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SIDING SPRING OBSERVATORY
DARK SKY COMMITTEE

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RESPONSE TO THE PARKES - NARROMINE SECTION OF INLAND RAIL ENVIRONMENTAL IMPACT STATEMENT BY SIDING SPRING OBSERVATORY, COONABARABRAN

1. BACKGROUND

Siding Spring Observatory (SSO) is Australia's national facility for optical astronomy. Situated on a high ridge in the Warrumbungle Mountains, it hosts a suite of more than 20 telescopes operated by the Australian National University (ANU) and other agencies, including significant international collaborations. Among the facilities are the two telescopes of the Australian Astronomical Observatory (AAO), a division of the Commonwealth Department of Industry, Innovation and Science. One of them (the 3.9-metre Anglo-Australian Telescope) is the largest optical telescope in Australia, and is expected to remain so for the foreseeable future. The total infrastructure investment at SSO is in excess of $110 million at today's costs.

The preservation of a night sky unpolluted by artificial light is imperative to the future operation of Siding Spring, which continues to attract infrastructure investment from domestic and international scientific institutions. The protection of the night sky under NSW planning legislation is one of the main reasons for Australia's success in attracting these ventures to the site. This legislation consists of the *Environmental Planning and Assessment Amendment (Siding Spring Observatory) Regulation 2016* and its subsidiary documentation, in particular the associated *Dark Sky Planning Guideline*.

These mandate the implementation of the provisions of the *Guideline* in four local government authorities within 100 kilometres of the observatory (Coonamble, Dubbo, Gilgandra and Warrumbungle), and on State Significant developments on land within 200 kilometres.

2. RESPONSE TO THE EIS

This submission is a response to the exhibition of the Inland Rail Parkes-Narrabri Section Environmental Impact Statement (EIS) made by the Siding Spring Dark Sky Committee on behalf of the Australian Astronomical Observatory, the Australian National University and other stakeholders on the Siding Spring site.

We acknowledge the cooperation of the Australian Rail Track Corporation (ARTC) and its willingness to engage with the Siding Spring Dark Sky Committee in order to mitigate the damaging effects of light sources associated with the project. ARTC has been at pains to have an open discussion with the Committee, which is greatly valued.

While the Parkes-Narrabri Section of the Inland Rail project is beyond the local government areas with development controls for lighting, its location within 200 kilometres of the observatory and its designation as State Significant Infrastructure mean that the provisions of the *Dark Sky Planning Guideline* must be implemented.

The good lighting design principles outlined in the *Guideline* must therefore be followed during construction and operation of this section of the Inland Rail network. These are relatively straightforward, and include the use of full cut-off luminaires (i.e. those emitting no light above the horizontal plane) and light sources with a correlated colour temperature of less than 3500K. Details may be found in the *Guideline*, a copy of which is submitted with this response.

The Siding Spring Dark Sky Committee recognises the many benefits of the Inland Rail project, and is keen to support it. The challenge is to carry out the activities required in constructing and operating the network while, at the same time, preserving the near-pristine environment of Siding Spring so it can continue as a major contributor to the nation’s scientific well-being. That being so, we are keen to continue working with ARTC to minimise any detrimental impact on the observatory from the project, and will make resources available to achieve that.

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Dark Sky Planning Guideline

Protecting the observing conditions at Siding Spring

NSW GOVERNMENT

Planning & Environment

The Dark Sky Planning Guideline | June 2016

This document titled The Dark Sky Planning Guideline contains information to assist the assessment of development and promote best practice outdoor lighting to protect the observing conditions in the Dark Sky Region for the Siding Spring Observatory.

To view an electronic version in PDF format, visit www.planning.nsw.gov.au

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Department of Planning and Environment
June 2016

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Siding Spring Observatory Site

Part 1

How to use this guideline

Part 1 How to use this guideline

1.1 Introduction

The Dark Sky Region in NSW is centred upon the site of Australia's most important visible-light Observatory at Siding Spring, located on the edge of the Warrumbungle National Park. The Observatory has over twenty telescopes and is one of few in the world that can observe the whole southern-hemisphere sky. It is critical to our understanding of the universe and the scientific endeavours of Australian and international astronomers. Each year the Observatory attracts over 24,000 visitors and injects more than $5 million directly into the local economy. Its continued operation is dependent on the dark night sky being free from light pollution. Light associated with development in the Dark Sky Region has the potential to reduce the ability of the optical telescopes to engage in scientific investigation and, therefore, impact on the future of the Observatory.

This Guideline informs state and local government, professionals and the community about the management of light in the Dark Sky Region (Figure 1). It demonstrates how light from development can be managed to reduce impacts on the operation of the Observatory. The Guideline informs development controls that apply to land within the local government areas of Coonamble, Dubbo, Gilgandra and Warrumbungle and the assessment of significant development within 200 kilometres of the Observatory. It supports the design and operation of development in the region and provides key information to ensure that lighting used in development does not impact on the effectiveness of the Observatory.

This Guideline provides guidance and technical information on good lighting design and encourages the use of shielded, downward facing and site appropriate lighting. This approach will deliver better quality lighting that supports the economy and cultural identity of the Dark Sky Region.

The management of light in the Dark Sky Region is important because the telescopes at Siding Spring Observatory require clear dark nights to operate effectively. Good lighting also promotes reduced energy waste and provides environmental, health and economic benefits to communities and ecosystems.

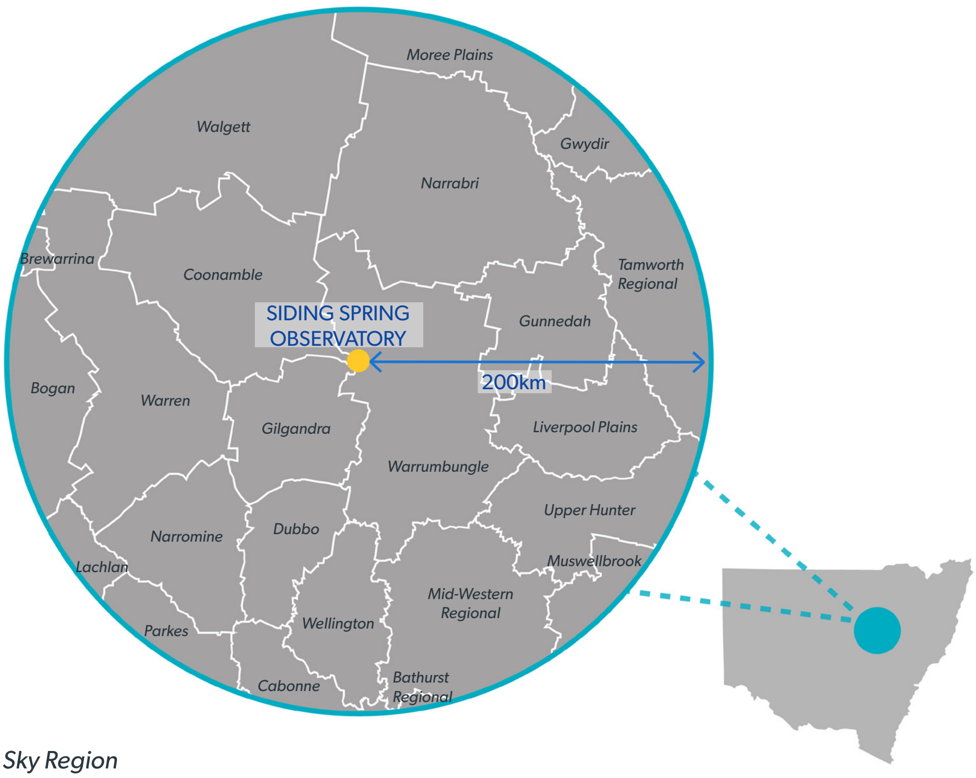


Figure 1 *The Dark Sky Region*

1.2 Structure of the Guideline

This Guideline includes the following parts:

