the lighting is located; e.g., "Campground restrooms", "Staff housing", "Administration building". If no location is otherwise available, give GPS coordinates (latitude/longitude).

FUNCTION:

The nominal purpose of the lighting, whether or not such lighting is warranted according to the park's LMP. "Function" should indicate why the lighting exists at the location. If the function is not evident, enter "Unknown".

FUNCTION EXAMPLES:

- Area (illuminates a large area of ground)
- Decorative (serves no safety or task performance purpose, but is installed for aesthetic reasons)
- Egress (as from a structure)
- Other
- Pathway (to prevent tripping or to point out a drop-off)
- Parking
- Roadway
- Safety (to point out specific safety hazards)
- Security (intended to discourage or prevent the incidence of property or violent crime; note that this is NOT a valid reason for lighting in an International Dark Sky Park/Reserve/Sanctuary)
- Sign
- Wayfinding (safe transit between points, marking, e.g., the edges of a trail)

HAZARDS:

What safety hazard is the lighting intended to mitigate? If no hazards are evident, enter "None". If hazards cannot be determined, enter "Unknown".

HAZARD EXAMPLES:

- Curb
- Pathway
- Stairs (indicating multiple steps)
- Step (indicating a single step)
- Uneven surface
- Water
- Other

CURB



STAIRS



NUMBER OF FIXTURES: If more than one identical fixture is present at a discrete location, group these together. For example, a restroom building might have several identical fixtures on its various sides.

LAMPS PER FIXTURE: The number of discrete lamps per individual fixture, regardless of the number of fixtures at a site. The total number of lamps at a site = number of fixtures × lamps per fixture.

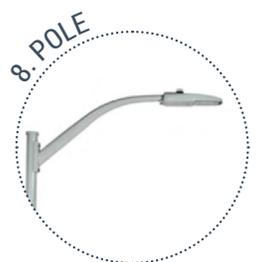
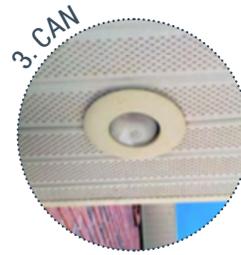
FIXTURE TYPE: The variety of fixture, usually relating to its function. If the fixture type is not evident, enter "Unknown".

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FIXTURE EXAMPLES:

1. Barn
2. Bollard
3. Can
4. Ceiling
5. Emergency
6. Flood
7. Phone Booth
8. Pole
9. Spot
10. String
11. Vending Machine
12. Wallpack
13. Wall Sconce

FIXTURE TYPE EXAMPLE IMAGES

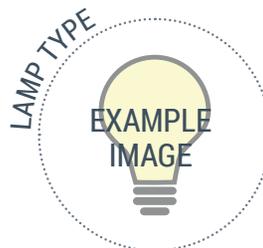


LAMP TYPE EXAMPLE IMAGES

LAMP TYPE: If no lamp is present, enter "Empty Socket". If the lamp type cannot be determined, enter "Unknown".

LAMP TYPE EXAMPLES:

1. Compact Fluorescent ("CFL")
2. Incandescent
3. Halogen
4. Neon (or other gas-filled tube)
5. High-pressure Sodium ("HPS")



SPECTRUM (COLOR)

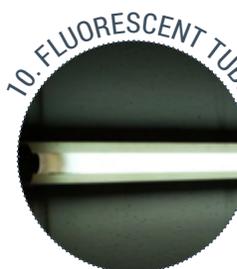


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MORE LAMP TYPE EXAMPLE IMAGES

MORE LAMP TYPE EXAMPLES:

6. Low-pressure Sodium ("LPS")
7. Mercury Vapor
8. Metal Halide ("MH")
9. LED (specify "amber", "white" or other color)
10. Fluorescent Tube



SHIELDING STATE:

To what extent is the fixture shielded? Response should be one of the following states.

SHIELDING STATES:

- Fully (shielded in such a way that no light can be seen above a horizontal plane passing through the lowest light-emitting part of the fixture with respect to the illuminated surface)
- Partially (some shielding, usually of the fixture top, but not meeting the definition of 'fully shielded')
- Unshielded (shielding is not a part of the design, with light emitted or diffused from all surfaces other than the mounting point)
- Other (some other arrangement not captured by 'fully shielded', 'partially shielded', or 'unshielded')
- Unknown (unable to determine in the field)

OPERABLE?: Can the fixture be operated according to the manufacturer's instructions? Response should be "Operable", "Inoperable", or "Unknown". Lights are typically inoperable because they are fully disconnected from a power supply, and are thus considered LMP-compliant by nature. Note that a light with a broken switch or missing lamp is not considered "inoperable".

