

Selwyn District Plan Review

Obtrusive Lighting Effects of Outdoor Lighting

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OBTRUSIVE LIGHTING EFFECTS OF OUTDOOR LIGHTING

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1 Introduction and Scope

The purpose of this report is to describe the different types of obtrusive or nuisance lighting that are typically created by artificial lighting systems associated with different night-time land use activities across the district areas and zones. Areas of concern include outdoor public areas (road reserves and public amenities), industrial/commercial areas (whether publicly or privately owned and operated) and residential areas, especially businesses operating within residential areas. This report also includes some examples of how other local authorities attempt to mitigate obtrusive lighting and recommendations specific to the Selwyn District.

2 Obtrusive Lighting Effects

With any outdoor lighting scheme (no matter what the land use activity is) it will not always be possible to contain all light within the boundaries of the property on which the lighting system is installed. Some light will inevitably spill outside the property boundaries, either directly or by reflection, which can potentially cause annoyance to people in adjoining areas.

There are three main types of obtrusive or adverse lighting effects that can cause nuisance to nearby residents, users of adjacent areas and to astronomical observation. These are:

- Glare
- Upward Waste Light (Sky Glow)
- Spill Light

2.1 Glare

Glare occurs when a light source directs a large percentage of the total light output directly into the eyes of an observer (e.g. motorist, pedestrian or resident). Glare can be disabling and/or uncomfortable and sensitivity to glare can vary based on a person's health and age. Older people are usually more sensitive to glare due to the aging characteristics of their eyes.

- **Disability Glare** impairs the visibility of objects without necessarily causing discomfort. The amount of disability glare can be determined from a Threshold Increment (TI) calculation. TI is a measure of disability glare expressed as the percentage increase in contrast required between an object and its background for it to be seen equally well with a source of glare present. Higher values of TI correspond to greater disability glare due to a reduction in contrast of the object being observed.
- **Discomfort Glare** is subjective and can cause discomfort without necessarily impairing the visibility of objects.

Excessive glare is not just a characteristic of lighting schemes operating at night. It can also happen naturally during the day when excessive sunlight is directed into the eyes of an observer rendering objects in their field of view extremely hard to see or even invisible. This is known as "sun strike" and normally occurs during sunrise or sunset when an observer is facing the sun.

The following photo is an example of glare from a building mounted luminaire¹ aimed directly at an observer:

¹ Luminaire is defined as a complete lighting unit consisting of a light source (LED modules or lamps) and all the component parts designed to distribute the light; house and protect the light source and control gear; and to connect the light source to an external power supply.



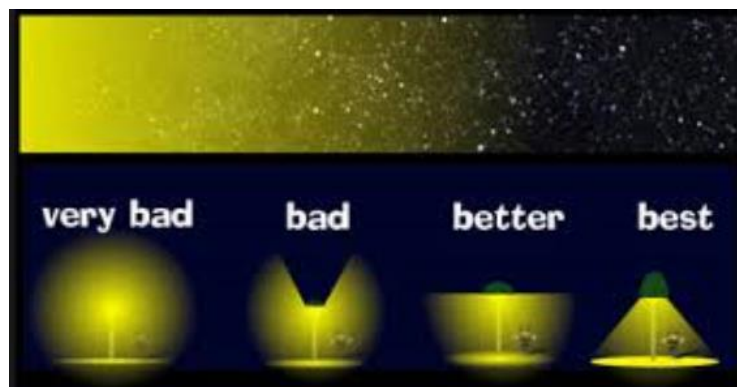
2.2 Upward Waste Light (Sky Glow)

Sky glow is the result of stray light being scattered in the atmosphere either directly or indirectly (reflected).

Direct upward waste light is more pronounced and can be eliminated by careful luminaire selection and site orientation. However, there will always be some reflected light contributing to sky glow that cannot be fully controlled or mitigated.

Excessive sky glow is a problem for Astronomers (and other night sky observers) because it reduces contrast and obscures the night sky so that they cannot identify stars and other celestial forms.