Part 2 – The Dark Sky Region

This part gives information about the Siding Spring Observatory and how light from development in the Dark Sky Region affects its operation.

Part 3 – Factors affecting the observing environment

This part describes the key factors associated with artificial lighting that have the potential to impact the observing conditions at the Observatory.

Part 4 - Good lighting design principles

This part sets out the design principles that must be considered in the preparation, design and assessment of development that involves lighting. The principles promote lighting practices that maintain dark night sky and support the operation of the Observatory as well as saving energy.

Glossary and Appendices

This part includes a glossary of key definitions, a Siding Spring Observatory location map , a table detailing the light output from common bulb types, references to resource documents and links to further information.

1.3 Who is this Guideline for?

This Guideline has been prepared to:

- assist planning professionals in state and local government with the assessment of development proposals;
- be a tool for planners, developers, builders and other professionals when preparing a development application; and
- inform the wider community about the lighting practices that support maintenance of a dark night sky and improve lighting practice.

Astronomy: role and importance

Astronomy is the observational and theoretical study of objects in space. It includes vast fields of knowledge in physics, chemistry and mathematics. Both professional and amateur astronomers study the whole universe, including the moon, planets, and stars such as the sun, galaxies, quasars and black holes. Knowledge gained from these studies helps us to understand the nature of the universe, from its origin 13.8 billion years ago to today. At the cutting edge of knowledge are profound questions on the nature of space and time, and whether there is life beyond the earth.

Astronomy is also an ancient science, associated with the earliest forms of time keeping, navigation and agricultural calendars. As a modern science, astronomy has improved our knowledge in applied physics and has allowed scientists to make advances in medicine, geology, solar energy, remote sensing and communications. It has stimulated the development of technologies such as digital cameras and Wi-Fi. Astronomy also provides an understanding of the great care required to protect our planet's fragile environment for future generations.

1.4 When does this Guideline apply

This Guideline is a matter for consideration for all development under the *Environmental Planning & Assessment Act 1979* (the Act) before development consent is granted within the local government areas of Coonamble, Dubbo, Gilgandra and Warrumbungle.

A consent authority must also consider this guideline under clause 92 of the *Environmental Planning & Assessment Regulation 2000* (the Regulation) for development described in Schedule 4A to the Act, State significant development or designated development that is likely to impact the night sky and is within 200 kilometres of the Siding Spring Observatory. The Regulation also requires a proponent to consider this guideline when preparing an environmental impact statement for State significant infrastructure.

Clause 5.14 of the Coonamble, Dubbo, Gilgandra and Warrumbungle local environmental plans sets out the matters that must be considered when assessing development to protect observing conditions at the Siding Spring Observatory and minimise light pollution. This has the benefit of ensuring that proposed lighting is shielded, site appropriate and directed to where it is most needed.

Under *State Environmental Planning Policy (Infrastructure) 2007* consultation with the Observatory Director is required for specified development that will contribute to artificial skyglow, on land within 200 kilometres of the Siding Spring Observatory. This aims to ensure that activities also apply best practice lighting.

Lighting requirements for exempt and complying development are set out in *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* and vary depending on the distance from the Observatory and the type of development. Certifying authorities must ensure that the lights installed in a development comply with certain standards when issuing an occupation certificate for complying development.

This Guideline will assist consent authorities to consider the impacts of lighting associated with a development application. The consent authority may impose conditions in relation to design of light fittings, shielding of light, the design and operation of development and hours of lighting operation to manage contribution to artificial skyglow. Other considerations may include the design of roads, dust mitigation and night time operations for extractive industries, coal seam gas and other development types.

1.5 Consultation requirements

Advice needs to be obtained from the Observatory Director where a development has the potential to impact the observing conditions at Siding Spring for large projects such as state significant, critical infrastructure or designated development within the Dark Sky Region.

Clause 5.14 of the Coonamble, Dubbo, Gilgandra and Warrumbungle LEPs also requires consultation with the Observatory Director for certain development and gives the Secretary of the Department of Planning and Environment a concurrence role for proposed development that have the potential to emit over one million lumens such as supermarket car parks, sports fields, commercial stock yards and transport terminals.

In some cases an assumed consultation may be established in agreement with the Observatory.

It is recommended that you discuss your proposal with your local council to find out whether consultation with the Observatory is needed in your case.

1.6 Where can more information be found?

Further information on the types of lighting that maintain the dark night sky, the impact of light on astronomical observations and the Siding Spring Observatory is available in Appendix C of this Guideline – Useful publications and references.

Where appropriate, consultation with your local council is recommended at an early stage in the design process to ensure lighting design and installation will be suitable. In certain cases consultation with the Observatory may be needed where a more significant impact is anticipated.

Siding Spring Observatory Site, Warrumbungle National Park

Part 2

The Dark Sky Region

Part 2 The Dark Sky Region

2.1 Overview

This part gives information about the Observatory and how light from development in the Dark Sky Region affects its operation.

The Dark Sky Region consists of the land within a 200 kilometre radius of Siding Spring Observatory (see Figures 1 and 2). Good lighting design within the Dark Sky Region supports the ongoing successful functioning of the Observatory. Lighting design is important because the steady increase in light pollution from both distant and nearby light sources impacts the observing environment and the operation of the Observatory. In particular, lights with a direct line of sight to the Observatory have a significant impact on observing conditions as do lights which shine above the horizontal plane of a light fitting.

2.2 Siding Spring Observatory

The Observatory is situated on the eastern boundary of the Warrumbungle National Park (see Figure 2) in the Warrumbungle Range. It is surrounded by the flat plains of Coonamble and Gilgandra Shires and the undulating terrain of Coonabarabran. The Timor Valley is situated to the east of the Observatory and comprises of a mixture of rural farmland, rural residential development and undeveloped bushland. The town of Coonabarabran is located approximately 20 kilometres east of the Observatory. Other surrounding centres include Baradine, Coonamble and Gulargambone to the north and north-west, and Tooraweenah, Gilgandra and Dubbo to the south. There are large areas of nature reserve and state forest to the north and north-east.