ADAPTIVE CONTROLS

ADAPTIVE CONTROLS:

Any electronic or mechanical device attached to a light intended to dynamically control the duration, intensity, spectrum, or area illuminated by the lighting.

ADAPTIVE CONTROL EXAMPLES:

- Automatic switch
- Motion sensor
- Timer

| ADAPTIVE CONTROL INFORMATION | | | | PHOTOS | |
|------------------------------|--|----------------|------------|---------------------------------|---------------------------------------|
| LIGHT SOURCE | ADAPTIVE CONTROLS | COLOR TEMP (K) | | BEFORE ADAPTIVE CONTROLS (2016) | AFTER ADAPTIVE CONTROLS (2017 - 2018) |
| LED | Programmed 10%-60%-10% Motion detection 15 sec. delay | 3000 K | 1600 (60%) | | |

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LMP COMPLIANT?:

Does the light meet all of the requirements of the park's Lighting Management Plan (if applicable)?

CLOSEUP PHOTO: An image of the light in place, taken sufficiently close to reveal some details about it.

CONTEXT PHOTO:

An image of the light in place, taken from further away to illustrate the function or other contextual information about it.

PHOTO EXAMPLES

CLOSEUP



CONTEXT



NOTES

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EXAMPLE LIGHTING INVENTORY TEMPLATE #2 [DOWNLOAD A BLANK WORKSHEET HERE](#)

Below is another example of how to record and organize your lighting audit data. Specific technology or technical assistance may be required to capture each data point. No matter what method or structure you use, be consistent and well organized.

| DAYTIME VISIT | | NIGHTTIME VISIT | |
|--|---|--|--|
| Visit Date: | Fixture Power: | Visit Date: | |
| Fixture Height (ft): | <input type="checkbox"/> Solar | Fixture Height (ft): | |
| Fixture Lighting Purpose: | <input type="checkbox"/> Utility | Correlated Color Temperature CCT: | |
| <input type="checkbox"/> Area | <input type="checkbox"/> Other | Illuminance: | |
| <input type="checkbox"/> Entrance/Egress | Fixture Adaptive Controls: | Footcandle: | |
| <input type="checkbox"/> Pathway | <input type="checkbox"/> Motion Sensor | | |
| <input type="checkbox"/> Parking | <input type="checkbox"/> None | | |
| <input type="checkbox"/> Roadway | <input type="checkbox"/> Photocell | | |
| <input type="checkbox"/> Sign | <input type="checkbox"/> Switch | | |
| <input type="checkbox"/> Stairway | <input type="checkbox"/> Timer Switch | | |
| <input type="checkbox"/> Other | <input type="checkbox"/> Other | | |
| Fixture Type: | Lamp Type: | MITIGATION | |
| <input type="checkbox"/> Barn | <input type="checkbox"/> CFL | Mitigation Required | |
| <input type="checkbox"/> Bollard | <input type="checkbox"/> Empty Socket | <input type="checkbox"/> Yes | |
| <input type="checkbox"/> Ceiling Mount | <input type="checkbox"/> Fluorescent Tube | <input type="checkbox"/> No | |
| <input type="checkbox"/> Dark Cowbell | <input type="checkbox"/> Halogen | Mitigation Date: | |
| <input type="checkbox"/> Flood | <input type="checkbox"/> HPS | | |
| <input type="checkbox"/> Hanging Light | <input type="checkbox"/> Incandescent | | |
| <input type="checkbox"/> Lamp Post | <input type="checkbox"/> Induction | | |
| <input type="checkbox"/> Phone Booth | <input type="checkbox"/> LED | | |
| <input type="checkbox"/> Recessed | <input type="checkbox"/> LPS | | |
| <input type="checkbox"/> Spotlight | <input type="checkbox"/> Mercury Vapor | | |
| <input type="checkbox"/> Tin Hat | <input type="checkbox"/> Metal Halide | | |
| <input type="checkbox"/> Tube | <input type="checkbox"/> Other | | |
| <input type="checkbox"/> Vending Machine | | | |
| <input type="checkbox"/> Wall Pack | Shielding: | | |
| <input type="checkbox"/> Wall Sconce | <input type="checkbox"/> Fully Shielded Eye | | |
| <input type="checkbox"/> Other | <input type="checkbox"/> Fully Shielded Fixture | | |
| Number of Fixtures | <input type="checkbox"/> Fully Shielded Lamp Lens | | |
| Lamps per Fixture: | <input type="checkbox"/> Partially Shielded Eye | | |
| Historic Fixture? | <input type="checkbox"/> Partially Shielded Fixture | | |
| <input type="checkbox"/> Yes | <input type="checkbox"/> Partially Shielded Lamp Lens | | |
| <input type="checkbox"/> No | <input type="checkbox"/> Unshielded | | |
| | | ADDITIONAL NOTES | |
| | | | |