The following picture illustrates the typical range (from very bad to best) of waste light produced by different pole mounted luminaires:



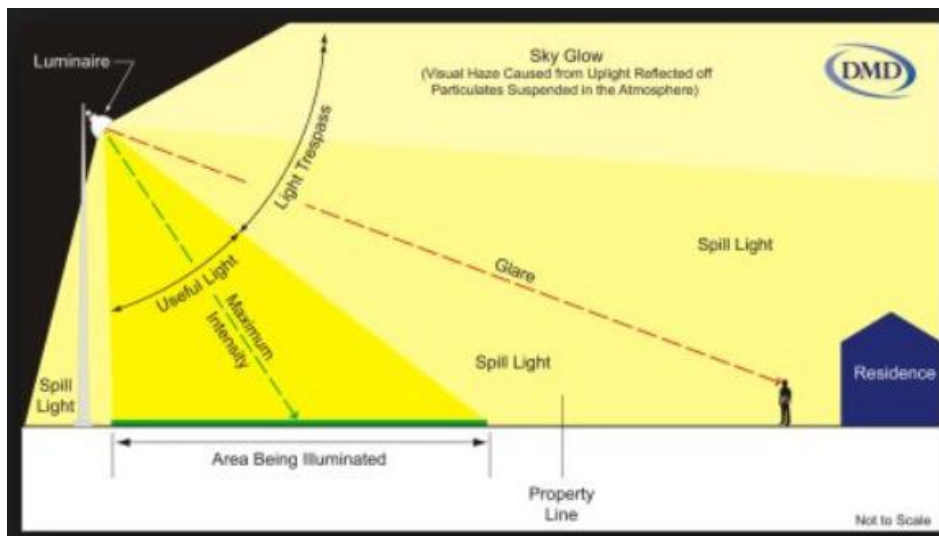
2.3 Spill Light

Spill light (sometimes called light trespass) can be obtrusive or beneficial (depending on application) and can be described as light that strays beyond defined areas or boundaries.

In certain situations, high levels of spill light from public road lighting installations can cause problems for people in residential areas as it may be obtrusive, particularly where light spills into properties or enters habitable rooms. Other forms of outdoor lighting, particularly wide area floodlighting (security, outdoor workplace, sporting venue, festivals, events, etc), can also cause excessive spill light that may adversely affect residents (within their own properties) and road corridor users such as pedestrians, cyclists and motorists.

Some degree of spill lighting can be beneficial, especially on main arterial roads and state highways, where a certain level of spill light is required to illuminate the surrounding verges, pathways and shoulders.

The following diagram illustrates the various types of obtrusive or adverse lighting effects that are normally associated with outdoor lighting applications:



3 Potential Obtrusive Lighting Effects of Outdoor Lighting Activities

Unless properly controlled to acceptable levels, all outdoor lighting schemes have the potential to generate some degree of obtrusive or adverse lighting effects.

The following sections describe the outdoor land use activities that typically create lighting effects and the potential effects generated.

3.1 Outdoor Land Use Activities

All outdoor lighting is intended for specific purposes which include security, public transportation (vehicles and pedestrians within the road corridor); and task orientated (workplace operations) or spectator based activities.

Outdoor land use activities that create lighting effects includes the following examples:

- **Public Lighting** - roads, car parks, transport interchanges, connecting elements, civic areas and pathways
- **Commercial Developments** - shops, malls, and retail outlets
- **Residential Developments** - outdoor security and amenity lighting, lighting of outdoor recreational areas (e.g. tennis court)
- **Industrial Developments** - dairy processing plants, truck depots, container yards and temporary construction sites
- **Illuminated Signs**
- **Sporting Venues** - playing/training fields/grounds or courts and sporting venues with the ability of providing televised coverage
- **Events** - shows, carnivals and concerts
- **Vehicle Headlights** - vehicles using public roads (cars, vans, trucks and motorcycles) and industrial moving machinery on construction sites (diggers, graders, bulldozers, forklifts, straddle cranes, etc)

3.2 Examples of High levels of Illumination

The objectives of the lighting scheme may not be compatible with the containment of light within the intended area of application. Some activities require the illumination of a volume or space, not just of a surface at ground level. The following are examples where high levels of illumination are required to provide specific task based lighting:

- a) Lighting for certain sports (e.g. rugby, soccer, tennis, cricket, etc) where it is essential to have the ability to see the movement of the ball in the space above the playing surface, especially for those sports being televised.

- b) Lighting of a freight terminal or port where it is necessary to identify containers in multiple container stacks and carry out unloading/loading operations safely.
- c) Security lighting within an industrial site or depot that is adjacent to a property boundary

Activities that require high levels of illumination may inadvertently spill onto adjacent properties unless properly controlled.