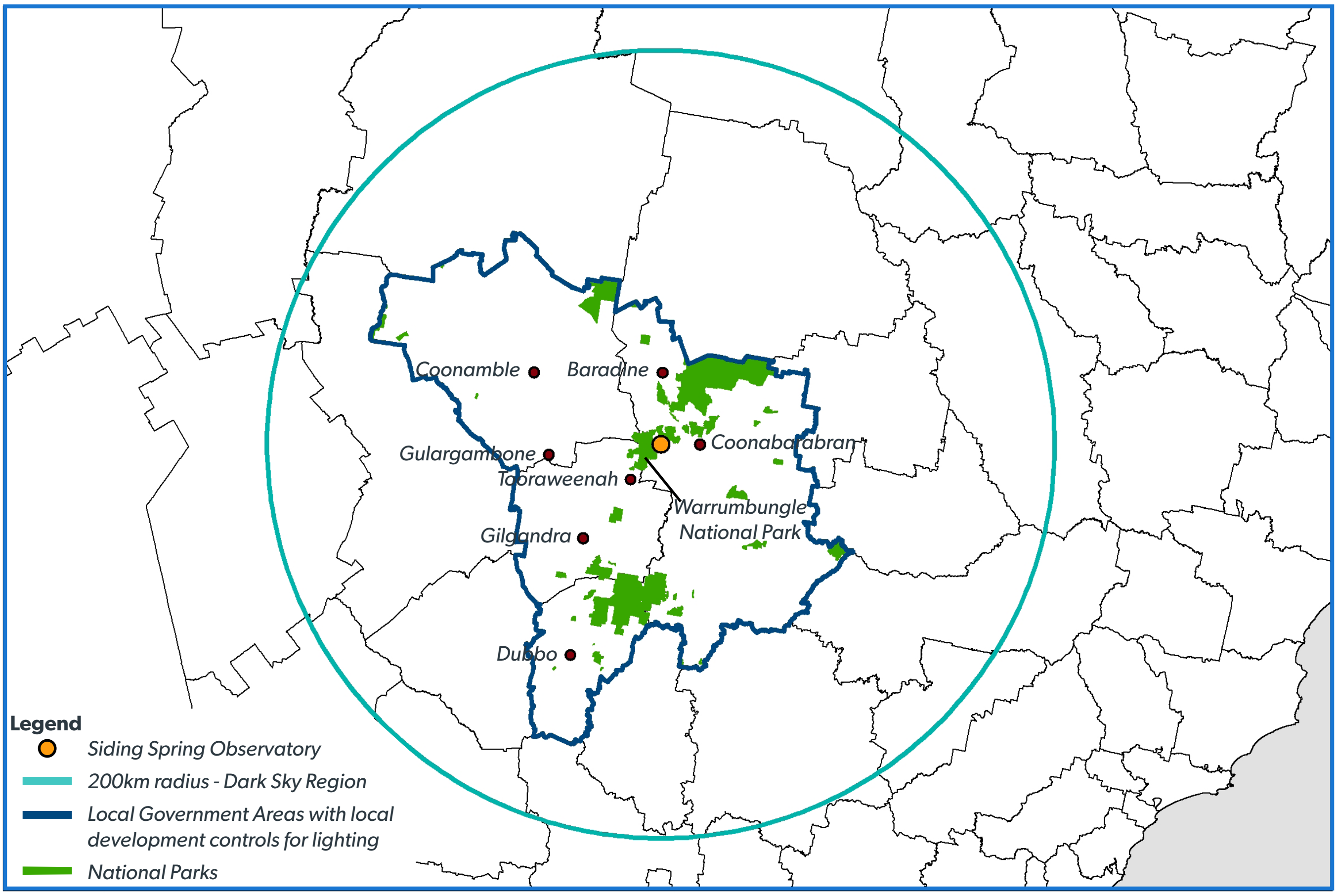


Figure 2 *Map illustrating the application of local controls for lighting in the Dark Sky Region*

The telescopes at the Observatory are owned and operated by a wide range of agencies including the Commonwealth Government, Australian and overseas universities and privately-funded enterprises. There are more than twenty telescopes on the site. The Anglo-Australian Telescope is the largest optical telescope in Australia with a mirror diameter of 3.9 metres, while the 1.2-metre UK Schmidt Telescope is the third-largest wide-angle telescope in the world. Both these instruments are operated by the Australian Astronomical Observatory, a Division of the Commonwealth Department of Industry, Innovation and Science. Other large telescopes on the site include the Australian National University's 2.3 metre telescope and the 2 metre Faulkes Telescope South which provides internet-accessible observing services for schools. Despite advances in the exploration of the universe from space there will always be a need for ground-based facilities such as the Observatory.

2.3 The impact of light on the Observatory

In the night sky there are two types of light – natural and artificial – that contribute to skyglow that affects astronomical observations.

Natural skyglow is the brightness of the night sky attributable to natural light sources such as the sun and the moon. It is primarily due to activity in the upper atmosphere and occurs in the night sky irrespective of light from any human-made structure. The darkness of the sky varies with natural occurrences but the benchmark level of natural skyglow is that amount measured at the time of the solar cycle when the sky is at its darkest.

Artificial skyglow is the brightness of the night sky attributable to light from human-made sources. It is the result of light from urban and regional development that is scattered and has interacted with molecules, aerosols and particulate matter in the atmosphere. Outdoor lights that shine into the night sky have the greatest impact on increasing artificial skyglow. Interior lights can also contribute where windows or openings are uncovered.

Advances in astronomy rely on the use of telescopes to detect and observe very faint objects in the depths of the universe. Discoveries and measurements of such objects by large telescopes need a pristine sky that is free from light pollution. Increased artificial light levels in the night sky mean that at some of the world's major observatories, particularly in the northern hemisphere, faint objects can no longer be observed. To protect the Observatory at Siding Spring from the cumulative impact of light, a critical light threshold has been determined. This is a measure of the maximum tolerable level of lighting in which astronomical observations can be made. The critical threshold is regularly monitored and used to guide assessment of cumulative impacts of artificial lighting associated with development.

2.4 Impact of existing and future development on the Observatory

New South Wales has the highest level of light pollution in Australia. In the Dark Sky Region lights from large urban centres, rural towns, rural development, significant infrastructure and resource projects are visible from the Observatory. The growth of towns and industries in the Dark Sky Region presents challenges for ensuring the dark night sky is free from light pollution and increased levels of atmospheric dust.

It is through the development assessment process that the impacts of lighting associated with development are considered by the applicant and the consent authority. The design principles that apply to lighting, which are to be considered when preparing a development application, or an activity under the *State Environmental Planning Policy (Infrastructure) 2007,* are provided in Part 4 of this Guideline.

Rural development

Many activities associated with agriculture in the surrounding rural area including grazing of livestock and the production of crops generally emit low levels of light into the atmosphere and have a minimal impact on levels of artificial skyglow. Rural industries and intensive livestock agriculture operations including dairies, feedlots, piggeries and poultry farms generally require more significant levels of lighting and, if not properly shielded, are likely to contribute to artificial skyglow.