ADAPTED FROM BRYAN BOULANGER, OHIO NORTHERN UNIVERSITY CONTACT: B-BOULANGER@ONU.EDU

DARK SKY ASSESSMENT GUIDE

ESTABLISH A SKY BRIGHTNESS MEASUREMENT PROGRAM

THINKING LONG TERM

A lighting inventory provides the foundational knowledge needed to improve lighting used at night. Before improvements are made, a **sky brightness measurement program*** should be established and maintained in order to monitor the evolution of light pollution in a community over time. **Note that evidence of a sky brightness monitoring program is a requirement for International Dark Sky Place Designation.*

WHAT ARE YOU MONITORING?

You are monitoring sky brightness (or quality) over time.

HOW IS SKY QUALITY MEASURED?

There are a variety of ways to conduct a sky quality survey including:

1. A Sky Quality Meter (SQM-L) Survey
2. Bortle Scale Interpretation
3. Photographic Evidence

Below is a brief description of how to conduct a sky quality survey using a Sky Quality Meter. For more information and descriptions of other methods visit: <http://darksky.org/our-work/conservation/idsp/become-a-dark-sky-place/sky-quality-survey/>

NEW TERMS

- **Zenith** the point in the sky directly above an observer.
- **Astronomical Darkness** When the sun is at least 18° below the local horizon. You can easily find times for sunset, sunrise, twilight, moon rise/set, etc. on sites like [Time And Date](#).

ADAPTED FROM THE INTERNATIONAL DARK SKY ASSOCIATION: HOW DO CONDUCT A SKY QUALITY SURVEY

TAKING A SKY QUALITY SURVEY

The Unihedron Sky Quality Meter (SQM-L version with "lens") is a small battery powered device that is used to take scientific-quality measurements of sky brightness.

To use a Sky Quality Meter simply hold the device directly above your head so that the photometer is pointed toward the sky (*at zenith*) and click the start button. The screen will then display the sky brightness at the point you are standing. The higher the number, the darker the sky is.

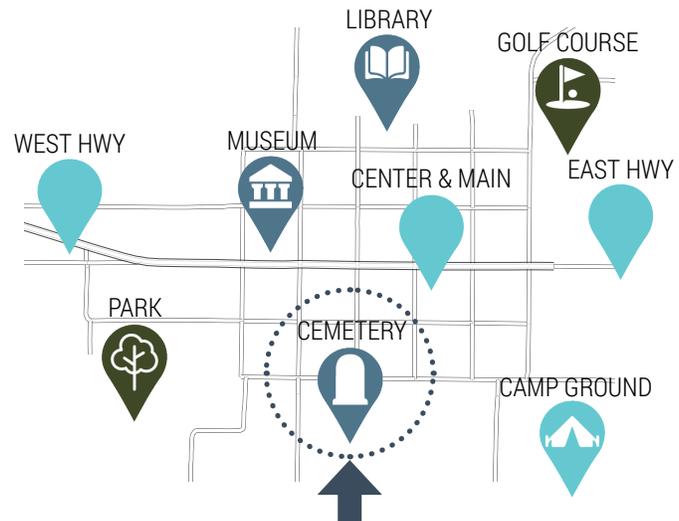
Take 5-6 measurements per location per visit, discarding the first measurement (the first measurement will not be accurate). Choose several locations throughout your community that will represent the darkest and the brightest areas in order to achieve a comprehensive survey of the location.

We recommend collecting data over several nights spaced out by a week or two. This dilutes the effects of fog, dust, and other atmospheric conditions that can reduce accuracy.

Remember that you will need to return to these locations in the future as you continue to monitor sky quality over time.



