TOMINGLEY
GOLD OPERATIONS PTY LTD
(A wholly owned subsidiary of Alkane Resources Ltd)
ABN 53 149 040 371

Tomingley Gold Extension Project

Light and Sky Glow Assessment

Part 2

Major Project Application No. PA 09_0155





Prepared by LAS *Lighting, Art & Science Pty Limited*

December 2021

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Lighting and Sky Glow Assessment

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COMMONLY USED ACRONYMS

AGI32	Lighting Analysts, Advanced Graphical Interface (32bit)
AHD	Australian Height Datum
CCT	Correlated Colour Temperature
DPE	Department of Planning and Environment
LAS	Lighting, Art & Science Pty Limited
LED	Light Emitting Diode
LEP	Local Environmental Plan
LTP	Light Technical Parameters
RWC	R.W. Corkery & Co. Pty Limited
SAR	San Antonio Roswell
SSO	Siding Spring Observatory
TGO	Tomingley Gold Operations
ULR	Upward Light Ratio

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EXECUTIVE SUMMARY

Lighting, Art and Science Pty Limited (LAS) has been engaged by RW Corkery & Co Pty Limited on behalf of Tomingley Gold Operations Pty Ltd (the Applicant) to complete Lighting and Sky Glow Assessment for the proposed Tomingley Gold Extension Project (the Project). The aim of this report is to assess the potential impacts of the Project on the Siding Spring Observatory.

The Project comprises two components, the existing Tomingley Gold Operations (TGO) and the proposed San Antonio and Roswell (SAR) mining operations. The TGO Mine Site is located immediately to the south of the village of Tomingley in central western NSW and the SAR Mine Site is located immediately to the south TGO Mine Site. Together these areas are referred to as the Project Site. The Project Site is located within the Narromine Local Government Area.

The purpose of the assessment is to form part of an Environmental Impact Statement (EIS) being prepared by RW Corkery & Co Pty Limited to accompany an application for development consent under Division 4.1 and 4.7 of Part 4 of the Environmental Planning and Assessment Act 1979 (EP&A Act) for the Project.

This assessment does not address the existing Tomingley Gold Operations (TGO) but is limited to the additional impact of the SAR mining operations. Where existing lighting equipment would be relocated from the TGO Mine Site to the SAR Mine Site it has been treated as existing lighting.

There is an Australian Standard, *AS/NZS4282:2019 Control of the obtrusive effects of outdoor lighting*[3] which LAS considers adequately addresses the requirements for dark rural environments with respect to the potential impact on residents in the area surrounding the Project Site, the impact on the other biota in the area surrounding the Project Site and the general impact on sky glow.

The Project Site falls within the Dark Sky Region defined by the *Dark Sky Planning Guideline*[2] which consists of the land within a 200km radius of the Siding Spring Observatory; and is triggered by Clause 92 of the *Environmental Planning and Assessment Regulation 2000*[1].

LAS has been provided information relating to the lighting to be reused from the TGO Mine Site and proposed additional lighting. Due to Covid-19 restrictions LAS was not able to visit the Project Site.

AS/NZS4282:2019 specifies limits for several lighting parameters. The limits vary according to the Environmental Zones and the time of night. There are 11 different Environmental Zones which reflect different ambient lighting conditions. The Standard also has a curfew period between 11:00pm and 6:00am, when lower limits are applied.

LAS has based the assessment on Zone A2, which is the third most stringent, being ‘Sparsely inhabited rural and semi-rural areas’, and has assessed both curfew and non-curfew periods.

The analysis indicated that the proposed lighting would fall well within the limits of AS/NZS4282:2019. The view of the lights from the north, west and south would be shielded by the SAR Amenity Bund. The works on the SAR and Coloma Waste Rock Emplacement mounds would be shielded by amenity bunds that would rise with the mound.

The bunds have not been included in the calculation, so the lighting conforms even without the bunds.

The luminous intensity limits in the eastern direction will only be relevant in the unusual situation that the lights were aimed in the direction of the residence and the angle of upcast was greater than 49 degrees. This could be further reduced by the addition of eyelid shields on some of the lights.

As the depth of the pit increases less lights would be visible.

AS/NZS4282:2019 acknowledges that lighting can also have an impact on biota, however the impacts are often species dependent and the research is often limited to specific species. The limits for the light technical parameters for environmental zones A0 to A2 take into account biota as large parts of these zones are generally uninhabited by humans.

AS/NZS4282:2019 has a provision to limit the upward light to reduce the impact on astronomy and sky pollution. Conformance can be achieved by limiting the upcast to 49 degrees or adding eyelid shields to the lights.

Siding Spring Observatory and Significant Regional Observatories

The Project Site is approximately 162 km from the Siding Spring Observatory (SSO) and falls within the Dark Sky Region.

LAS has measured the reflectivity of the ore and waste rock that is proposed to be mined within the SAR Mine Site and calculated the total additional lumens produced by the external lighting from the Project Site and the total reflected and direct lumens emitted into the sky.

These figures have been provided to the SSO.

SSO have responded to say that the impact of the Project on the SSO would be negligible. Their response in included in **Annexure D**.

AS/NZS 4282:2019 specifies that the impact on significant community and scientific observatories should be considered and refers to the Australian Astronomical Societies List of Significant Observatories for guidance.

In addition to the SSO, are other observatories in the area that are included on the Australian Astronomical Societies List of Significant Observatories. The closest of these is in the Bathurst area and they are of a similar distance to Siding Springs Observatory. The Astronomical Societies list of significant observatories is divided in the following categories:

- Major Facilities, which includes Siding Springs.
- University/Publicly funded observatories.
- Significant Amateur Society/Private Observatories.

The observatories in the Bathurst area are in the Significant Amateur Society/Private Observatories category. We have assumed that as these are not significantly closer to the Project Site than Siding Springs, that acceptance by Siding Springs would also cover these sites.

CONCLUSIONS

Local Environment

The additional lighting associated with the Project would have negligible impact on the surrounding area

The Siding Spring Observatory and other local Significant Observatories

The proposed lighting within the Project will emit less than 1% of the light directly above the horizontal plane.

LAS has calculated the total lumens, total upward lumens and submitted them to SSO for review. SSO's response states that it would have negligible impact on SSO. Their response is included in **Annexure D**.

Conclusion

Based on the analysis carried out by LAS the Project could operate on a 24hour basis without generating excessive light obtrusion to the area surrounding the Project Site or the surrounding observatories.

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1. INTRODUCTION

Lighting, Art and Science Pty Limited (LAS) has been engaged by RW Corkery & Co Pty Limited on behalf of Tomingley Gold Operations Pty Ltd (the Applicant) to complete Lighting and Sky Glow Assessment for the proposed Tomingley Gold Extension Project (the Project). The aim of this report is to assess the potential impacts of the Project on the Siding Spring Observatory.

The Project comprises two components, the existing Tomingley Gold Operations (TGO) and the proposed San Antonio and Roswell (SAR) mining operations. The TGO Mine Site is located immediately to the south of the village of Tomingley in central western NSW and the SAR Mine Site is located immediately to the south TGO Mine Site. The together these areas are referred to as the Project Site. The Project Site is located within the Narromine Local Government Area.

Any additional lighting has an impact on the environment and that impact is an inherent part of population expansion and industrialisation. The important criterion is one of reasonableness to determine whether the Project represents an unacceptable impact on the environment, the operation of the SSO or the amenity of the people in the surrounding area.

Our expertise does not extend to astronomy, so LAS has provided our base information and analysis to the SSO for further analysis.

Figure 1 shows the location of the Project Site in relation to the SSO.

Figure 2 shows a section showing the relative elevation of the SSO with respect to the Project Site. Direct view of the Project Site from SSO is obstructed by Needle Mountain.

Figure 3 shows the Project Site layout, including the existing and approved TGO Mine Site and the proposed SAR Mine Site.