3.3 Vehicle Headlights

Vehicle headlights can cause spill light (into properties) and high levels of glare (either towards oncoming traffic or as seen in the rear-view mirror of a leading vehicle) especially when drivers fail to dip their headlights in well illuminated areas.

Spill light into properties (adjacent to the road reserve) is not a major concern due to the transitory nature of vehicle movements. Unless a property is directly opposite a tee intersection (controlled by signage and/or signals), then spill light should not be present for significant periods of time. In situations where the vehicle is stationary and there are sustained periods of time where the headlights are facing a property there may be some degree of nuisance, especially if the headlights are on full beam (not dipped).

The effect of vehicle headlights that are too bright causing disabling glare to other motorists is more significant as it has the potential to cause serious (or fatal) injuries to vehicle occupants and/or pedestrians, especially in high speed areas.

3.4 Influence of Proposed Developments

The magnitude of obtrusive lighting effects may be significantly influenced (positively or negatively) by the following factors:

- a) The topography of the area surrounding the lighting installation (of the proposed development). Residential areas at a lower level than the development's lighting installation are more likely to be subjected to direct views of the luminaires which may result in excessive glare and spill light.
- b) Physical features (such as adjacent buildings, trees and spectator stands) may be effective in limiting obtrusive lighting levels beyond the boundaries of the development.
- c) The amount of existing ambient light relative to the lighting of the proposed development. If the existing lighting levels are high any obtrusive lighting effects (from the new lighting) will appear to be less pronounced; whereas if the existing lighting levels are low the impact of the proposed lighting may be severe resulting in high levels of obtrusive light.
- d) The location of the proposed development relative to:
 - i) Areas of cultural, environmental, historical or scientific importance;
 - ii) Transportation areas (harbours, airports, waterways, roads or rail) where spill light from the proposed development may interfere with the visibility of signalling systems; or
 - iii) Community and scientific optical observatories where spill light from the proposed development may interfere with astronomical observations of celestial bodies.

3.5 Specific Effects

3.5.1 Effects on Residents

The magnitude of obtrusive lighting effects on residents can be subjective but generally there is a perceived reduction of amenity resulting from any combination of the following:

- a) Obtrusive spill light resulting in unwanted illumination of the property and in particular where the light enters habitable rooms.
- b) Glare due to bright luminaires being within the normal viewing direction of residents, which can cause annoyance, distraction or discomfort.
- c) Changes in intensity (from a light source) occurring within a person's peripheral vision due to effects such as variable images or changing colours from illuminated signage.

The degree of tolerance (or annoyance) will be influenced by the ambient lighting of the existing environment.

3.5.2 Effects on Transport System Users

Obtrusive lighting effects on transport system users (motorists, cyclists and pedestrians) normally involve a reduction in the ability to see caused by disability glare from bright light sources. The contrast of objects

against the surrounds (as viewed from an observer) will be lower making them difficult to see or even invisible, especially if the area has low ambient lighting levels or dark surrounds.

Transport signalling systems can also be affected by obtrusive lighting and normally involves a reduction in the visibility of signals due to:

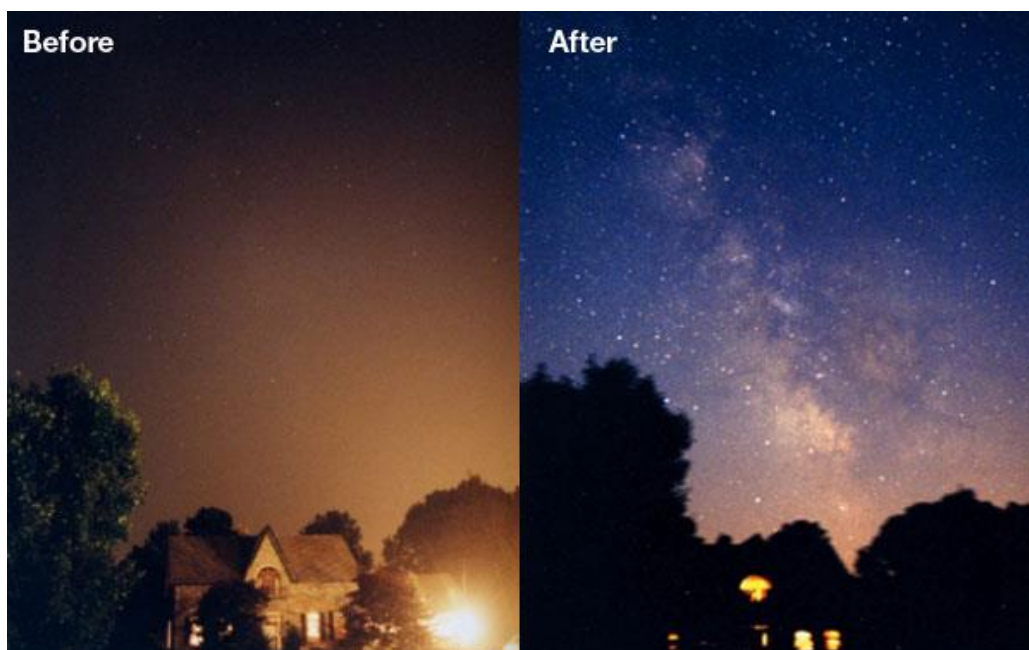
- d) Disability glare (as described above); or
- e) Visual clutter where signals are hard to distinguish against a competing background of other lights, especially if the background lighting is made up of variable colours.

3.5.3 Effects on Observatories

Effects on astronomical observations generally involve the modification of night sky viewing conditions (sky glow) by:

- f) Lightening of the dark sky caused by the scattering of light within the atmosphere from installed lighting;
- g) Spectral characteristics of the sky glow where the light (from the glow) cannot be filtered out by optical means at the telescope; or
- h) Direct light from the lighting installation falling onto the observatory.

The following photos depict night-time scenes taken before and during the 2003 electricity blackout of the north eastern United States and the Canadian province of Ontario. The photograph on the left was taken before the blackout when all the road lights were operating and illustrates the sky glow effect. The photo on the right was taken during the power outage.



4 Mitigation Measures

There will always be some degree of obtrusive light (spill light, glare and/or sky glow) wherever there are outdoor lighting systems, however nearly all forms of obtrusive light can be controlled or mitigated to be within tolerable and generally acceptable levels. There needs to be some balance between achieving the objectives of providing functional lighting (suitable for the task or activity) and any obtrusive lighting effects resulting from the lighting that may cause nuisance.

4.1 LED and Control Technology

With the development of light emitting diode (LED) technology the ability to direct (or control) the light onto the surface or area requiring the lighting is now achievable. LED luminaires have more accurate spill light control (sharper cut-offs) compared to older high intensity discharge (HID) luminaires which produce higher levels of spill light and are harder to control.

LEDs also have an advantage over HID lamps, because they can be supplied with dimmable drivers to provide lower levels of lighting based on night-time usage patterns. During periods of no activity LED lighting can be turned off or dimmed to a percentage of their maximum output to provide background lighting. When activities resume the LED lighting levels can be raised to provide full output. LED installations can also be controlled via computerised central management systems (CMS).

The availability of smart CMS technology now makes it possible to provide remote control and dimming functions across a lighting system resulting in more flexible and variable operating parameters. For road lighting applications, the lighting levels can be dimmed down based on traffic usage over certain time periods e.g. from sunset to 11pm full output can be delivered and from 11pm to 4am output can be reduced to provide low level background lighting only. The lighting could also be triggered to provide full output via sensor input when vehicles are detected.

Along with the generally lower levels of obtrusive light produced by LED luminaires (already mentioned above) some road lighting luminaire manufacturers can provide additional optical shielding (integral to the luminaire) to restrict spill light in any direction. External shields can also be fitted if required. The ability to provide shielding also extends to other lighting applications such as security, outdoor workplaces and sports fields.

4.2 Standards and Rules

Within New Zealand there are a number of national based standards, rules, policies and/or plans that set lighting limits and include requirements to mitigate obtrusive lighting effects of a proposed development.

4.2.1 National Standards

There are national/international standards that cover all types of outdoor activity lighting including public spaces, workplaces, sporting venues and obtrusive light. Some of the national standards have prescriptive requirements while others only provide general guidance of a descriptive nature.

The following is a list of the relevant national/international standards and a brief description on what they cover.