PHOTOMETER
START BUTTON



LOCATION EXAMPLE MAP

BEST PRACTICES

- Never take a measurement directly underneath a light source or anything that might block the clear sky.
- Always take measurements under a clear, open, cloudless sky,
- Always take measurements when the moon is below the horizon or when the moon is new.
- Always take measurements under conditions of "astronomical darkness" meaning the sun is at least 18° below the local horizon.
- The success of your sky brightness measurement program will depend on staying organized and consistent with your data.
- Share your data with the Globe at Night citizen science project at globeatnight.org

DATA TO CAPTURE (WITH EXAMPLES)

- Location:** Cemetery
- Latitude:** 39.686
- Longitude:** 110.846
- Altitude:** 1,814m
- Time:** 9:15pm
- Date:** 5/20/19
- SQM measurements taken at zenith:**
 1. 21.02 (record the first number but remember that it should be discarded later for accuracy)
 2. 20.95
 3. 20.95
 4. 20.96
 5. 20.95
 6. 20.97

CEMETERY
AVERAGE SQM RATING = 20.96

DARK SKY ASSESSMENT GUIDE



DIFFERENT ASSESSMENT TOOLS

There are a variety of ways to collect information for your dark sky assessment. The following pages describe different methods for collecting, documenting, and organizing information. While the DOE and IDA offers basic guidelines, each community is unique, and the methods used and data collected will depend on individual goals, capacity, and access to technology. Dark Sky Community status won't be the goal for every community, but a formal audit will provide a baseline for limiting light pollution.

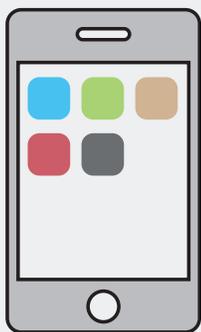
USE TECHNOLOGY

A wide variety of Iphone and Android apps can be used to take night sky brightness measurements. Other applications, such as [COLLECTOR FOR ARCGIS](#) can capture a comprehensive set of geographic data points.

For more precise measurements, the IDA recommends using a [SKY QUALITY METER](#) with lens (SQM-L) see *page 13*. Choose apps and resources that make sense for you and your community or contact a dark sky expert for help. Below is a list of basic apps to get you

NOTES

MOBILE APPS AND RESOURCES



DATA COLLECTION

[COLLECTOR FOR ARCGIS](#)

Collector can capture geolocated measurements for:

- Shielding
- Fixture height
- Lamp type
- Color temperature
- Lumens (Lux)
- Footcandles (fc)

SKYGLOW

[SKY QUALITY METER](#)

[DARK SKY METER APP \(IOS\)](#)

[CITIES AT NIGHT PROJECT](#)

[GLOBE AT NIGHT PROJECT](#)

[MY SKY AT NIGHT PROJECT](#)

[LOSS OF THE NIGHT APP](#)

WHO CAN I CONTACT IF I HAVE QUESTIONS?

The International Dark Sky Association (IDA)

(520) 293-3198

<http://www.darksky.org>

The Colorado Plateau Dark Sky Cooperative

(435) 213-7026

<https://cpdarks skies.org/>

darkskycooperative@gmail.com

The Consortium for Dark Sky Studies

<http://www.darkskestudies.org/>

daniel.l.mendoza@gmail.com

valspal13@gmail.com

National Park Service Natural Sounds & Nights Skies Division

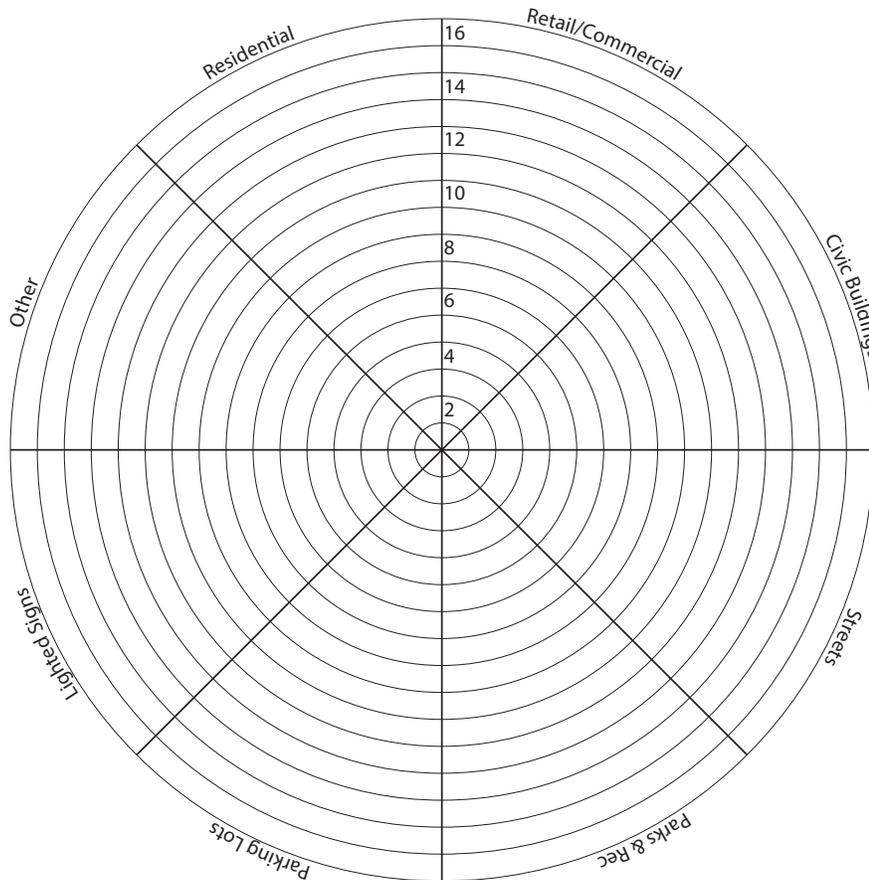
<https://www.nps.gov/orgs/1050/index.htm>