Dust associated with rural industries and some extractive industries has the capacity to disperse light at night. Dust minimisation measures will need to be incorporated into the design and management of sites and development to reduce light pollution.

Urban development

Urban development, including sports fields, industrial and commercial buildings, housing, advertising signage and street lights, has a significant effect on the level of artificial skyglow. The nearest urban centre is the town of Coonabarabran which is approximately 20 kilometres east of the Observatory. Other nearby urban areas include Barradine, Coonamble, Narrabri, Gunnedah, Tooraweena, Gilgandra and Dubbo. Future light generating activities associated with housing and industry growth in these and other urban areas, due to either their size or proximity to the Observatory, have the potential to significantly increase levels of artificial skyglow.

Other development

Other major emitters of light in the Dark Sky Region include mining and extractive industries, in particular gas flares on gas fields. The operation of these large projects will need to consider air quality, dust emissions and night lighting impacts including from rail or truck movements on maintaining clear skies. Night operation of this development has the potential to increase skyglow and will need effective management.

Exempt and complying development carried out under the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* also has certain limitations, exclusions and specific development standards for development within the local government areas of Coonamble, Dubbo, Gilgandra and Warrumbungle regarding lighting.

Anglo-Australian Telescope, Milky Way - Siding Spring Observatory

Part 3

Factors affecting the observing environment

Part 3 Factors affecting the observing environment

3.1 Overview

This part describes the key factors associated with artificial lighting that have the potential to impact the observing conditions at the Observatory.

There are four key factors associated with artificial lighting which influence the effectiveness of optical telescopes at the Observatory:

- the distance between the light source and the telescope;
- the quantity of light;
- the type of light emitted; and
- the direction in which the light shines.

These factors are measurable and can be considered and managed in land use and development assessment.

3.2 Distance between the light source and the telescope

The distance between the light source and the telescopes at the Observatory is the most critical factor in determining the level of artificial skyglow. Sky brightness reduces rapidly the further the light source is from the Observatory. For example, the impact of light emitted from a single dwelling one kilometre from the Observatory can be comparable to 150 dwellings located 20 kilometres away.

To control the impact of lighting from development located within critical distances from the Observatory, three different lighting areas are applied to land in the local government areas (LGAs) of Coonamble, Dubbo, Gilgandra and Warrumbungle. These areas are defined by clause 5.14 of the LEP as:

a) 0 -12 kilometres from the Observatory – where a maximum of four shielded outside lights of no more than 900 lumens each is appropriate;

b) 12 -18 kilometres from the Observatory – where a maximum of four shielded outside lights of no more than 1800 lumens each is appropriate; and

c) Greater than 18 kilometres from the Observatory – where a variety of light controls apply, relevant to the type of development and the potential impact on the Observatory.

A Siding Spring Observatory Location Map, available at Appendix B, illustrates the 0-12 kilometres and 12-18 kilometres radii from the Observatory.

On land over 18 kilometres from the Observatory, a dwelling house, secondary dwelling or each dwelling in a dual occupancy must have no more than seven shielded outside light fittings with at least two of these light fittings being automatically activated by a sensor. A household should not have more than five outside lights that are not activated by a sensor. These measures ensure that light emitted from both an individual development, and the cumulative impact of light emissions, do not adversely affect the observing conditions at Siding Spring.

Within 18 kilometres certain development that is not lit or will not require lighting is permitted as exempt development. This includes fencing, cubby houses, green houses, mail boxes and other low impact development. A development requiring lighting within 18 kilometres will require a development application and need to be designed to incorporate measures to manage light pollution.

A skylight or roof window is not permitted as exempt or complying development on land within the four local government areas. A skylight or roof window may be considered as part of a development application and conditions attached to a consent.

3.3 Quantity of light

The observing conditions at Siding Spring are directly impacted by small amounts of light within the Dark Sky Region.

The effect of individual sources of light on the level of artificial skyglow is cumulative. Detailed computer modelling can estimate the cumulative effect of artificial light on the level of skyglow at any given landmark.

At the Observatory, a threshold figure of 10 per cent of the natural skyglow at 30 degrees above the horizon has been adopted as the maximum tolerable level of artificial light.

This threshold has been ratified by the Astronomical Society of Australia and is critical to the assessment of impacts on the observing conditions at the Observatory. Historical levels of artificial skyglow can be accessed online at the Observatory website (see Appendix C).

For development with 24 hour operations, night lighting measures need to be implemented to manage cumulative impacts.

The quantity of light associated with bulb types, expressed in lumens, is provided in the table at Appendix A to this guideline.

3.4 Type of light emitted

A variety of light bulbs are available for different applications. The most common bulbs used for outdoor lighting include light emitting diodes (LEDs), high pressure sodium, low pressure sodium, fluorescent and incandescent.

The major difference between the types of bulbs is the distribution in light wavelength. This accounts for the different colour of light. For example, a high pressure sodium bulb gives a peach coloured light, whereas a metal halide bulb produces a whiter light.

Choice of light type can affect the Observatory because telescopes can filter light at certain wavelengths and prevent it from interfering with observations. Low pressure sodium bulbs have a narrow light spectrum which can be filtered by telescopes without blocking out all other light. Metal halide bulbs produce a wide spectrum that cannot be blocked. The perceived colour of light, ranging from blue to white and yellow is referred to as colour temperature.

As the atmosphere scatters blue-rich light the most, outdoor lighting should have a colour temperature of below 3,500 Kelvin to reduce the impact of light on the observing environment. Table 1 provides information on common bulb types and their associated colour temperature.

***Table 1** Common bulb types and associated colour temperature*

Bulb type	Colour temperature	Colour appearance	Best lighting
Full spectrum fluorescent	5000K	Cool	Least preferred
Cool white fluorescent	4100K	Intermediate	↓
Metal halide	4000K	Intermediate	
Soft white fluorescent	3500K	Intermediate	
Warm white fluorescent, tungsten halogen	3000K	Warm	
Standard incandescent	2700K	Warm	
High pressure sodium	2200K	Warm orange/peach	Most preferred

Note: With LEDs, any colour temperature can be produced, but warm colours are preferred.

3.5 Direction of light

Reducing artificial skyglow can be achieved by changing how a light fitting is mounted and aimed.

When light shines below the horizontal plane of the light fitting there is a dramatic reduction in the level of artificial skyglow produced. The design of light fittings, buildings and the use of landscaping can also support good lighting outcomes by shielding light from shining above the horizontal plane of a light fitting. Local suppliers now stock a range of shielded light fittings for residential, commercial and industrial applications.

To control spill light it is preferable in most situations to select a greater mounting height, a narrow beam and an appropriate vertical aiming angle.