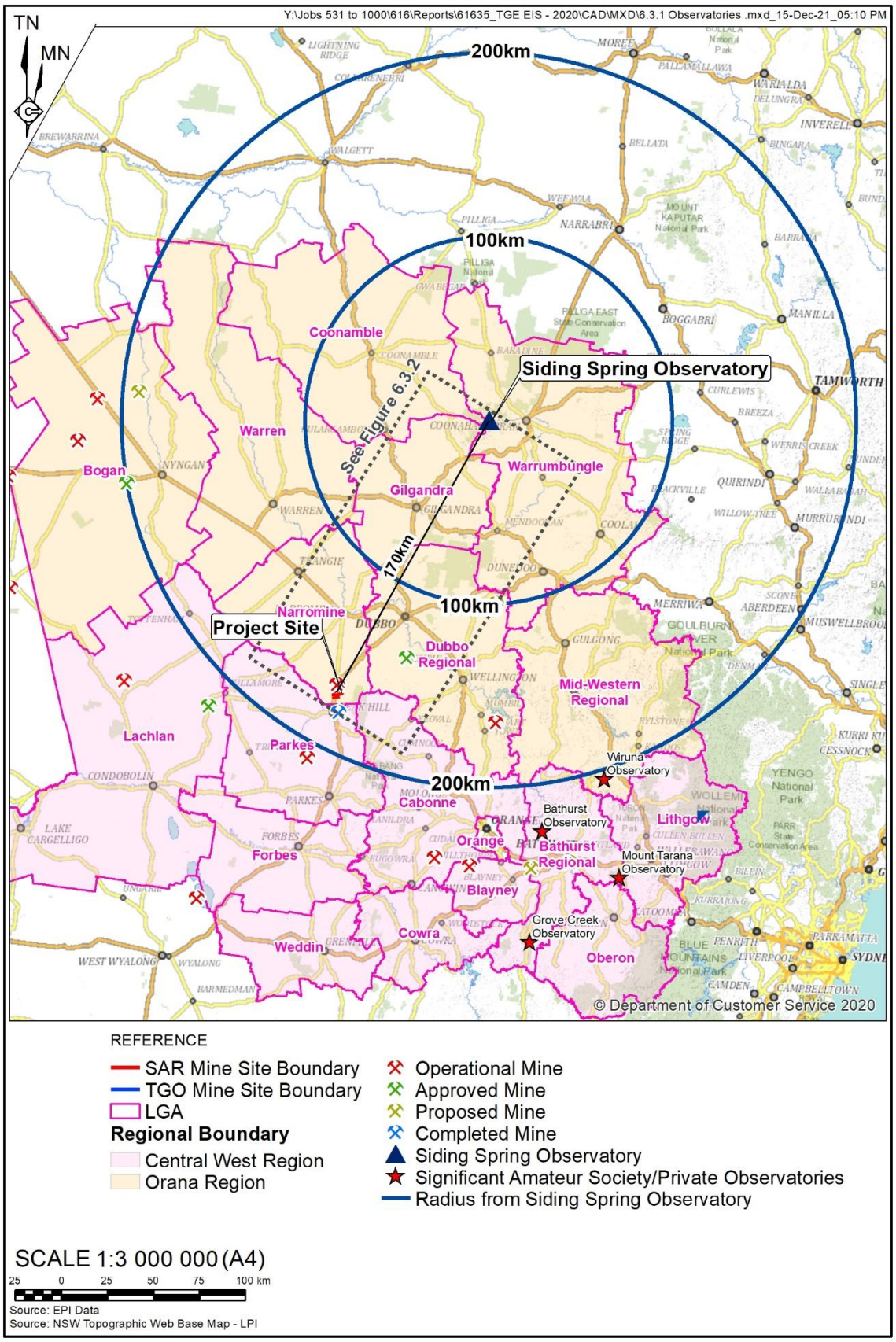


Figure 1 Location of the Project Site with respect to SSO

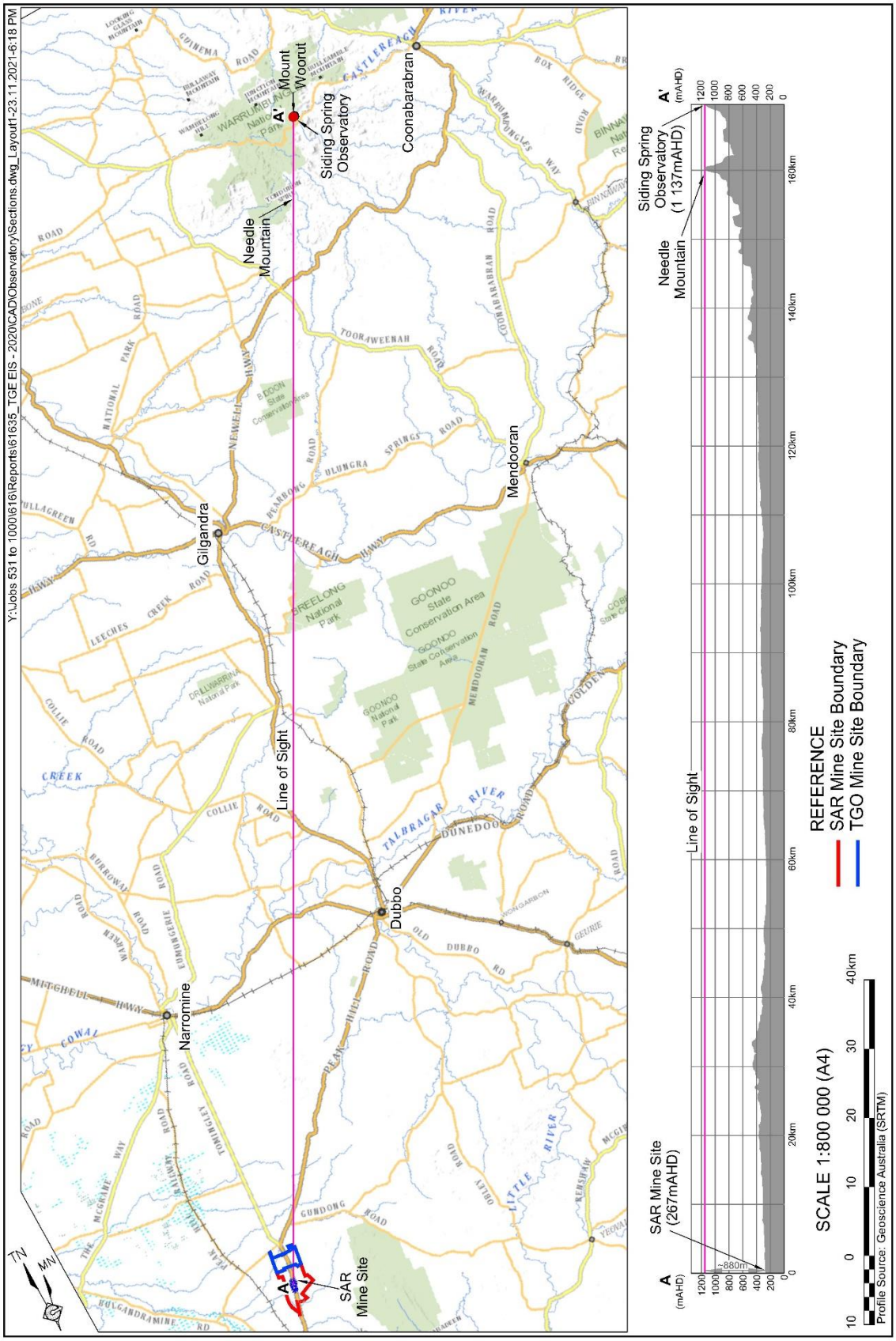


Figure 2 Elevation of the Project Site with respect to SSO

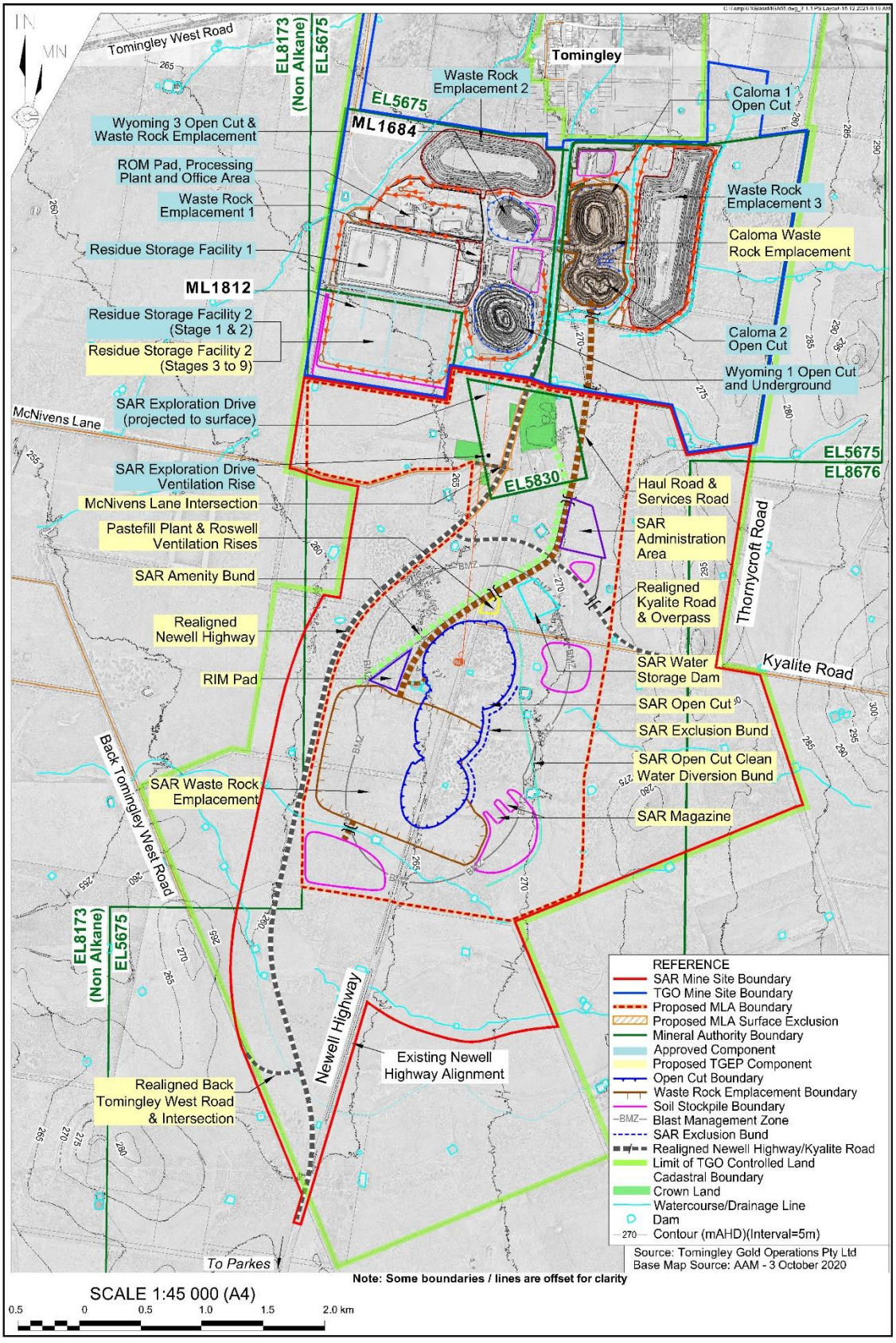


Figure 3 Site of the proposed extension (red) in relation to the existing Mine

2. SCOPE OF ASSESSMENT

The assessment is required by the Secretary's Environmental Assessment Requirements (SEARs) that state that the *Environmental Impact Assessment* for the Project considers the potential lighting impacts of the Project, including impacts on Siding Spring Observatory in accordance with the *Dark Sky Planning Guideline* and AS/NZS4282:2019[1] *Control of the obtrusive effects of outdoor lighting*.

The assessment is limited to the additional impact of the Project only. Where lighting would be relocated from the existing TGO Mine Site, it has not been included as it would have no additional impact.

Where the lights would be relocated with respect to the location of residences, this has been assessed.

AS/NZS 4282:2019: *Control of the obtrusive effects of outdoor lighting* includes new environmental categories for 'Intrinsically Dark', 'Dark' and 'Low District Brightness' areas. The Intrinsically Dark areas are the areas adjacent to research observatories and declared Dark Sky areas.

The Dark areas are natural bushland and National Parks and relatively uninhabited rural areas. The limits for these areas are much lower than the limits in the previous standard and address the need to preserve dark spaces and limit the impact on biota.

The Low District Brightness areas relate to sparsely populated areas, where the major impact is on the environment.

The impact of light on biota varies from species to species and a lighting solution for one species may be detrimental to another. There is considerable research on some species whereas for the majority of species that is little research and much of the information has little research backing.

As the Environmental Zones and Upward light limits were only introduced in the 2019 edition of AS/NZS 4282 the limits that would apply to the Project Site would be more stringent than those applied to the existing mines in the area.

It is acknowledged that different people will have a totally different opinion as to what is acceptable. One of the main purposes of AS/NZS 4282:2019 is to provide a benchmark for what people can reasonably be expected to accept.

[1] The SEARs for the Project specified AS4282-1997 *Control of the obtrusive effects of outdoor lighting*, however this was updated in 2019 and therefore this assessment is in accordance with the most recent version of this standard.

3. POLICIES, STANDARDS AND GUIDELINES

The following policies, standards, and guidelines are applicable to the Lighting and Sky Glow Assessment.

Environmental Planning and Assessment Regulation 2000[1]

Clause 92, Additional matters that consent authorities must consider, states that:

> *"(1) For the purposes of section 4.15(1)(a)(iv) of the Act, the following matters are prescribed as matters to be taken into consideration by a consent authority in determining a development application—*
>
> *(a) (Repealed)*
>
> *(b) in the case of a development application for the demolition of a building, the provisions of AS 2601,*
>
> *(c) in the case of a development application for the carrying out of development on land that is subject to a subdivision order made under Schedule 7 to the Act, the provisions of that order and of any development plan prepared for the land by a relevant authority under that Schedule,*
>
> *(d) in the case of the following development, the Dark Sky Planning Guideline—*
>
> *(i) any development on land within the local government area of Coonamble, City of Dubbo, Gilgandra or Warrumbungle Shire,*