randy.stanley@nps.gov

DARK SKY ASSESSMENT GUIDE

LIGHTING ISSUE CONCERNS & LAND USE

Another tool for documenting light pollution sources is to mark the number of issues (e.g. poor shielding, blue/white lighting color, excessive lighting) observed in relation to land use. This can help identify focus areas and large-scale opportunities. Color in the number of issues related to the “three-legged stool” observed in the radial table below. Optional “issue-related” color coding is suggested below. The goal is to be able to compare the size of the “pie slices” after the assessment.



OPTIONAL “ISSUE” COLOR CODING

- Shielding
- Lighting Color
- Inappropriate/ Excessive Lighting

RESIDENTIAL

All types, single-family, apartments, etc.

RETAIL

Stores, shops, businesses, restaurants, etc.

CIVIC BUILDINGS

Government, post office, schools

STREETS

Street lighting

PARKS & REC

Sports parks, baseball fields, tennis courts, etc.

PARKING LOTS

Lighted parking lots

LIGHTED SIGNS

Business signs, advertising signs, etc.

OTHER

Any other uses, industrial, etc.

PUBLIC ENGAGEMENT & EDUCATION

Community engagement is an essential part of any kind of community-wide initiative. The support of local leaders, residents, and business owners can be gained from talking to people on an individual level and addressing their concerns. Make an effort to talk to neighbors and friends about light pollution and educate them on the benefits of improved lighting.

2 MINUTE SURVEYS...

Ask residents and business owners about their experience with light pollution. As you survey people educate them about basic light pollution concepts and issues. Why should they care?

QUICK QUESTIONS

Is preserving dark skies important to you?

Would you support simple changes to limit light pollution?

What concerns do you have?

EDUCATE

Briefly explain why light pollution is an issue.

Describe why preserving the night sky is important to you.

Discuss the “three-legged stool” and simple ways to mitigate light pollution.

DARK SKY ASSESSMENT GUIDE

MARKING A MAP

Marking lighting issues on a map can help identify and document spatial clusters and provide a reference for others.

An official zoning map, Google map, or other reference map of your community can be used to document sources of light pollution as well as examples of “dark-sky friendly” lighting.

Some areas may require a map that is “zoomed in on an area” such as on main street or a sports park. Your assessment may include just publicly owned lighting or all lighting including commercial, residential, and open space. The scale and amount of detail are up to the community.

Marked lighting issues should relate to the “three-legged stool” but should also be tailored to your community’s specific dark sky assessment goals.