On average 14 per cent of light that is shielded is reflected off surfaces into the sky. The amount reflected varies greatly dependent on the type of surface, for example a clay tennis court will reflect much more than a bitumen road. Consideration should also be given to the reflective properties of ground and wall surfaces to minimise reflected light.

The direction of light is also impacted by particles of dust in the atmosphere. When lit, fine particles of dust scatter light, which may contribute to skyglow. Development with the potential to generate dust must particularly consider lighting to ensure that dust will not be illuminated. Figure 5 depicts dust particles redirecting light towards the Observatory.

Where dust emissions have the potential to impact on the observing conditions at Siding Spring, dust minimisation measures should be implemented, including through conditions on an approval.

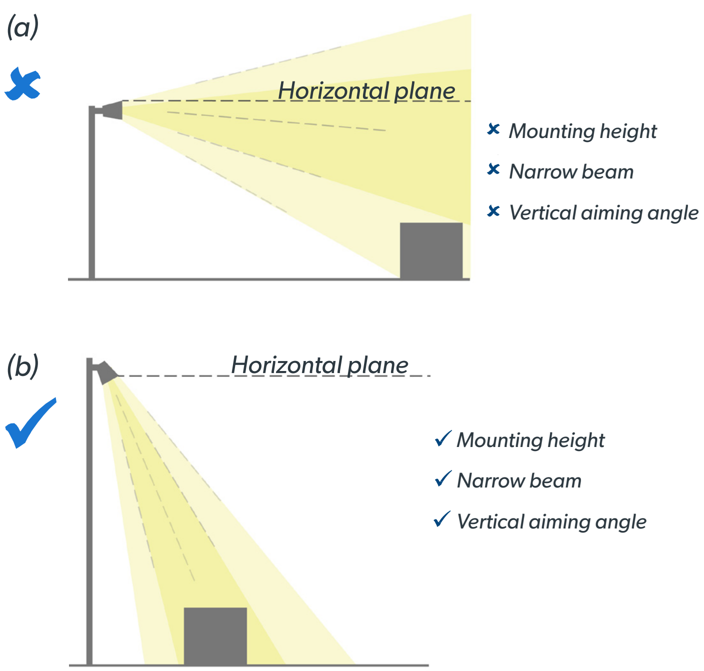


Figure 3 *Application of mounting height and vertical aiming angle to control light spill*

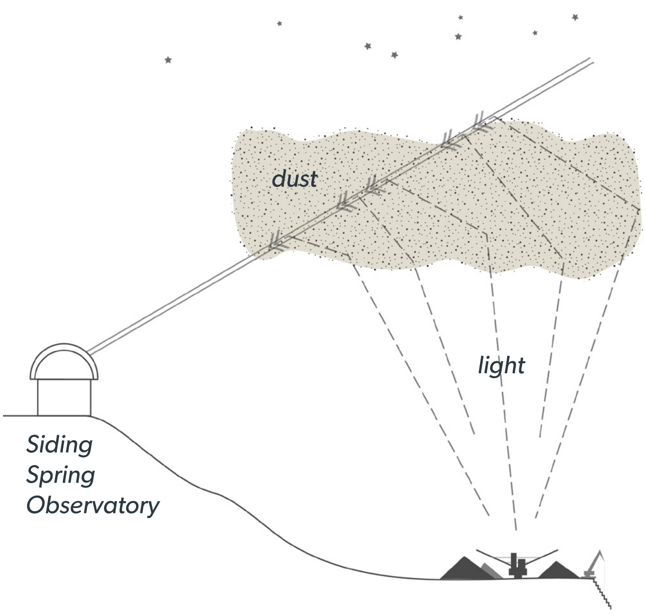


Figure 4 *Scattering of artificial light by dust in the atmosphere*

Anglo-Australian Telescope dome

Part 4

Good lighting design principles

Part 4 Good lighting design principles

4.1 Overview

This part sets out the design principles that must be considered in the preparation, design and assessment of development.

Good lighting design demonstrates adoption of the following principles:

1. Eliminate upward spill light
2. Direct light downwards, not upwards
3. Use shielded fittings
4. Avoid 'over' lighting
5. Switch lights off when not required
6. Use energy efficient bulbs
7. Use asymmetric beams, where floodlights are used
8. Ensure lights are not directed towards reflective surfaces
9. Use warm white colours

4.2 The design principles

Principle 1 Eliminate upward spill light

Spill light is light that falls outside the area that is intended to be lit. Spill light from the internal and external lighting of a development can cause glare and wastes energy. Spill light above the horizontal plane contributes directly to artificial skyglow.

All light fittings should be located, aimed or shielded to avoid lighting unintended areas, especially above the horizontal plane of the light fitting (see Figure 5).

Light can be prevented from shining above the horizontal plane by:

- installing light fittings with an opaque cover and flat glass, mounted horizontally on both axes, or
- mounting the light under part of a building like an awning, verandah or roof, so that light is blocked from shining above the horizontal plane, and
- designing buildings to internalise light and prevent it from escaping into the night sky.

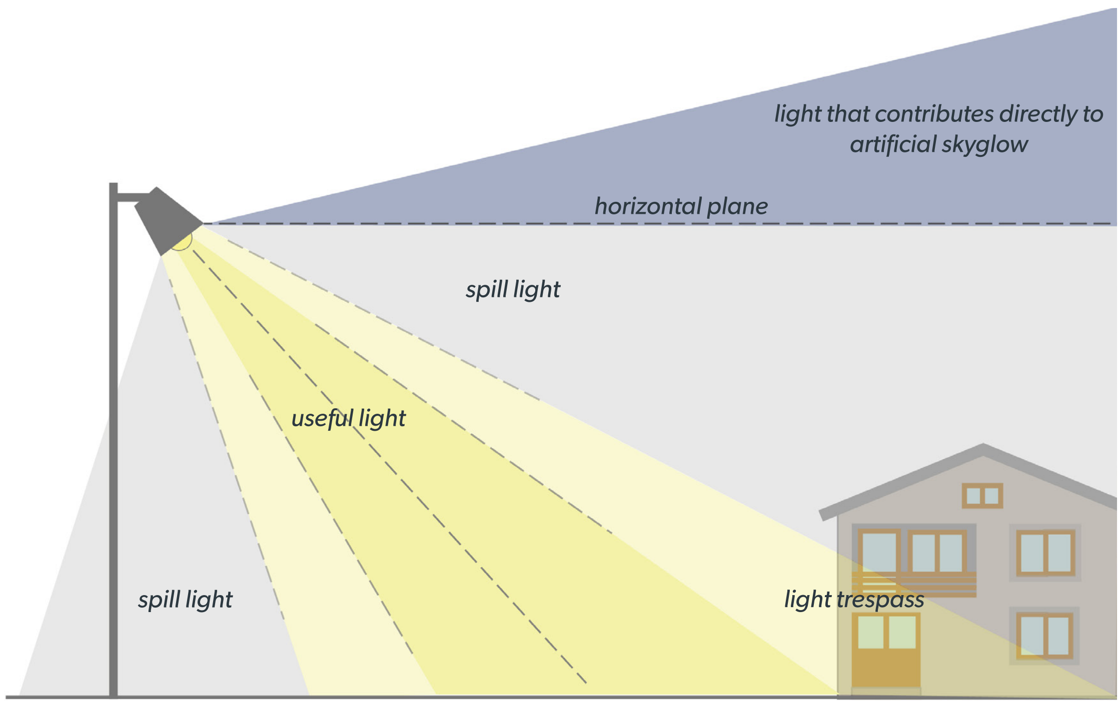
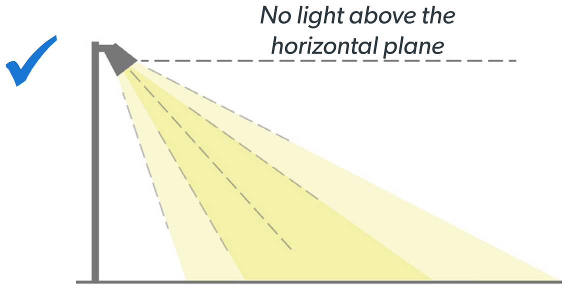