>
> *(ii) development of a class or description included in Schedule 4A to the Act, State significant development or designated development on land less than 200 kilometres from the Siding Spring Observatory,"*

As the Project falls within the 200km zone, the Dark Sky Planning Guideline must be considered as part of the assessment for the Project.

Dark Sky Planning Guideline [2]

The Dark Sky Planning Guideline was published by the Department of Planning and Environment (DPE) and it referenced in the *Environmental Planning and Assessment Regulation 2000* above. The guideline informs the assessment of significant development within 200km of the SSO and provides guidance and technical information on good lighting design. The Project Site is located approximately 168km from the SSO.

State Environmental Planning Policy (Infrastructure) 2007[3]

Under Clause 16(2)(g) of the *State Environmental Planning Policy (Infrastructure) 2007*, the Project is determined to be a Specified Development as it is within 200km of the Siding Spring Observatory, and therefore the Director of the Observatory is a Specified Authority.

State Environmental Planning Policy (Exempt and Complying Development Codes) 2008[4]

Subdivision 13 of the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* lists the relevant LGAs to which the minimum standards outlined in the Dark Sky Planning Guideline are applicable. As the Narromine Shire is not listed in this subdivision, the *State Environmental Planning Policy (Exempt and Complying Development Codes) 2008* does not apply.

AS/NZS 4282:2019 Control of the obtrusive effects or outdoor lighting [5]

AS 4282:1997 was originally written to control the impact of sports lighting on the amenity of surrounding residents but has a much wider scope of application. It was republished in 2019 and includes restrictions for intrinsically dark areas and light emissions to the sky. The standard is not referred to in legislation but is commonly relied upon when formulating conditions of consent by local government and as a benchmark for what is reasonable.

AS/NZS 4282:2019 standard specifies limits for the vertical illuminance surrounding the Project Site, the upward light emitted and the glare from the luminaires. Although primarily written to limit the impact of light on people, the standard also includes limits relating to astronomy and the environment and, as such, is applicable to the Project.

The previous edition is referenced in The Dark Sky Planning Guidelines; however, it does not specify conformance.

AS 4282:1997 is listed in the table of “Coverage of Secretary’s Environmental Assessment Requirements”. We have based our analysis on AS/NZS 4282:2019.

CIE Technical Report 126:1997 *Guidelines for minimising Sky Glow* [6]

This was one of the first reference documents on the minimisation of sky glow. The guidelines set out in CIE Technical Report 126:1997 provide a good explanation of the basic concepts of sky glow and available mitigation measures. It is still current and has been the basis for many later documents.

IAU/CIE 001 *Guidelines for minimizing urban Sky Glow near astronomical observatories* [7]

This guideline overlaps with the CIE technical report but was produced in conjunction with the International Astronomical Union. It provides a more detailed account of the mechanisms and effects of Sky Glow.

4. LIGHTING TERMS AND CONCEPTS

4.1 INTRODUCTION

The following subsections provide a summary of lighting terms and concepts relevant to this report.

4.2 LIGHTING PARAMETERS

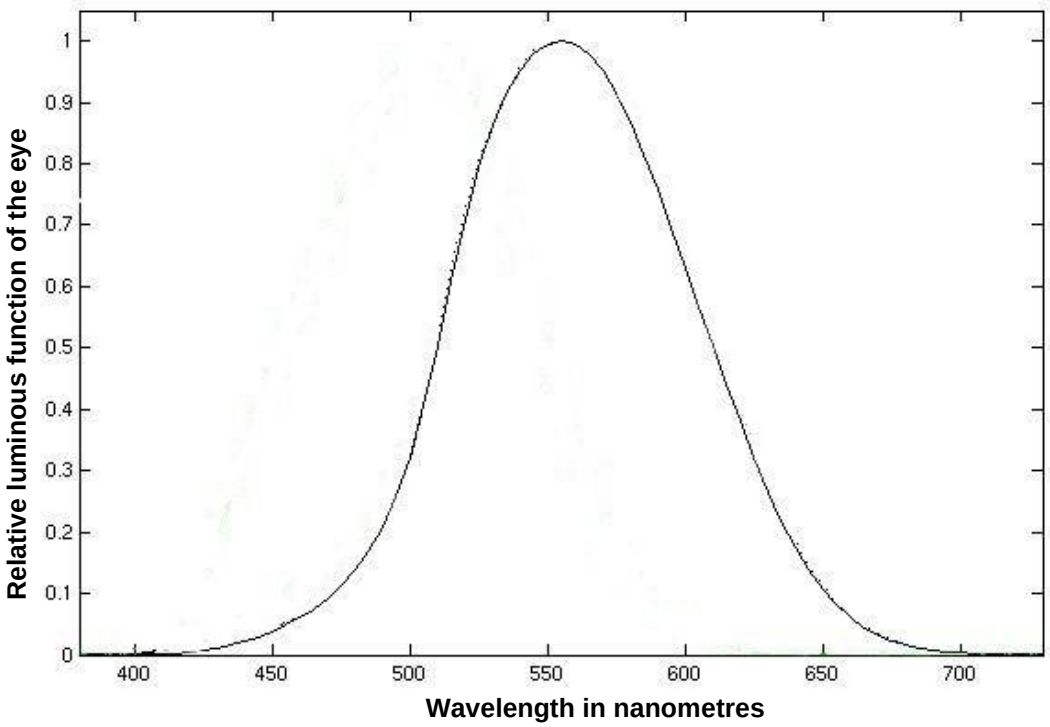
Visible Spectrum

The visible spectrum is the band of wavelengths of electromagnetic radiation that is visible to the human eye. This is normally accepted as the band between 380 (violet) and 740 (red) nanometres.