Public Spaces:

AS/NZS 1158.0: Lighting for roads and public spaces, Part 0: Introduction

AS/NZS 1158.1.1: Lighting for roads and public spaces, Part 1.1: Vehicular traffic (Category V) lighting - Performance and design requirements

AS/NZS 1158.1.2: Lighting for roads and public spaces, Part 1.2: Vehicular traffic (Category V) lighting - Guide to design, installation, operation and maintenance

AS/NZS 1158.2: Lighting for roads and public spaces, Part 2: Computer procedures for the calculation of light technical parameters for Category V and Category P lighting

AS/NZS 1158.3.1: Lighting for roads and public spaces, Part 3.1: Pedestrian area (Category P) lighting - Performance and design requirements

AS/NZS 1158.4: Lighting for roads and public spaces, Part 4: Lighting of pedestrian crossings

AS/NZS 1158.5: Lighting for roads and public spaces, Part 5: Tunnels and underpasses

AS/NZS 60598.2.3: Luminaires - Particular requirements - Luminaires for road and street lighting

SA/SNZ TS 1158.6: Lighting for roads and public spaces - Luminaires - Performance

Workplaces:

AS/NZS 1680.5: Interior and workplace lighting - Outdoor workplace lighting

Sporting Venues:

AS 2560.2.1: Sports lighting - Specific applications - Lighting for outdoor tennis

AS 2560.2.3: Sports lighting - Specific applications - Lighting for football (all codes)

AS 2560.2.4: Guide to sports lighting Specific recommendations - Lighting for outdoor netball and basketball

AS 2560.2.6: Guide to sports lighting - Specific recommendations - Baseball and softball

AS 2560.2.7: Guide to sports lighting - Specific recommendations - Outdoor hockey

AS 2560.2.8: Sports lighting - Specific applications - Outdoor bowling greens

Vehicle Headlights:

NZTA - Land Transport Rule: Vehicle Lighting 2004

NZTA - Land Transport (Road User) Rule 2004

The NZTA headlight rules specifically relate to the safety effects that headlights have on other road users, rather than any spill light or glare issues that may be experienced by residents within their properties. There are no controls on the levels of obtrusive light that may fall into adjacent properties from vehicles operating within the road corridor.

Vehicle headlights of heavy machinery operating inside construction sites may be subject to any site specific obtrusive light rules that apply as the rules will be equally applicable to all light sources within that site. Applying any obtrusive light rules or limitations to moving machinery may be difficult to enforce, unless there are complaints from local residents.

Obtrusive Lighting Effects:

AS 4282: Control of the obtrusive effects of outdoor lighting

The current revision of AS 4282 excludes public lighting, as it is provided to facilitate all-night safety and security for the public at large and this requirement is deemed a greater consideration than the negative effects of obtrusive light. The current revision also excludes internally or externally illuminated advertising signs, floodlit buildings, lighting systems installed for the purposes of colour television broadcasting and cyclic or flashing lights. AS 4282 currently has limits of obtrusive light based on three environmental settings being: residential areas within commercial zones; residential areas with light surrounds; and residential areas with dark surrounds. It is likely that parts of Selwyn District Council will fall within the three broad areas currently covered by AS 4282.

AS 4282 is currently under review by a joint (AS and NZ) standards committee to address the shortcomings (and exclusions) of AS 4282. The revised standard (AS/NZS 4282) is proposing to include public lighting, internally or externally illuminated advertising signs and lighting systems installed for the purposes of colour television broadcasting. The classifications of environmental areas are being expanded to include environmentally sensitive areas and better align the categories to international standards.

International Dark-Sky Association (IDA) - general information and guidelines on minimising sky glow.

Compliance with the recommendations of the IDA is not mandatory, however the association website does provide general information, reference material and guidelines on how to design IDA friendly lighting schemes. This report cannot verify the validity, objectivity and technical accuracy of the information provided by the IDA.

4.2.2 Selwyn District Council Specific Documents

The following is a list of **Selwyn District Council** specific technical standards, guidelines, and plans that cover outdoor lighting installations. Some documents provide more comprehensive lighting requirements than others, and the list has been compiled from documents downloaded from the Selwyn District Council website.

The Operative District Plan provisions are addressed in the main report – 'Review of District Plan Provisions and Best Practice' and therefore have not been addressed below (apart from reference to Rule 9.18 West Melton Lighting).

The main document appears to be the **Selwyn District Council Engineering Code of Practice** which covers the lighting of public outdoor areas.