IDEAS FOR WHAT TO MARK



Unshielded lighting



Glare/ intense brightness



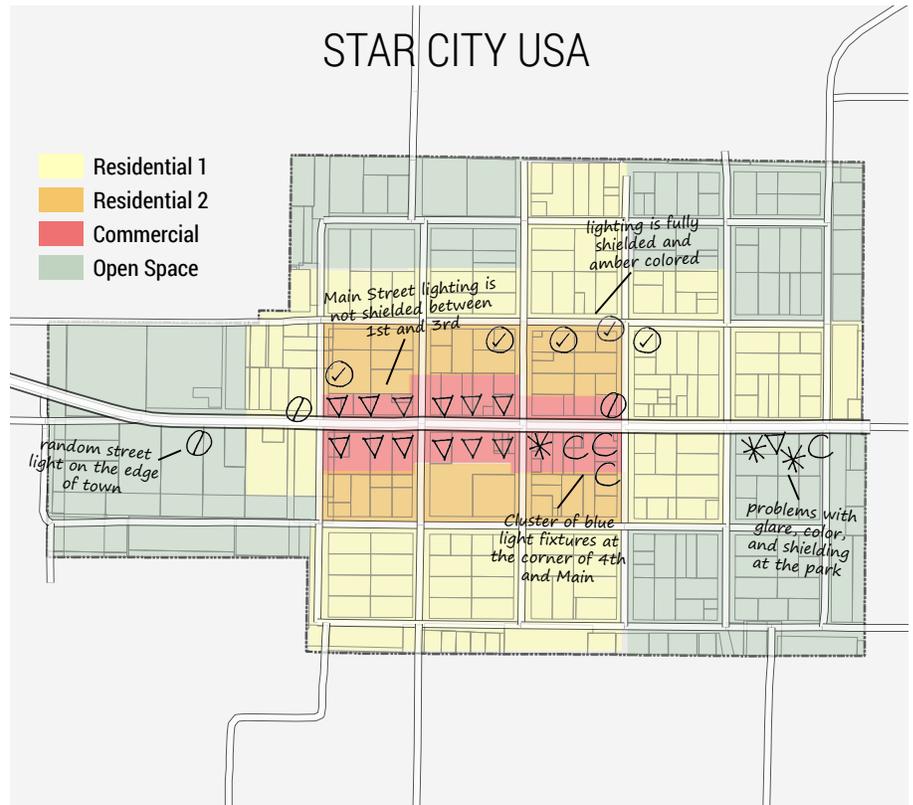
Unnecessary lighting



Blue/ White Colored Light



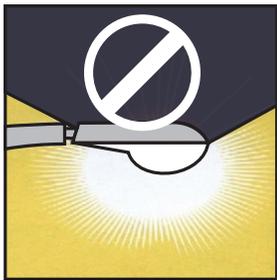
Good lighting



TAKING NIGHT PHOTOS

Documenting light pollution is an important way for educating the public on the actual situation and to support a case for improved lighting.

UNSHIELDED



SHIELDED



NIGHT PHOTO GUIDELINES

The following are helpful guides on settings for taking certain types of photos at night. Remember, always use a tripod. These settings should be adjustable on the manual mode for any DSLR camera.

- **DSLR** stands for “digital single-lens reflex.” DSLR cameras are versatile cameras with changeable lenses that produce high-quality photos.

| | SHUTTER | APERTURE | ISO | FLASH |
|---------------|---------|----------|------|-------|
| SIGNS | 1/50 | F/2.8 | 100 | N |
| CITY SCAPE | 1/320 | F/4.5 | 100 | N |
| BRIDGES | 15/1 | F/5.6 | 100 | N |
| STREET | 1/5 | F/4 | 320 | Y |
| MONUMENTS | 15 | F/16 | 250 | Y |
| LIFE | 6 | F/9 | 100 | Y |
| THE MILKY WAY | 20+ | F/2.8 | 1600 | N |

IMAGES FROM IDA INTRO TO LIGHTING POWERPOINT

DARK SKY ASSESSMENT GUIDE

CALCULATE THE SAVINGS

Many communities are now realizing the benefits of controlling energy waste through better-quality and better-designed lighting. Calculating potential energy savings and payback for upgrade conversions is another way to understand how adopting dark sky policies and best practices can benefit your community. Use the following formula from the Federal Department of Energy's Exterior Lighting Guidelines to calculate an estimation of lighting power and energy use. Compare your current lighting energy costs with estimated energy costs of an upgrade conversion. Calculating an energy use estimation for prospective lighting replacements is an effective way to illustrate cost savings.

LIGHTING POWER & ENERGY USE ESTIMATION

1. COMPUTE THE TOTAL POWER (kW) USED BY THE EXISTING SYSTEM

| EXISTING LAMP OR LUMINAIRE WATTAGE | | NUMBER OF LAMPS | | TOTAL POWER CONSUMED |
|------------------------------------|---|-----------------|-------|--------------------------------|
| _____ | W | x | _____ | lamps = <input type="text"/> W |