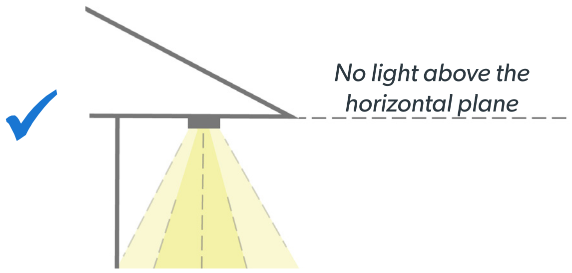
Figure 5 *Common aspects of light pollution*

Figure 6 provides design solutions to minimise light spill above the horizontal plane.

(a) Installing shielded outside light fittings



(b) Installing outside light fittings under a building element (e.g. awning or eave)



(c) Using building design e.g. verandahs and block-out blinds to control the spill of internal lighting

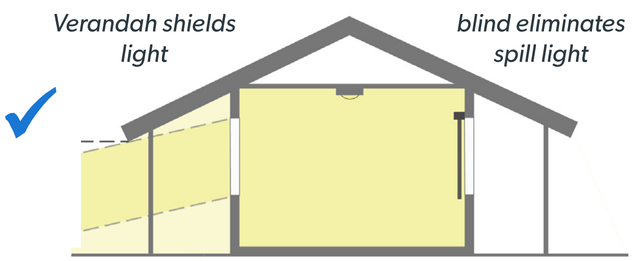


Figure 6 *Design solutions to minimise interior spill light above the horizontal plane*

Adequate measures to avoid and minimise interior light escaping through windows, roof windows, sliding doors and skylights include full block-out curtains, blinds or shutters. Suitable conditions should be imposed to manage the spill of internal light into the night sky.

Principle 2 Direct light downwards, not upwards

Wherever possible, light should be directed downwards, not upwards. This includes light used for roads, public amenities and the vertical lighting of structures such as advertising boards and building facades. If there are extenuating circumstances requiring up-lighting, it must be demonstrated that the light will not spill into the night sky. This may be achieved by using a wide overhang to the building that stops the light shining directly into the night sky or relocating the lights to shine down the building façade to achieve the same effect.

Directional fittings (for example floodlights, spot lights and sign lights) should be installed so that they do not shine directly into a neighbouring residence, onto a roadway, skyward or outside of a property boundary.

To keep glare to a minimum use higher mounting heights that allow lower main beam angles that are closer to vertical.

The lighting of all night operations such as mines, extractive industries and intermodal hubs will need to be downward facing, of a peach colour and shielded. Where strong light is needed or there are gas flares or burning associated with the development, consultation with the Observatory Director is required to assist in identifying an appropriate way to light the development.

Principle 3 Use shielded fittings

Light fittings that are specifically designed to minimise light shining near to or above the horizontal plane should be used.

Shielded fittings are those that do not allow any light above the horizontal plane. Figure 8 shows a fitting with a bulb that is completely exposed allowing light to shine in all directions (a); a bulb that is fitted with a partial shield minimising light above the horizontal plane (b); and a shielded fitting which allows only the downward projection of light (c). The shielded fitting is the preferred design in the Dark Sky Region.

The effective light distribution or shielding characteristics of a light fitting can be verified by referring to manufacturer's specifications. These are available from the manufacturer or relevant sales outlet.

In some urban locations, particularly within heritage conservation areas, outdoor lights are fitted with a decorative cover. These designs may leave the bulb completely exposed and allow light to shine in all directions. To minimise light spill the bulb should be fitted into the top of the fitting, allowing only the downward projection of light (see Figure 8).

(a) Non-shielded outside light fitting

(b) Shielded outside light fitting with bulb fitted to the top

Figure 8 *Exposed bulb that allows light to shine in all directions and a fitting designed to minimise light spill by only allowing downward projection of light.*

(a)

Non-shielded light fitting

(b)

Partially shielded outside light fitting

(c)

Shielded outside light fitting

Figure 7 *Shielding characteristics of light fittings*

Lighting suppliers stock a range of shielded light fittings suitable for residential, commercial and industrial applications.

If a supplier is unable to provide a shielded fitting, a shielding device should be applied. Most outside light fittings are equipped with or are capable of being fitted with a baffle, visor or hood to ensure light is appropriately directed (see Figures 9 and 10).

Figure 9 *Floodlight fitted with shielding attachment*

Figure 10 *Floodlight that incorporates shielding in the fitting design (no attachment necessary)*

What is a light fitting?

A light fitting, or luminaire, is the complete lighting unit. It includes the bulb, elements designed to give light output control such as a reflector (mirror) or refractor (lens), the ballast, housing and the attached parts.

(a) One light fitting

(b) Two light fittings

Where multiple light fittings are mounted on a single base, as illustrated in (b) above, these are to be counted as additional light fittings. For example, a dwelling house with seven outside light fittings may have three type (a) light fittings and two type (b) light fittings, of which two must be automatic light fittings.

Principle 4 Avoid over lighting

Lighting levels should be appropriate for the activity. To avoid 'over' lighting, select an appropriate bulb type and light the task, rather than the environment.

Improvements in technology mean that many new bulb types produce significantly greater amounts of light while using equivalent or smaller amounts of energy. Halogen bulbs produce more light than standard incandescent bulbs for the same energy use. LED lights produce between two and five times the amount of light as incandescent bulbs. Careful selection of bulb type will ensure the amount of light produced is appropriate for the activities.

The amount of light produced (lumen), rather than the amount of energy used (watt) is the most important consideration in ensuring that an area is not over lit. Table 2 provides an appropriate light output for common activities as a guide. Common bulb types and their associated lumen output can be found in Appendix A.