Engineering Code of Practice - Part 11: Lighting (Dated June 2011)

This code of practice document provides comprehensive design and installation requirements, associated with the provision of outdoor public activity lighting in accordance with AS/NZS 1158, however the effects of obtrusive lighting (spill light and glare) are only referred to in a few sections. Obtrusive lighting control is described in the following sections:

- **Section 11.9.3 (Category P Cycleways and Pathways in Reserves)**

There are no specific obtrusive lighting limits specified, however luminaires are required to meet the type specifications of AS/NZS 1158.3.1 (Table 2.10) to help control upward waste light, glare and spill light. For

walkways wider than 4m, column mounted luminaires are required and the control of glare and spill lighting should be considered. Following these rules will help to minimise obtrusive light, but may not always restrict obtrusive lighting levels to acceptable levels.

- **Section 11.9.18 (Lighting Requirements for Dairy Crossings)**

There are no specific obtrusive lighting limits specified, however luminaire mounting height and positioning must consider any possible glare to other road users, road traffic and nearby dwellings and other buildings. This is a descriptive requirement that is not measurable, so the effectiveness of it would be difficult to assess and open to interpretation.

- **Section 11.9.5 (West Melton Lighting)**

Outdoor lighting shall be shielded to avoid upward light spill as detailed in Rule 9.18 of the District Plan. According to Rule 9.18 the provision of permanent outdoor lighting is a permitted activity provided any spill light is restricted to specific limits based on particular areas adjacent to or within the West Melton Observatory Lighting Area. There are some exclusions including vehicle headlights and lighting for temporary activities.

Asset Delivery Procurement Strategy (Dated 18 October 2010)

This strategy document covers the provision of street lighting design, installation and maintenance activities via professional services (asset management and design) and maintenance/installation contracts; but does not deal with specific design requirements or the control of obtrusive light.

Community Facilities Activity Management Plan (Dated June 2015)

This management plan identifies specific locations that require outdoor lighting improvements including: sports fields, parks and reserves; and security lighting of community centres, swimming pools and halls. This plan does not address specific design requirements for the control of obtrusive light.

Transportation Activity Management Plan (Dated June 2015)

This management plan identifies specific locations that require outdoor lighting improvements including: rural and urban roads (state highways, main roads and local residential roads); public car parks; and pathways. This plan does not include any specific design requirements, but requires new lighting to “follow specific standards for any new street light installations to reduce spill light and glare while remaining effective”. The plan states that AS/NZS 1158 has been adopted to provide minimum requirements for the lighting of roads and other outdoor public areas, however AS 4282 has not been referenced.

Good Solutions Guide Subdividing Large Rural Style Lots (Dated September 2009)

This guide provides no specific requirements for outdoor lighting apart from some generic comments about providing safe and appropriate lighting. This guide does not deal with specific design requirements or the control of obtrusive light.

Subdivision Design Guide - Design Guide for residential subdivisions in the urban living zones (Dated September 2009)

This guide provides no specific requirements for outdoor lighting apart from some generic comments about selecting street lights to reflect the character of the subdivision. This guide does not deal with specific design requirements or the control of obtrusive light, however it does refer to the Engineering Code of Practice.

4.2.3 Other Local Authority Technical Standards

Most local authorities have their own technical standards, policies or rules that cover outdoor lighting schemes and include requirements for providing sufficient lighting levels for planned activities as well as obtrusive light mitigation. Collectively the local authority technical standards provide guidance and make reference to relevant national and international standards to control the effects of obtrusive light, however some are more clear and comprehensive than others.

The following is a list of some other local authority technical standards that include outdoor lighting of roads, car parks, pathways, pedestrian crossings, public precincts and connecting elements. They are all based on following the design requirements of AS/NZS 1158 (lighting for roads and public spaces) however some authorities have opted to impose different (more onerous) requirements that exceed those quoted in AS/NZS 1158. Some local authorities also make reference to AS 4282 (Control of the obtrusive effects of outdoor lighting) and the International Dark-Sky Association (IDA) for general information and guidelines on minimising spill light, glare and sky glow.

Auckland Transport - Technical Design Manual

This technical manual has particular requirements to limit glare and spill light and it also refers to AS 4282 for further guidance on minimising obtrusive lighting effects.