2. COMPUTE THE TOTAL ENERGY (kWh) CONSUMED ANNUALLY BY THE EXISTING SYSTEM.

| TOTAL POWER CONSUMED BY SYSTEM LUMINAIRE | | HOURS OF USE PER DAY | | DAYS OF USE PER WEEK | | WEEKS OF USE PER YEAR | | TOTAL ENERGY CONSUMED | | |
|--|---|----------------------|-------|----------------------|---|-----------------------|---------|-----------------------|-------|------------------------------------|
| _____ | W | x | _____ | hrs/day | x | _____ | days/wk | x | _____ | wks/yr = <input type="text"/> kWh/ |

3. COMPUTE THE TOTAL ENERGY COST (DOLLARS) ANNUALLY FOR OPERATION OF THE EXISTING SYSTEM.

| TOTAL ENERGY CONSUMED | | ENERGY RATE | | TOTAL COST |
|-----------------------|--------|-------------|--------|------------------------------|
| _____ | kWh/yr | _____ | \$/kWh | = <input type="text"/> \$/yr |

BACK TO THE BASICS

- **W (watt)** the standard unit of power in the International System of Units (SI)
- **Wh (watt hour)** a unit of energy equal to the power of 1 watt operating for 1 hour
- **kW (kilowatt)** a measure of 1,000 watts of electrical power.
- **kWh (kilowatt hour)** a measure of electrical energy equivalent to a power consumption of 1,000 watts for 1 hour.
- **Luminaire** a complete lighting unit that usually includes the fixture, ballasts, and lamps.

IN A NUTSHELL...

$$\text{ENERGY} = \text{POWER} \times \text{TIME}$$

DARK SKY ASSESSMENT GUIDE

SWOT ANALYSIS

A SWOT analysis is a strategic planning and brainstorming tool that encourages participants to assess and reflect on the **Strengths**, **Weaknesses**, **Opportunities**, and **Threats** of a place, situation, or goal. Use a SWOT analysis to assess the strengths, weaknesses, opportunities, and threats that are relative to your community's goal to preserve and protect dark skies (see example content below).

SWOT ANALYSIS SUBJECT: Star City USA - becoming a dark sky destination

| | |
|--|--|
| STRENGTHS <ul style="list-style-type: none">- Shared values among community members- Tourist destination- Friendly- Small town values- Low population- Historical assets- Close to outdoor recreation | WEAKNESSES <ul style="list-style-type: none">- Lack of cultural resources- Limited funding- Perception town is anti-business- Lack of destination facility- Vacant store fronts- Lack of rental housing- Codes are too flexible |
| OPPORTUNITIES <ul style="list-style-type: none">- Public education- Retrofittable lighting- Room to grow- Explore astro-tourism- Attract new businesses and families | THREATS <ul style="list-style-type: none">- Light pollution from nearby city- Attitudes towards change- Afraid to try new things- Youth leaving- High employee turnover |

DARK SKY ASSESSMENT GUIDE



NOW WHAT? AFTER YOUR DARK SKY ASSESSMENT

What you do after your dark sky assessment is almost as important as the assessment itself. Depending on your specific goals, the following steps can lead to an organized and effective action plan.

1. Debrief after the assessment

- Hold a post-assessment meeting with all assessors.
- Compile information, recording comments and clarifying notes.
- Brainstorm and record suggestions for changes and improvements. Develop ideas for projects that take advantage of opportunities, improve strengths, strengthen weaknesses, or mitigate threats.
- Invite participants to be involved in your project and identify how they will be committed.
- Thank everyone for their participation and outline next steps.

2. Form a local Dark Skies Group

(adapted from Advice on Starting a Local Dark Skies Group, Ed Stewart, Dark Skies, Inc., of the Wet Mountain Valley)

- Educate yourself on the various aspects of light pollution.
- Develop a core working group to support the initiative.
- Build awareness and education through local media and social media.
- Personally contact business owners and managers on the benefits of proper outdoor lighting.
- Provide a vendors list of dark sky friendly fixtures to contractors, hardware stores, and home improvement businesses.
- Contact the local power company for potential incentives or discounts on amber LED fixtures.
- Individually approach town leadership to get a feel for local support.
- Take the long-range approach. This may be seen as a “tree hugger” issue, but is about protecting the rural environment and quality of life.
- Stay positive and focus on benefits and advantages: reduced power consumption, cost savings, improved quality of life, and improved potential tourism.

3. Pursue International Dark Sky Places certification

- Provide the compiled report to local leadership, with suggested actions.
- Gauge the level of willingness of local leadership to take action.
- Outline the current project prioritization for leaders and ask leaders for input.
- Examine the potential to become a dark-sky certified community at <http://www.darksky.org/idsp/become-a-dark-sky-place/>.
- Fill out the application at <http://www.darksky.org/idsp/become-a-dark-sky-place/dark-sky-community-inquiry/>.