The eye does not have equal sensitivity across the visual spectrum. The spectral response of the eye is standardised as the V(ʎ) as shown in **Figure 4**.

The curve is the photopic response which occurs under normal lighting levels. The V(ʎ) curve shows the variation in the sensitivity of the eye at different wavelengths across the visual spectrum.

Figure 4 V(ʎ) Average Eye response



Light Source

A light source is any surface or object that emits light. The source may generate light, or it may reflect or transmit the light.

Radiant Flux

Radiant flux is the radiant energy emitted by a source, per unit time and is measured in **Watts**.

For the purpose of this study the radiant flux has been limited to the visible spectrum.

Radiant flux is not modified for the response of the human eye.

Luminous Flux

Luminous flux is the radiant flux emitted by a source, per unit time multiplied by V(ʎ) so that it reflects what is seen by the eye. Luminous flux is measured in **lumens**.

The luminous flux therefore understates the intensity of the red and blue end of the spectrum.

Luminous Intensity

Luminous intensity is the amount of luminous flux leaving the light source in a given direction.

It is measured in lumens/steradian or **candelas**.

Illuminance

Illuminance is the amount of light that falls on a surface or plane. The illuminance is independent of the characteristics of that surface or plane.

Illuminance from a small source reduces inverse proportionally to the square of the distance. As a result, the illuminance falls off rapidly with distance.

Illuminance is measured in Lumens/metre^2 or **lux**.

Luminance

The luminance is the amount of light leaving a surface. It may be reflected or transmitted.

The luminance is usually measured in **candelas/metre^2**.

Upward Light Ratio (ULR)

Upward Light Ratio is a light technical parameter used in AS/NZS 4282:2019 and other Australian external lighting standards.

It is defined as “The proportion of the flux of a luminaire and/or installation that is emitted at or above the horizontal, excluding reflected light, when the luminaire(s) is/are mounted in its installed position(s). ULR=upward flux/total flux from the luminaire”.[3]

Some standards also refer to it as Upward Waste Light Output Ratio (UWLR). The terms are interchangeable.

As ULR is a ratio, it is unitless.

The upward light limits were only introduced into AS/NZS4282 in 2019. As a result, this requirement did not apply to the existing TGO Mine Site.

Glare

Glare is any light that reduces the visual performance.

Correlated Colour Temperature (CCT)

This is an assessment of the colour appearance of the light source with reference to the appearance of a black body radiator at a specific temperature. While it is indicative of the tendency of the light to warm or cool, it does not provide definitive information with respect to the spectral distribution.

It assumes that the light source colour is close to white.

CCT is expressed in **Kelvin** units (K). Kelvin is a temperature scale. The units are the same as Celsius except that Kelvin uses absolute zero as a base rather than the freezing point of water.

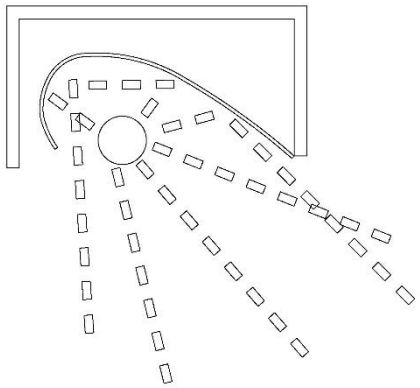
Luminaire

Luminaire is the technical term for a light fitting, and it includes the light source, the enclosure and optical control mechanism and the control equipment.

Forward Throw Luminaire

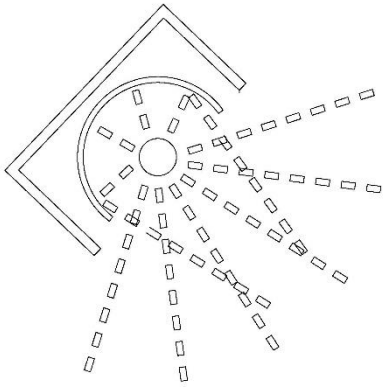
A forward throw luminaire is a fitting designed to be mounted with the front glass near horizontal and use reflectors or lenses to project the light forward without having to raise the tilt or upcast of the fitting. These fittings have minimal upward light contribution when used as designed (see **Figure 5**).

Figure 5 Forward Throw Floodlight



A luminaire with a symmetrical distribution throws the same amount of light above and below the axis of the luminaire. Because the peak intensity is perpendicular to the glass the luminaire has to be tilted up to light the area in front the of the luminaire. As a result, a significant part of the light is projected into the sky (see **Figure 6**).

Figure 6 Symmetrical Distribution Floodlight



A forward throw luminaire is also more efficient as less light is wasted.

4.3 REFLECTANCE

Reflectance is a property of a surface that determines the proportion of light that is reflected, transmitted or absorbed by the surface. The sum of the reflectance and absorption is 1.

The reflectance is the ratio of the reflected light divided by the incident light, expressed as a unitless decimal.

As the transmittance of these materials is zero, the absorptance is 1 minus the reflectance.

Diffuse reflection

A true diffuse (Lambertian) surface scatters the light uniformly in all directions independent of the angle of incidence of the light. The reflectance is related to the density of the colour of the surface. A perfect white surface will have a reflectance of 1 whereas a perfect black surface will have a reflectance of 0.

The relationship between illuminance and luminance for a perfect diffuser is:

Luminance of the surface = Illuminance x Reflectance/π

Specular reflection

A specular surface is a mirror like surface where there is a real image of the light source visible in the surface. The angle of reflection is equal to the angle of incidence.

Luminance of the image = Luminance of the source x Reflectance.

This relationship only applies to area of the surface where the image can be seen.

Most real surfaces are a combination of specular and diffuse properties in varying degrees.

Colour and Reflection

The colour of an object is function of the spectral response of the material.

An object has a specific colour because the surface absorbs all wavelengths in the light other than those of the object. The spectral response of the material is constant however the colour appearance of the surface will change with the spectral distribution of the incident light. The spectral response of the material also affects the spectral composition of the reflected light. As a result, different coloured surfaces will affect the spectral content of the reflected light. For example, if light that is predominately blue is reflected off a red object the reflectance would be much lower than the same light on a blue surface, even though they may have the same reflectance under white light. The light that is reflected off the surface will also have a much lower blue content as it has been absorbed by the surface.

4.4 SKY GLOW

Sky glow is the brightening of the night sky that results from the reflection of radiation (visible and non-visible), scattered from the constituents of the atmosphere (gas molecules, aerosols and particulate matter) in the direction of observation. It comprises two separate components. [5]

1. Natural sky-glow - that part of the sky-glow which is attributable to radiation from celestial sources and luminescent processes in the Earth's upper atmosphere. [5]

2. Man-made sky-glow - that part of the sky-glow which is attributable to man-made sources of radiation (e.g. artificial outdoor lighting), including radiation that is emitted directly upwards and radiation that is reflected from the surface of the Earth. [5]

Units

"Lighting engineering and astronomy both rely on photometry. The fundamentals are the same, but the conventions and the practical units differ. In lighting engineering, photometric units are usually related to photopic vision."

"In astronomy, the visual classification of cosmic objects is based on the 'magnitude' of the luminous objects like e.g. stars as they present themselves to the (mesopic) eye.

The magnitude scale is essentially a logarithmical one, where the magnitude difference of 5 relates to a flux ratio of 100." [5]

There is therefore not direct conversion factor between magnitude and cd/m^2.

Upcast

The angle of adjustment of the luminaire in the vertical plane above the horizontal, face down position; also referred to as tilt.

5. METHODOLOGY

5.1 INTRODUCTION

The sky glow information required by the Dark Sky Planning Guideline [2] for the assessment by the SSO requires the total luminous flux (lumens) generated by the installation. This is an overall figure and is independent of where the lights are aimed. It is a reasonably rough tool but is designed principally as a screening test.

In addition to this information, we have measured the reflectance of the ground material and, using the typical aiming of the lighting on site, we have calculated the actual lumens that enter the sky either directly or by reflectance. This is a better indication of the impact of the installation on sky glow.

AS/NZS4282:2019 has a different approach to the control for the obtrusive light.

The standard principally addresses the impact of the lighting on things at ground level including the impact on residential dwellings and drivers on roads.

The skyglow is calculated on the basis of the proportion of the light from the luminaires, in their normal aiming position, that directly leaves above the horizontal plane. This is the Upward Light Ratio.