Christchurch City Council - Infrastructure Design Standard - Part 11: Lighting

This design standard does not impose specific limits to control obtrusive lighting however it provides a descriptive requirement to minimise the impact of glare and spill light and refers to the luminaire selection criteria of AS/NZS 1158 (Part 3.1) for the control of glare and upward waste light. Note that Part 3.1 only covers pedestrian area (Category P) public lighting.

Waimakariri District Council - Engineering Code of Practice - Part 11: Lighting

This design standard does not impose specific limits to control obtrusive lighting however it provides a descriptive requirement to minimise the impact of glare and spill light and refers to the luminaire selection criteria of AS/NZS 1158 (Part 3.1) for the control of glare and upward waste light. Note that Part 3.1 only covers pedestrian area (Category P) public lighting.

NZTA M30: Specification and Guidelines for Road Lighting Design

This design standard only covers road lighting and provides a general guide on maximum permitted spill light and glare levels. M30 does require that temporary lighting of construction sites and security lighting shall be compliant with the obtrusive lighting requirements of AS 4282. M30 also requires that all lighting applications must demonstrate adherence to the principals of the International Dark-Sky Association (IDA).

QLDC Southern Light - Lighting Strategy and Technical Specifications

The QLDC strategy and technical specifications require designers to minimise adverse lighting effects by applying the limits provided in NZTA M30. The documents also refer to AS 4282 and the IDA for further guidance and information.

General Comments on other Local Authority documents

In addition to the technical standards and specifications (listed above) there are also numerous local authority district plans and rules that are specific to individual areas or regions, but are too numerous to list within this report. Many of them appear to be historical and have little relevance to modern lighting applications or the requirements are open to interpretation, ambiguous or impractical to apply.

For example, the Auckland Unitary Plan (AUP) requires that the illuminance limit (at a property boundary) during curfew hours (10pm to 7am) is 10 Lux above background levels. It is not easy or practical to establish what the background levels may be (produced by existing public lighting) unless the existing levels can be calculated or measured. The existing levels could be calculated provided there is accurate "As Built" information of the existing lighting installation before any upgrade. Although it is possible to take site measurements they may be influenced by other light sources and/or environmental conditions that compromise the accuracy of the readings. In practice, a maximum spill light limit of 10 Lux (absolute) is applied during the design of a new lighting installation, and any existing background lighting levels are not included in the calculations.

Another AUP requirement imposes maximum vertical illumination limits at the windows of habitable rooms of lawfully established dwellings, although it does not provide a practical method of achieving this. At the design stage this is difficult to accomplish unless a survey is made of all residential buildings facing the proposed lighting scheme. A practical alternative to incorporate this requirement is to apply the point vertical illuminance limit to the entire vertical face of any dwellings that face the proposed new lighting, thus ensuring any windows are incorporated into the assessment.

5 Summary and Recommendations

Wherever there is outdoor lighting there will always be some degree of obtrusive lighting that can cause nuisance.

Local authorities (including NZTA) have their own internal technical standards and policies (or refer to national/international standards) to ensure correct lighting levels are provided and any obtrusive effects from this lighting are minimised or limited to acceptable levels.

This report recommends that Selwyn District Council adopts a 'standards based approach' to control the effects of obtrusive lighting by updating the Selwyn District Council Engineering Code of Practice and referencing the standards provided in section 4.2.2 and in particular AS 4282. The obtrusive lighting requirements of the District Plan can be retained as they are already broadly aligned with AS 4282. Refer to the separate Stantec report **Review of Lighting and Glare Provisions and Best Practice** for more specific District Plan information.

Although AS 4282 is currently under review, its replacement (AS/NZS 4282) is expected to provide a comprehensive set of requirements that can be implemented (by any authority) to mitigate the effects of obtrusive lighting. The proposed updates to AS 4282 should be beneficial to local authorities as most forms of outdoor lighting are to be included; area classifications are to be expanded to include environmentally sensitive areas; area categories are to be better aligned with international standards; and design methodologies are to be improved to more accurately reflect calculation surfaces associated with current and future dwelling locations.

Note that at this point in time the proposed update of AS 4282 (AS/NZS 4282) cannot be referenced as it is still under review by the applicable standards committee. A draft version is expected to be released for public consultation later this year with the official standard due for release some time next year ahead of the proposed notification of the Proposed Selwyn District