4. Plan action

- Create an implementation plan based on prioritized projects or actions.
- Identify potential funding sources as needed, required partners, and any needed changes to town code.
- Plan completion of small simple tasks first to build momentum for larger projects.
- Build critical mass—get the word out! Notify and continually engage and invite stakeholders, land owners, business owners and general public.

NOTES

IDA DARK SKY COMMUNITY

An IDA Dark Sky Community (DSC) is a town, city, or municipality that has shown exceptional dedication to the preservation of the night sky through the implementation and enforcement of quality lighting codes, dark sky education, and citizen support of dark skies.

Communities apply to the IDA who will make a decision in an average of one-to-two years from the initial request.

Requirements that must be maintained:

- Quality comprehensive lighting code
- Community commitment to dark skies
- Broad support from community organizations
- Community commitment to education on dark skies
- Success in light pollution control
- A continuing sky brightness measurement program

For full instructions and information:

<http://www.darksky.org/idsp/become-a-dark-sky-place/>

DARK SKY ASSESSMENT GUIDE

ADDITIONAL RESOURCES

GENERAL

International Dark Sky Association: <http://www.darksky.org>

Colorado Plateau Dark Sky Cooperative: <https://cpdarkskies.org>

The Consortium for Dark Sky Studies: <http://darkskystudies.org>

Dark Sky Planning Guidance & Best Practices: <http://ruralplanning.org/assets/dark-sky---web.pdf>

Dark Sky Lighting Ordinance Walkthrough: <https://utah.maps.arcgis.com/apps/MapSeries/index.html?appid=1cb7c9aa1aa543dea3c813ec9f1f7f93#>

CPDSC Educational Video Series: <https://vimeo.com/user95912242>

Interactive light pollution mapping tool: <https://www.lightpollutionmap.info>

Building Energy Codes Program: <https://www.energycodes.gov/comcheck>

Watts-to-lumens free calculator: <http://www.rapidtables.com/calc/light/watt-to-lumen-calculator.htm>

Sensible outdoor lighting: <https://darkskywisconsin.uwex.edu/files/2015/11/township-brochure.pdf>

The new world atlas of artificial night sky brightness: <http://advances.sciencemag.org/content/2/6/e1600377.full>

Federal Department of Energy's Exterior Lighting Guidelines: http://cltc.ucdavis.edu/sites/default/files/files/publication/2010_DOE_FEMP_Exterior_Lighting_Guide.pdf

How to carry out a dark sky survey: <https://darkskydiary.wordpress.com/2010/12/18/how-to-carry-out-a-dark-sky-survey/>

Luginbuhl and Hall. "How Flagstaff is Preserving Dark Skies." *Astronomy*, Sept. 2017, pp. 56-60.

RECREATION LIGHTING

International Dark Sky Association criteria for community-friendly sports lighting: <https://www.darksky.org/wp-content/uploads/2018/03/IDA-Criteria-for-Community-Friendly-Outdoor-Sports-Lighting.pdf>

Powder Mountain Night Skiing: 6,248,060 total lumens for 19 acres of skiable terrain (ratio of 7.6 lumens per square foot). 6500 Kelvin color temp. <http://ultratechlighting.com/wp-content/uploads/2016/01/SNBT-FL-300W-B2.pdf>

Nordic Valley Night Skiing: 6,639,390 lumens and about 54 acres of skiable terrain (ratio of about 3 lumens per square foot). 6500 Kelvin color temp.

International Tennis Federation: <http://www.itftennis.com/technical/facilities/facilities-guide/lighting.aspx>

FLAG LIGHTING

Federal law for US flag: <http://www.senate.gov/reference/resources/pdf/RL30243.pdf>

Federal and state facilities: See UCA §17-27a-304. <http://le.utah.gov/xcode/Title17/Chapter27A/17-27a-S304.html>

Canopy lighting a parking lot light: See IDA model ordinance regarding lumens per gas pump and lumens per parking stall: <http://darksky.org/our-work/public-policy/mlo/>

TOWER LIGHTING

Federal Aviation Administration: https://www.faa.gov/regulations_policies/faq_regulations/

Federal Communications Commission: <https://www.fcc.gov/general/rules-regulations-title-47>

ILLUMINATION STANDARDS

Illuminating Engineering Society (IES): <https://www.ies.org/standards/>



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