None of the AS/NZS4282:2019 calculations include light reflected from the ground or other objects.

5.2 BACKGROUND INFORMATION

The following background information was provided by the Applicant.

a) Project Site Layout.

b) Topographical cross-section showing the elevation and obstructions between SSO and the Project Site.

c) Topographical map of the area showing the location of residential buildings.

d) Scenario for the progressive establishment of the emplacement mounds and access roads.

e) Details of the proposed and reused lighting.

f) Samples of the ore and waste rock be mined.

g) Information of the existing tower light to be reused.

This information is included as **Annexure A**.

Independently LAS has sourced:

h) Photometric data to enable the modelling.

Typical luminaire information is included as **Annexure B**.

5.3 SITE INSPECTION

The Project Site was not inspected due to covid restrictions. The assessment was based on the information and set of specific site photos requested by LAS.

5.4 LOCAL ENVIRONMENT LIGHTING CRITERIA

The local environment is principally controlled by the requirements of AS/NZS 4282:2019 which recommends limits for specific light technical parameters based on the ambient lighting conditions.

LAS considers that the current edition of AS/NZS 4282:2019 adequately addresses the requirements for a rural environment.

5.4.1 Environmental Zone

AS/NZS 4282:2019 nominates 11 Environmental Zones – see **Table 1**.

Table 1
Environmental Zones Identified in AS/NZS 4282:2019[3]

Zones	Description	Examples
A0	Intrinsically dark	UNESCO Starlight Reserve. IDA Dark Sky Parks. Major optical observatories No road lighting -unless specifically required by the road controlling authority
A1	Dark	Relatively uninhabited rural areas No road lighting - unless specifically required by the road controlling authority
A2	Low district brightness	Sparsely inhabited rural and semi-rural areas
A3	Medium district brightness	Suburban areas in towns and cities
A4	High district brightness	Town and city centres and other commercial areas Residential areas abutting commercial areas
TV	High district brightness	Vicinity of major sports stadium during TV broadcasts
V	Residences near traffic routes	Refer AS/NZS 1158.1.1
R1	Residences near local roads with significant setback	Refer AS/NZS 1158.3.1
R2	Residences near local roads	Refer AS/NZS 1158.3.1
R3	Residences near a roundabout or local area traffic management device	Refer AS/NZS 1158.3.1
RX	Residences near a pedestrian crossing	Refer AS/NZS 1158.4
Source: AZ/NZ 4282:2019 – Table 3.1		

Based on **Table 2**, the area immediately surrounding SSO would be classified as an A0 zone as it is a Dark Sky Park, the area within the village of Tomingley would be an A3 zone. The Project Site and surrounding area would be an A2 zone.

The A0 and A1 zones are assumed to be virtually unpopulated by humans. As a result, the levels that are set primarily relate to minimising the impact on other biota and to maintaining a dark environment. As the Project Site surroundings have been assessed to be within an A2 Zone, the required limits in AS/NZS4282:2019 adequately protect the night environment of the area surrounding the Project Site.

5.4.2 Curfew

AS/NZS 4282:2019 also specifies a curfew period between 11:00pm and 6:00am when a lower set of limits are specified.

An assessment for both the pre-curfew and curfew periods has been undertaken at the Project Site boundary. The curfew limits are required to be calculated at the windows of habitable rooms of the buildings, however if the limits are achieved at the Project Site boundary it is deemed that they will comply beyond that point.

5.4.3 Light Technical Parameters

The light technical parameters that are controlled by AS/NZS 4282:2019 are listed in **Tables 2** and **3**.

Table 2
Maximum Values of Light Technical Parameters in AS/NZS 4282:2019 [3]

	Vertical illuminance levels (E_v) lx		Threshold increment (*TI*)		Sky glow
Zones	**Non-curfew**	**Curfew**	**%**	**Default adaptation level (L_{ad})**	**Upward light ratio**
A0	See Note 1	0	N/A	N/A	0
A1	2	0.1	N/A	N/A	0
A2	5	1	20%	0.2	0.01 (1%)
A3	10	2	20%	1	0.02 (2%)
A4	25	5	20%	5	0.03 (3%)
TV	N/A	N/A	20%	10	0.08 (8%)
V	N/A	4	Note 2	Note 2	Note 2
R1	N/A	1	20%	0.1	Note 3
R2	N/A	2	20%	0.1	Note 3
R3	N/A	4	20%	0.1	Note 3
RX	N/A	4	20%	5	Note 4

Note: Grey colour indicates values applicable to the Project Site.
Source: AZ/NZ 4282:2019 – Table 3.2

Table 3
Maximum Luminous Intensities per Luminaire in AS/NZS 4282:2019[3]

	Luminous intensity (*I*), cd		
Zone	**Non-curfew L1**	**Non-curfew L2**	**Curfew**
A0	See Note	See Note	0
A1	2 500	5 000	500
A2	7 500	12 500	1 000
A3	12 500	25 000	2 500
A4	25 000	50 000	2 500
TV	100 000	150 000	0

Note: Grey colour indicates values applicable to the Project Site.
Source: AZ/NZ 4282:2019 – Table 3.3

5.4.3.1 Vertical Illuminance

The non-curfew vertical illuminance is calculated in the vertical plane at the Project Site boundary facing inward. Due to the presence of the proposed SAR Amenity Bund (**Figure 3**) which would minimise the visual impact of the Project, the vertical illuminance has been calculated outside of the SAR Amenity Bund. Vertical illuminance is calculated on a grid of points from the ground to the highest light luminaire or light distribution of the luminaire. For the purposes of this assessment, vertical illuminance has been calculated to 90m above ground level.

The curfew vertical illuminance it calculated at the windows of habitable rooms.

If the curfew vertical illuminance is achieved at the Project Site boundary, there is no need to calculate it at the individual windows as they are much further away.

The limits for A2 would be 5 lux and 1 lux, respectively.

5.4.3.2 Threshold Increment

Threshold increment (TI) is a measure of the disability glare caused by the lighting to drivers of vehicles outside the site.

The TI is calculated using the illuminance at the eye of the driver from the light sources compared with the background luminance. The magnitude is also reduced as the angle of offset from the driver's direction of view increases.

The calculation also ignored the amenity bund at the top of the emplacement mound.

The TI was calculated for SAR Waste Rock Emplacement mound heights at ground level, 20, 40 and 70 metres with two towers on the top of the mound.

The TI was calculated for the Coloma Waste Rock Emplacement mound at ground level, 15, 30 and 40 metres.

The lights on the Project Site would be too far from the local roads to be relevant for threshold increment and the Newell Highway would be protected by the SAR Amenity Bund.

5.4.3.3 Upward Light Ratio

Upward light ratio limits the light emitted into the sky to limit the impact on sky glow. For an A2 zone, the limit is 0.01 (1%) This does not mean that there is no light emitted into the sky because the calculations in AS/NZS 4282:2019 do not include the light reflected off surfaces.

5.4.3.4 Luminous Intensity

This is an indication of the glare caused to people located outside of the Project Site, who have direct view of the lights within the Project Site.

The limits for an A2 zone would be 7,500cd and 1,000cd, respectively.

There is good correlation between luminous intensity and glare for lights with a small source within a range of a few hundred metres. The correlation is not as accurate when the light source is large or the distance to the light source is large.

5.4.4 Conformance to AS/NZS 4282:2019

Conformance calculations for AS/NZS 4282:2019 were carried out using AGi32 Version 20.4, a high-end industry standard lighting software package which has a specific module for calculation of obtrusive light to AS/NZS 4282:2019.

5.5 SUPPLEMENTARY ASSESSMENT

The impact on the village of Tomingley would be minimal as mining activity and the associated lighting would be moving further from the township. It will therefore not be considered further in this assessment.

5.6 ASTRONOMICAL OBSERVATIONS

The requirements for the SSO are different to the local environment as they are concerned about light much higher in the atmosphere. The standard angle for assessment for the observatory, nominated in the Dark Sky Planning Guideline [2] is 30 degrees above the horizontal. This would mean that this would be 93km above the Project Site.

5.6.1 Upward Light Ratio

The ULR has been calculated as part of the AS4282:2019 assessment for the local environment (see Section 5.4). This is also applicable for the SSO assessment.

5.6.2 Total Lumens Produced

This is a total lumen output of all the additional external fittings that would likely be used on the Project Site. It does not take into account the aiming, shielding or the efficiency of the fittings. It is only useful as an overall benchmark of the size of the Project.

5.6.3 Reflectance of the Ground

LAS has measured the reflectance of samples of the anticipated waste rock from the SAR Mine Site to determine the amount of light that would be reflected into the sky. The samples were taken from the cores so that it also indicates how the reflectance of the material may vary as the pit becomes deeper. Refer Annexure A3.

The reflectance measurements were taken on the smooth cut face of the rock sample as this represents the likely maximum reflectance value. This would be applicable if the Project Site was a perfectly flat plane of that colour. In practice the stockpiled ore and waste rock would be stacked as rough pieces. This means that the actual average reflectance would be much lower as much of the light will be trapped within the crevices between the rocks and the finer crevices on the surface of the rocks so that the reflectance measurements of the rock are very conservative.