Table 2 *Typical levels of outdoor lighting for common activities*

Activity type	Lumens emitted
Dwelling	1800-7200
Single porch light	900
Tennis Court (domestic purposes)	100 000
Farm building	1800-7200
Single security light	900-4000
Swimming pool	12 000
Public open space/ small car park	12 000
Small sports oval (single field)	1 000 000
Road lighting	Refer to AS/NZS 1158
Rural industries	<1 000 000
Stockyards (commercial)	<1 000 000
Mining and extractive industries	>5 000 000
Advertising signage (externally lit)	1800-7200
Small motel or commercial building	12 000
Recreational, decorative, promotional and special events lighting	No greater than necessary

Principle 5 Switch lights off when not required

Lights should be switched off when not required to light a task or an area for safety or security purposes. The concept of a curfew with further limitations on lighting levels between agreed hours is encouraged. Examples include extinguishing or dimming advertising and decorative lighting after 11:00pm. Light fittings with timers that switch on at dusk and switch off by 11:00pm are also encouraged.

The use of automatic light fittings is recommended. Lights that are activated by a sensor and switch off automatically after a period of time reduce the cumulative amount of light emitted from development benefiting the Observatory and reducing energy waste.

Principle 6 Use energy efficient bulbs

Improvements in technology mean that many recently developed bulb types use significantly smaller amounts of energy to produce the same amount of light.

Energy efficient globes include LEDs, metal halide, induction bulbs, high pressure sodium, linear and compact fluorescent. High pressure sodium lights emit a peach coloured light and are suitable for a range of applications. They are energy efficient and have a lower impact than white lights.

White lights such as LEDs, modern fluorescent lights and metal halide lights should be used where recognising colour is important, for example at pedestrian crossings, major road intersections and sports grounds. Blue-white mercury bulbs have commonly been used for roadway lighting, but they are no longer permitted in new installations. An Australian Standard (AS/NZS 1158) addresses lighting for roads and public spaces, including parks and gardens and must be applied, where relevant.

Principle 7 Use asymmetric beams (when floodlights are required)

Where floodlights are required, for example sports lighting applications and commercial stock yards, wherever possible use fittings with asymmetric beams that permit horizontal glazing. These are to be kept at or near parallel to the surface being lit, usually the ground and should only light the area that needs to be lit, preventing spill light, see Figure 11.

An asymmetric beam also allows the light fitting to be mounted on the edge of an area, and avoids the need for fittings to be tilted upwards. Flat glass light fittings should be installed with the glass horizontal to make efficient use of the brightest part of the beam and to eliminate spill light.

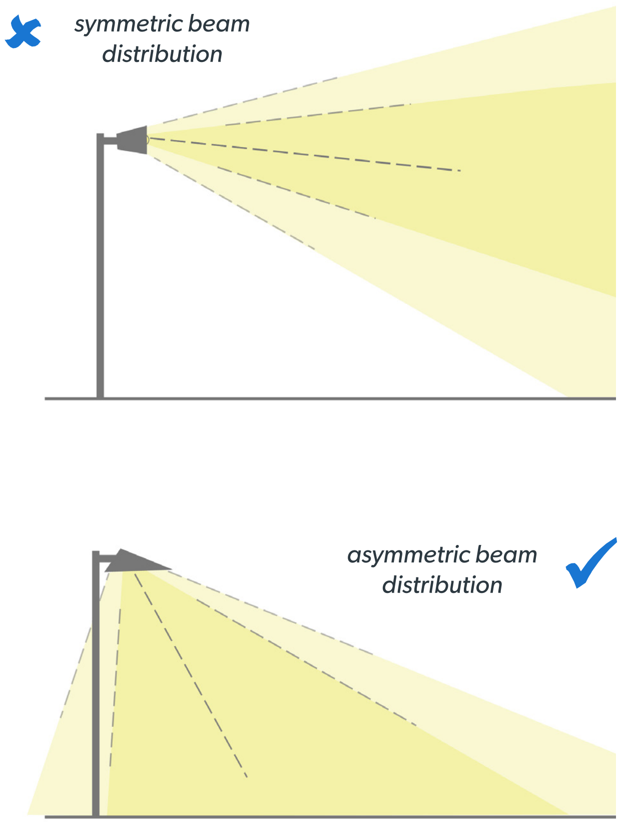


***Figure 11** Appropriate floodlighting design includes use of an asymmetric beam*

Principle 8 Ensure lights are not directed towards reflective surfaces

At the design stage, it is desirable that surfaces with a low level of reflectivity be installed in the vicinity of outdoor lighting, compatible with the function of the area.

Illuminance is a measure of the amount of light reflected by a surface and is determined by the reflective properties of the surface. Where a natural grass surface is used the illuminance will be low, but may be significant where the surface is relatively light in colour, for example uncoloured concrete, artificial grass with sand infill or light coloured walls. Table 3 provides a guide to the reflective properties of common surfaces.

***Table 3** Reflective properties of common surfaces*

Surface	Reflective properties
Natural grass and vegetation	Low
Painted surface (dark)	Low
Pre-coloured factory metal (dark)	Low
Brick (dark)	Low
Raw or stained timber	Medium
Stone surface	Medium
Uncoloured concrete	High
Painted surface (light)	High
Artificial grass (sand base)	High
Pre-coloured factory metal (light)	High
Brick (light)	High
Zincalume steel (unpainted)	High

Internally lit signage contributes to the luminance component of artificial skyglow. The internationally accepted limit on illuminated signage should be implemented as provided in Table 4.

***Table 4** Maximum luminance of illuminated signage*

Illuminated area (square metre)	Maximum luminance at any point (candela per square metre)
More than 10	300
2 to 10	600
0.5 to 2	800
Less than 0.5	1000

Principle 9 Use warm white colours

Use warm coloured light bulbs and avoid using cool blue-rich high colour temperature bulbs that are the least sky-friendly.

More information on bulb types and colour temperature is provided in Table 1.

Glossary

Artificial skyglow is the part of the skyglow that is attributable to human-made sources of light.

Baffle is an opaque or translucent element to shield a light source from direct view, or to prevent light reflecting from a surface like a wall.

Brightness is the strength of the visual sensation on the naked eye when lit surfaces are viewed.

Bulb is the source of electric light and is a component of a light fitting, not a light fitting on its own.

Candela is the unit of intensity of light. A candle emits light with a luminous intensity of approximately one candela.

Colour temperature is the perceived colour of a light source ranging from cool (blue) to warm (yellow), measured in Degrees Kelvin (K). A low correlated colour temperature such as 2500K will have a warm appearance whilst 6500K will appear cold.

Horizontal plane, in relation to the light fitting, means the horizontal plane passing through the centre of the light source (for example the bulb) of the light fitting.

Illuminance is the amount of light reflected from a surface.

Incandescent bulb is a bulb that provides light by a filament heated to a high temperature by electric current.

Intensity is the amount of energy or light in a given direction.

Light is the radiant energy that is visible to humans and animals. Light stimulates sight and makes things visible.

Light fitting is the complete lighting unit. It includes the bulb, elements designed to give light output control, such as a reflector (mirror) or refractor (lens), the ballast, housing and the attached parts.