There may be some oxidation of the rock on the surface of the emplacement mound, however it is our opinion that the increase in the reflectance of the rock would be less than the conservative assessment above.

Wetting the rock would further reduce the reflectance of the rock.

As the colour of the material affects the spectral distribution of the reflected light, LAS has measured the CCT of the incident light source and that of the light leaving the sample. If the CCT of the reflected light is lower, it can represent a reduction in the blue content of the light.

5.6.4 Total Upward Lumens

Although the total lumens is the common way of indicating the magnitude or the lighting installation, it is not a particularly good indicator of the impact on SSO as this is dependent on how much light is directed into the sky and how much is reflected from the ground. We have calculated the total upwards lumens by subtracting the light that is absorbed by the ground from total lumens.

6. ASSESSMENT

6.1 SITE INFORMATION

Due to Covid restrictions we were not able to physically inspect the Project Site, and have based the analysis on the information provided by the Applicant on the Project and existing TGO Mine Site.

The information provided is included in **Annexure A** and is summarised as follows.

a) There would be no fixed lighting or buildings on the SAR Mine Site other than a small Administration Area (**Figure 3**).

b) The lighting would be provided by mobile lighting towers, and all mobile lighting towers would be sourced from existing units from the TGO Mine Site. There would be no additional mobile lighting towers, however the replacement of existing units may occur due to maintenance or other issues.

c) The existing mobile lighting towers are Promac Prolite LED towers with 6 LED heads and a total of 2400Watts. The maximum height of the mobile lighting towers are 7.5 metres. We have not been provided with the CCT or photometric information for the existing mobile lighting towers.

d) There would be a maximum of 10 mobile lighting towers operating at any given time, with an approximate split of 6 located in the operational areas of the open cut pits and 4 located within the operational areas of the surface, namely the SAR Waste Rock Emplacement (**Figure 3**). The mobile lighting towers would be facing into the Project Site. The positioning of the mobile lighting towers would be relocated according to the area of work.

e) All Project-related vehicles would use standard headlights only. Roads on the Project Site would be unlit.

f) The primary operational areas of the Project Site would be surrounded by the SAR Amenity Bund on the south, west and north of the SAR Mine Site. The location of the SAR Amenity Bund is indicated on **Figure 3**. The SAR Amenity Bund would have a maximum height of 7 meters above ground level.

g) There would be an Administration Area as part of the Project Site (**Figure 3**). This would have external lighting. The buildings have not been designed yet, however an indicative layout and lighting points has been provided based on the existing layout and lighting of the TGO Mine Site

6.2 MOBILE LIGHTING TOWERS

The information provided by the Applicant indicates that the mobile lighting towers currently used at the TGO Mine Site are Promac Prolite 75H2400W-6LEDDC-CHN.

We have not been able to source photometric data for these mobile lighting towers as the model is superseded and Promac no longer appear to be in business. The telephone number is disconnected, and their web address is unresponsive.

We have calculated the overall luminous flux output based on the known wattage and typical efficacy (lumens/Watt) for similar luminaires.

The beam spread of the units is more difficult to determine as the information on the data sheet is for the whole unit and does not indicate how the individual heads are aimed.

The distribution is important as it affects the light technical parameters:

- The narrower the beam the higher the luminous intensity but also the less upward light output
- The narrower the beam the higher the vertical illuminance at the calculation plane, but the smaller the area affected.
- A wide horizontal beam reduces the intensity at any angle and therefore reduces the obtrusive impact.
- The width of the vertical beam is significant as it impacts the upward light.

In the absence of specific light distribution information, we have modelled the lighting with both 30 degree and 60 degree symmetrical distribution.

The 30 degree distribution will give a higher vertical illuminance and luminous intensity while the 60 degree distribution will give a higher upward light component.

6.3 WASTE ROCK EMPLACEMENTS

There would be two additional Waste Rock Emplacement mounds that would be constructed as part of the Project; one located within the existing and approved Caloma Open Cut Pits within the TGO Mine Site, and another within the SAR Mine Site.

The SAR Waste Rock Emplacement indicated on Figure 3 would progressively grow to a height of 70 metres.

The Coloma Waste Rock Emplacement would rise to a height of approximately 38 metres.

Both Waste Rock Emplacements would have an amenity bund wall around the upper working area to help obscure the vision of the activities.

This amenity bund would be constructed during daylight hours so there would be no lighting impact of the construction of the bund wall.

The bund wall would obscure the view of the lighting towers and headlights on the top of the waste rock emplacement from the north, south and west.

We have assessed the vertical illumination at the perimeter and the threshold increment at different heights, without the bund wall, at various heights each of the Waste Rock Emplacement mounds, as this is a more conservative approach.

We have also calculated the vertical illuminance and luminous intensity at a selection of typical residential buildings close to the Project Site.

Several scenarios for the Waste Rock Emplacements are included in Annexure A.

6.4 REFLECTANCE MEASUREMENTS AND OBSERVATIONS

LAS was supplied with a set of samples of the rock from drill cores of the proposed SAR Mine Site. Samples were selected to represent different depths in the proposed open cut pits.

The reflectance of the samples was measured against a sample of known reflectance and the CCT of the incident light and reflected light was measured.

Table 4 lists the measured reflectance and change in CCT.

Table 4
Reflectance and change in CCT of sample rocks

	Correlated Colour Temperature (CCT)	Reflectance
Reference	3828	
RWD003 172.4-172.47	3510	0.49
RWD003 313.11-313.19	3727	0.32
RWD005 225.75-225.80	3671	0.46
RWD025 262.4-262.46	3577	0.24
Average	3621	0.37
Change in CCT	-207	

The rock samples have an average reflectance between 0.24 and 0.49. LAS used an average of 0.37 to calculate the reflected light into the atmosphere.

The CCT indicates that the reflected light from the rock reduces the CCT by an average of 207K. This would indicate a warming upward light and a reduction on the blue content.

6.5 LIGHTING EQUIPMENT

Table 5 presents the indicative list of mobile and fixed lighting equipment that would be used for the Project. As much of the lighting required for the Project is being transferred from the existing TGO Mine Site to the SAR Mine Site, it the only new lighting that would have an additional impact on the SSO.

Table 5
Schedule of Lighting Equipment

Light	Quantity	Wattage	Luminous Flux per tower (lumens)	Total Flux (lumens)	New/Existing
Light Tower	10	2400	336,000	3,360,000	Existing
Admin Building					
Small Area Lights	4	70	14,000	56,000	New
Large Area Lights	4	400	56,000	224,000	New
Maintenance Shed					
External lighting	10	150	21,000	210,000	New
Mill Extension	20	17	2,380	47,600	New
TOTAL LUMENS				3,897,600	Total
TOTAL ADDITIONAL LIGHT TO THE SITE				537,600	New

It is anticipated that the Project would consist of the same type of vehicles as that used for the existing fleet of mining-related vehicles at the TGO Mine Site. The number of trucks would vary throughout the life of the operation with the maximum number of 21 haulage trucks in 2026. All the mining-related vehicles are fitted with standard headlights and light fittings.

From SSO the headlights will be indistinguishable from the trucks on the adjacent Newell Highway.

As can be seen from **Table 5**, the Project would generate a total luminous flux of 537,600 lumens.

AS/NZS4282:2019, requires that for an A2 Environmental Zone, the maximum light emitted from the luminaires, in their aiming positions, is 1% of the total light emitted by the luminaires.

This mean that only 5,376 lumens would be emitted directly into the sky and the remaining light being reflected off the ground. As the ground reflectance is approximately 0.37, the total reflected light would be approximately 196,922 lumens giving a total upward lumens of approximately 202,300 lumens.

6.6 AS/NZS 4282:2019 CALCULATIONS

A model of the Project Site was built in AGi32-20.4. The program was used to calculate the light technical parameters for the obtrusive light conformance.

While the relocation of the mobile lighting towers would have negligible impact on SSO, due to the distance, the lighting may have an impact on the local residences and the environment.

The difficulty in calculating this is that there would be no fixed location for the mobile lighting towers and the six heads on the mobile lighting towers can be directed in different directions.

Initially all ten towers would be at ground level but six would drop with the pit level and would not be visible from outside the Project Site once the level of the pit drops.

The SAR Amenity Bund would be 7 meters above ground level, compared to the maximum height of the mobile lighting towers which is 7.5 metres. As a result, even when the towers are at ground level, the lights would only be visible over the SAR Amenity Bund from an elevated position. The ground to the west and south is lower than the Project Site.

The mobile lighting towers on the Waste Rock Emplacements would be located on the upper operational surface, however the amenity bund around the top of the Waste Rock Emplacement would obscure the view of the lights to the south and the west.

As there would be no direct vision of the mobile lighting towers from the Newell Highway, there can be no Threshold Increments implications.

As the lighting locations are not fixed, we have placed six mobile lighting towers in the pit and the other four mobile lighting towers in the surrounding area. Within the pit we have aimed the lights towards the pit wall. The lights outside the pit have been aimed to cover a wider area. We have included some of the lights facing the boundaries.

We have calculated the lighting for 30 and 60 degree beam spreads with angles of upcast of 30, 45 and 60 degrees. We also calculated an intermediary angle between 45 and 60 degrees to indicate the angle at which non-conformance occurred.

The actual luminaire would appear to have a wider beam than the height of the beam. This would give better ground coverage and throw less light into the sky.

The 60 degree beam luminaire is therefore a conservative substitute since, as the luminous flux of the luminaire is fixed, as the beam width is extended there is less light to be directed into the sky and the luminous intensity at the higher angles would also reduce.

As the mobile lighting tower has six heads, each with eight lights, and the total power rating is 2400Watts, the individual light is 50 watts.

In the absence of specific photometric information, we have used high performance We-ef floodlights of similar output in the model. The diameter of the We-ef luminaire is approximately double that Promac luminaire, however the luminous intensity is independent of luminaire size.

We also modelled luminaires for the Administration Area within the SAR Mine Site and extension to the Mill withing the TGO Mine Site.

As there are no lights designed for the facilities at this stage, we included the number of luminaires indicated in **Table 5** in appropriate area for each facility.

The luminaire information is included in **Annexure B**.

Table 6 shows the light technical parameters limits required by AS/NZS 4282: 2019 and the calculated results for the Project.

The calculations have ignored the obstruction provided by the SAR Amenity Bund, the waste rock emplacement bunds or other obstructions. The calculations do take into account the respective elevation of the lights and the surrounding houses.

Although the curfew limits apply at the windows of habitable rooms, we have calculated them at the Project Site boundary. If the levels at the Project Site boundary conform to the curfew limit then it is assumed that any point beyond the boundary would still conform.

Table 6 assumes that all the lights are at ground level.

Tables 7 & 8 assess the potential impact of the increase in the height of the Mobile Lighting Towers upon the operational surfaces of the Waste Rock Emplacement mounds

Table 6
AS/NZS4282:2019 Conformance for various upcast angles

	AS/NZS 4282: 2019 Criteria		AGi32 calculations	
	Pre-curfew	**Curfew**	**Pre-curfew**	**Curfew**
Parameter	**Environmental Zone A2**		**Maximum calculation point**	
Run 1 – 30 degree beam width – 30 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0016 lux	0.0016 lux
Luminous Intensity	7500 cd	1000 cd	35 cd	35 cd
ULR	1.0%	1.0%	0.0%	0.0%
Conformance			Conforms	Conforms
Run 2 – 30 degree beam width – 45 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0048 lux	0.0048 lux
Luminous Intensity	7500 cd	1000 cd	90 cd	90 cd
ULR	1.0%	1.0%	0.4%	0.4%
Conformance			Conforms	Conforms
Run 3 – 30 degree beam width – 55 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0104 lux	0.0104 lux
Luminous Intensity	7500 cd	1000 cd	221 cd	221 cd
ULR	1.0%	1.0%	0.8%	0.8%
Conformance			Conforms	Conforms
Run 4 – 30 degree beam width – 60 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0264 lux	0.0264 lux
Luminous Intensity	7500 cd	1000 cd	552 cd	552 cd
ULR	1.0%	1.0%	1.2%	1.2%
Conformance			Refer Note 1	Refer Note 1

Table 6 (Cont'd)
AS/NZS4282:2019 Conformance for various upcast angles

Parameter	AS/NZS 4282: 2019 Criteria		AGi32 calculations	
	Pre-curfew	Curfew	Pre-curfew	Curfew
	Environmental Zone A2		Maximum calculation point	
Run 5 – 60 degree beam width – 30 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0024 lux	0.0024 lux
Luminous Intensity	7500 cd	1000 cd	45 cd	45 cd
ULR	1.0%	1.0%	0.1%	0.1%
Conformance			Conforms	Conforms
Run 6 – 60 degree beam width – 45 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0112 lux	0.0112 lux
Luminous Intensity	7500 cd	1000 cd	262 cd	262 cd
ULR	1.0%	1.0%	0.6%	0.6%
Conformance			Conforms	Conforms
Run 7 – 60 degree beam width – 49 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.0296 lux	0.0296 lux
Luminous Intensity	7500 cd	1000 cd	643 cd	643 cd
ULR	1.0%	1.0%	1.0%	1.0%
Conformance			Refer Note 1	Refer Note 1
Run 8 – 60 degree beam width – 60 degree upcast				
Vertical Illuminance	5 lux	1 lux	0.148lux	0.148lux
Luminous Intensity	7500 cd	1000 cd	3197 cd	3197 cd
ULR	1.0%	1.0%	4.6%	4.6%
Conformance			Refer Note 1	Refer Notes 1& 2

Note1: The Upward Light Ratio exceeds the AS/NZS4282 limit at this angle of upcast.

Note 2: The curfew luminous intensity has been calculated at the same location as the non-curfew level. AS/NZS4282:2019 specifies that the curfew levels should be calculate at the windows of habitable rooms so the where the luminous intensity above exceeds the curfew limit it is not non-conformance unless the luminous intensity also exceeds the limit at one of the windows of a habitable room.

6.6.1 SAR Waste Rock Emplacement

To consider the impact of the change in height of the lights as the rock emplacement mound increases in height we have repeated the 60 degree beam width, 49 degree upcast option for elevations above ground level of 20, 40 and 70 metres. In addition, we have calculated the Threshold Increment for the Newell Highway and Kyalite Road.

These results are shown in Table 7.

Table 7
AS/NZS4282:2019 Conformance SAR Waste Rock Emplacement
Changes in Waste Rock Emplacement mound height

	AS/NZS 4282: 2019 Criteria		AGi32 calculations	
	Pre-curfew	Curfew	Pre-curfew	Curfew
Parameter	Environmental Zone A2		Maximum calculation point	
Run 11 – 60 degree beam width – 49 degree upcast – Ground Level				
Vertical Illuminance	5 lux	1 lux	0.0296 lux	0.0296 lux
Luminous Intensity	7500 cd	1000 cd	643 cd	643 cd
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	0.63%	0.63%
Conformance			Conforms	Conforms
Run 12 – 60 degree beam width – 49 degree upcast – 20m				
Vertical Illuminance	5 lux	1 lux	0.0312 lux	0.0312 lux
Luminous Intensity	7500 cd	1000 cd	771 cd	771 cd
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	0.63%	0.63%
Conformance			Conforms	Conforms
Run 13 – 60 degree beam width – 49 degree upcast – 40m				
Vertical Illuminance	5 lux	1 lux	0.0328 lux	0.0328 lux
Luminous Intensity	7500 cd	1000 cd	910 cd	910 cd
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	0.63%	0.63%
Conformance			Conforms	Conforms
Run 14 – 60 degree beam width – 49 degree upcast – 70m				
Vertical Illuminance	5 lux	1 lux	0.034 lux	0.034 lux
Luminous Intensity	7500 cd	1000 cd	1170 cd	1170 cd Refer Note 1
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	1%	1%
Conformance			Conforms	Conforms

Note1: The curfew luminous intensity has been calculated at the same location as the non-curfew level. AS/NZS4282:2019 specifies that the curfew levels should be calculate at the windows of habitable rooms so the where the luminous intensity above exceeds the curfew limit it is not non-conformance unless the luminous intensity also exceeds the limit at one of the windows of a habitable room.

6.6.2 Coloma Waste Rock Emplacement

To consider the impact of the change in height of the lights as the Caloma Waste Rock Emplacement mound increases in height we have repeated the 60 degree and 30 degree beam width, 49 degree upcast option for elevations above ground level of 0, 15, 30 and 40 metres. In addition, we have calculated the Threshold Increment for the Newell Highway and Kyalite Road.

These results are shown in Table 8.