Light pollution means the brightening of the night sky caused by artificial light.

Lumen is the unit of luminous flux which is the light emitted by a bulb. Lumens are a measure of light output from a bulb. The quantity of lumens produced by a bulb is independent of the wattage. Some types of bulb are more energy efficient than others and produce more lumens per watt. A guide to lumen values for common bulb types is provided in Appendix A to this Guideline.

Luminance is the amount of light emitted in a given direction by the light source or illuminated surface and is measured in candelas per square metre.

Lux is the unit of measure of illuminance, equal to one lumen per square metre.

Natural Skyglow is that part of the skyglow which is attributable to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere.

Mounting height is the height of the fitting or bulb above the ground.

Outdoor lighting is the nighttime illumination of an area by any form of outside light fitting.

Outside light fitting means a light fitting that is attached or fixed outside or on the exterior of a building or structure, whether temporary or permanent.

Reflected light is light that bounces off a surface. Light coloured surfaces reflect more light than darker coloured surfaces.

Shielded light fitting means a light fitting that does not permit light to shine above the horizontal plane. If a fitting is to be used which is not a shielded fitting, some form of permanent physical opaque shield must be used to provide the shielding requirement. This can be a cover or part of a building. Care must be taken to also shield adjacent surfaces, if they are lightly coloured, to prevent excessive reflected light from adding to skyglow. The shielding should be constructed to minimise emissions in the 10 degrees below horizontal.

Skyglow is the brightness of the night sky caused by the cumulative impact of reflected radiation (usually visible light), scattered from the constituents of the atmosphere in the direction of observation. Skyglow comprises two separate components: natural skyglow and artificial skyglow.

Spill light is light that falls outside the boundaries of the object intended to be lit. Spill light serves no purpose and, if directed above the horizontal plane, contributes directly to artificial skyglow.

Wattage is the amount of electricity needed to light the bulb. Generally, the higher the wattage, the brighter the light will be and the more lumens it will produce.

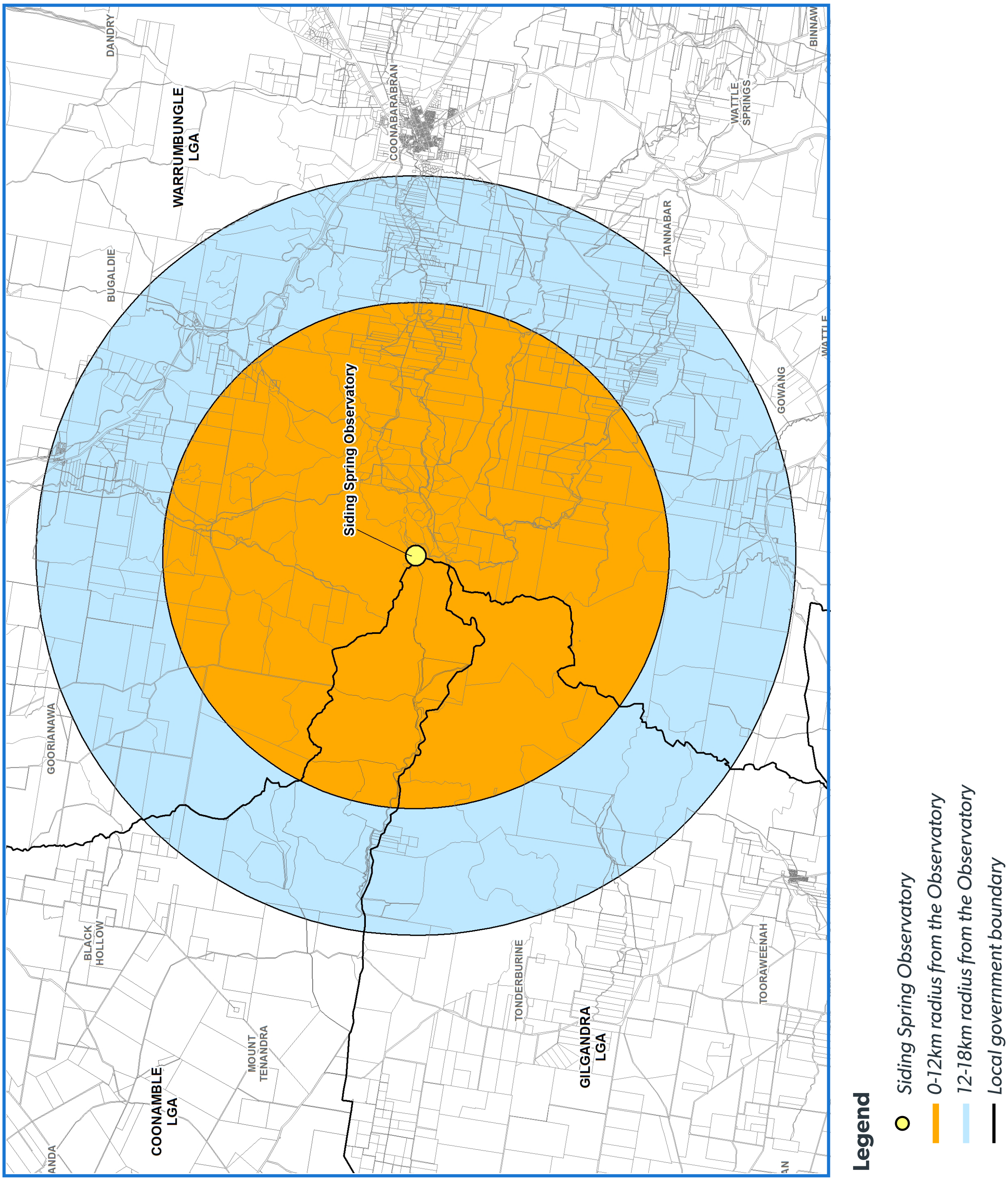
Appendix A Lumen values for common bulb types (general lighting)

Light output (Lumens)	Power (Watt)			
				
	Incandescent	Tubular Florescent Bulb	Compact Florescent Bulb	LED
150	25			
250			5	
400			7	
460	40			
600-700			8-10	9
890	60			
900			13	
1000			13-18	6-7
1190		21		
1210	75			
1200			18	15
1750	100			
1800			26	18
2050		30		
2450		36		
2880	150			
2900			32	
3000		39		
3700		50		
3900		52		
4600		55		
5400		70		
6300		75		
6360	300			
23800	1000			

Note: Industrial and sportsground lighting requires specialist design with a variety of different bulb types

Appendix B Siding Spring Observatory location map

This map is a composite representation of the Siding Spring Observatory Location Maps for Coonamble, Gilgandra and Warrumbungle local environmental plans (LEP). It indicates the 0-12 and 12-18 kilometre distance bands from the Observatory where particular lighting measures apply. On land beyond 18 kilometres within the LGAs of Coonamble, Dubbo, Gilgandra and Warrumbungle a range of lighting measures apply and are set out in the relevant LEP.



Appendix C Useful publications and references

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