Table 8
AS/NZS4282:2019 Conformance Coloma Waste Rock Emplacement
Changes in Waste Rock Emplacement mound height

	AS/NZS 4282: 2019 Criteria		AGi32 calculations	
	Pre-curfew	**Curfew**	**Pre-curfew**	**Curfew**
Parameter	**Environmental Zone A2**		**Maximum calculation point**	
Run 21 – 30 degree beam width – 49 degree upcast – Ground Level				
Vertical Illuminance	5 lux	1 lux	0.0072 lux	0.0072 lux
Luminous Intensity	7500 cd	1000 cd	157 cd	157 cd
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	0.29%	0.29%
Conformance			Conforms	Conforms
Run 22 – 30 degree beam width – 49 degree upcast – 15m				
Vertical Illuminance	5 lux	1 lux	0.0072 lux	0.0072 lux
Luminous Intensity	7500 cd	1000 cd	157 cd	157 cd
ULR	1.0%	1.0%	0.5%	0.5%
TI	20%	20%	0.3%	0.3%
Conformance			Conforms	Conforms
Run 23 – 30 degree beam width – 49 degree upcast – 30m				
Vertical Illuminance	5 lux	1 lux	0.0072 lux	0.0072 lux
Luminous Intensity	7500 cd	1000 cd	173 cd	173 cd
ULR	1.0%	1.0%	0.5%	0.5%
TI	20%	20%	0.3%	0.3%
Conformance			Conforms	Conforms
Run 24 – 30 degree beam width – 49 degree upcast – 40m				
Vertical Illuminance	5 lux	1 lux	0.0072 lux	0.0072 lux
Luminous Intensity	7500 cd	1000 cd	185 cd	185 cd
ULR	1.0%	1.0%	0.5%	0.5%
TI	20%	20%	0.29%	0.29%
Conformance			Conforms	Conforms
Run 31 – 60 degree beam width – 49 degree upcast – Ground Level				
Vertical Illuminance	5 lux	1 lux	0.0344 lux	0.0344 lux
Luminous Intensity	7500 cd	1000 cd	1166 cd	1166 cd Refer Note 1
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	1%	1%
Conformance			Conforms	Conforms

Table 8 (Cont'd)
AS/NZS4282:2019 Conformance Coloma Waste Rock Emplacement
Changes in Waste Rock Emplacement mound height

	AS/NZS 4282: 2019 Criteria		AGi32 calculations	
	Pre-curfew	Curfew	Pre-curfew	Curfew
Parameter	Environmental Zone A2		Maximum calculation point	
Run 32 – 60 degree beam width – 49 degree upcast – 15m				
Vertical Illuminance	5 lux	1 lux	0.0344 lux	0.0344 lux
Luminous Intensity	7500 cd	1000 cd	1170 cd	1170 cd Refer Note 1
ULR	1.0%	1.0%	1.0%	1.0%
TI	20%	20%	1%	1%
Conformance			Conforms	Conforms
Run 33 – 60 degree beam width – 49 degree upcast – 30m				
Vertical Illuminance	5 lux	1 lux	0.0344 lux	0.0344 lux
Luminous Intensity	7500 cd	1000 cd	1357 cd	1357 cd Refer Note 1
ULR	1.0%	1.0%	1%	1%
TI	20%	20%	1%	1%
Conformance			Conforms	Conforms
Run 34 – 60 degree beam width – 49 degree upcast – 40m				
Vertical Illuminance	5 lux	1 lux	0.0344 lux	0.0344 lux
Luminous Intensity	7500 cd	1000 cd	1539 cd	1539 cd Refer Note 1
ULR	1.0%	1.0%	1%	1%
TI	20%	20%	1%	1%
Conformance			Conforms	Conforms

Note1: The curfew luminous intensity has been calculated at the same location as the non-curfew level. AS/NZS4282:2019 specifies that the curfew levels should be calculate at the windows of habitable rooms so the where the luminous intensity above exceeds the curfew limit it is not non-conformance unless the luminous intensity also exceeds the limit at one of the windows of a habitable room.

6.6.3 Impact on Residential Buildings

The vertical illuminance and luminous intensity was calculated at the front face of sample Residences to confirm the curfew conformance of the lighting**.**

The selected Residences were R3, R6, R43, R44, R45, R62 & R82. The calculations were based on the 30 degree beam spread and at the maximum height and upcast, as this is the worst case. Refer Annexure A2 for the location of the Residences.

It should be noted that for the purposes of this assessment, Residences R43, R44, R62 & R82 are Project-related.

Table 9
AS/NZS4282:2019 Conformance Impact on Residential Buildings

	AS/NZS 4282: 2019 Criteria	AGi32 calculations
	Curfew	Curfew
Parameter	Environmental Zone A2	Maximum calculation point
Residence R3		
Vertical Illuminance	1 lux	0.0016 lux
Luminous Intensity	1000 cd	95 cd
Conformance		Conforms
Residence R6		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	118 cd
Conformance		Conforms
Residence R43		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	116 cd
Conformance		Conforms
Residence R44		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	47 cd
Conformance		Conforms
Residence R45		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	123 cd
Conformance		Conforms
Residence R62		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	116 cd
Conformance		Conforms
Residence R82		
Vertical Illuminance	1 lux	0.0000 lux
Luminous Intensity	1000 cd	47 cd
Conformance		Conforms

The maximum luminous intensity calculated was 123 cd, compared to the curfew limit of 1000 cd. The vertical illuminance at R3 was 0.0016 compared to the curfew limit of 1 lux. All other residences were less than 0.0000 lux. The impact on the residences would therefore be negligible.

6.6.4 Summary of Calculations

6.6.4.1 Luminaires

As we did not have photometric information for the existing luminaires, we have based the assessment on a 60 degree and a 30 degree beam width luminaire.

The 30 degree beam width would give better illuminance on the working surface and would provide less upward light. If the aiming however was such that it was directed to a location outside the Project Site boundary then the luminous intensity would be greater than the 60 degree luminaire. As the lights are generally down to a working area or towards a rack face this situation is unlikely to occur.

The 60 degree beam width has more impact on the upward light and luminous intensity from locations outside the Project Site. The 60 degree beam width therefore creates the limiting factor for the upcast angle.

We believe that in practice the luminaires would be likely to have a combination of both distributions with a vertical beam width of around 30 degrees and a horizontal beam width of 60 degrees. This means that our assessment is conservative.

6.6.4.2 Vertical Illuminance

The non-curfew vertical illuminance is calculated at the boundary of the Project Site. The curfew vertical illuminance is calculated at the windows of habitable rooms of the nearest Residential Receivers, where relevant.

The main operations in Project Site where there is significant light occur more than 500m from the Project Site Boundary. As the illuminance reduces proportionally to the square of the distance this is the main contributor to the reduction in the vertical illuminance.

The vertical illuminance has been calculated at the Project Site boundary for both the non-curfew and the curfew limits. The curfew limit is normally calculated at the windows of habitable buildings. The vertical illuminance is calculated on a vertical plane that extends 90 metres high.

The maximum vertical illuminance calculated at any point on the Project Site Boundary is 0.29 lux, excluding the aiming angles that do not meet the ULR limit, which is 30% of the curfew limit and 6% of the non-curfew limit.

The maximum vertical illuminance at any point on the window line of habitable rooms is ≤0.0016 lux compared with the curfew limit of 1 lux.

The SAR Amenity Bund would further protect the residences on the south, west and north from direct view and would ameliorate the potential impact of the lighting of the Project Site on any surrounding wildlife.

6.6.4.3 Luminous Intensity

Luminous intensity is only relevant where someone has a direct view of the light source or the reflector. The comments with respect to luminous intensity only address the mobile tower lights as all the other lighting on site will have zero light emitted in the horizontal plane and the residences would be too far away to be impacted by these lights.

The SAR Amenity Bund would again prevent direct view of the lights from the south, west or north.

The only direct view of the Project Site lighting would be from the eastern side. This view would be from an elevated position so the upcast of the luminaire would have less impact. In addition, it would only apply to those luminaires that are facing the Property or Residence.

The Project Site lighting would generally face into the work and away from the Residences and once the pit depth exceeds 8 metres below ground level the lights in the pit will not be visible.

Irrespective, the results in **Tables 6, 7 & 8** indicate that the luminous intensity non-curfew limit would not be exceeded when the luminaire has an upcast of 49 degrees and would still comply with an upcast of 60 degrees.

Tables 6, 7 & 8 indicate that the 60 degree beam width luminaires, with and upcast of 49 degrees, exceed the curfew level at the Project boundary, however this was only calculated to indicate that in the majority of situations the curfew limit is achieved at the Project boundary.

AS/NZS4282:2019 requires the curfew limit is assessed at the window line of habitable rooms. The maximum luminous intensity calculated at one of the windows of non-project related buildings is 118 cd compared with the curfew limit of 1000 cd.

6.6.4.4 Upward Light Ratio

The ULR requirements for pre-curfew and curfew are the same. This requirement was introduced in the AS/NZS 4282:2019 standard.

For an A2 Environmental Zone the maximum Upward Light ratio is 1%. This means that the total light that is emitted above the horizontal from all the lights in their normal aiming position, must be less than 1% of the total light emitted by all the lights on the site.

As the lighting towers will require some level or upcast to distribute light onto the working area, it will be necessary to reduce the upward light in the administrative and maintenance areas to give the flexibility for the mobile lighting towers.

The upward light is calculated based on direct light only where lighting is aimed above the horizontal but obstructed from the sky it is not included.

LED luminaires are now available with forward throw characteristics that will enable a wide area to be illuminated without tilting the luminaire more than a few degrees. Typical luminaries are included in Annexure B. These are the luminaires that have been used in the calculation model.

The ULR for the Project Site conforms for the A2 requirement provided that the upcast of the tower lights is less than 49 degrees.

If the actual distribution of the lights can be determined, then it may be possible to aim the lights at a higher angle of upcast and still conform.

The ULR is calculated by dividing the total lumen of all luminaires, above horizontal by the total lumen output of all the luminaires. We have calculated the ULR with all the lights at the same upcast angle. This means that if some luminaires are aimed at a lower angel then others could be aimed at a higher angle and still achieve the ULR.

As the luminaires will be aimed at different levels in different situations, we believe that it is practical to limit the upcast to 49 degrees as a general rule.

6.6.4.5 Threshold Increment

The threshold Increment was calculated for different heights on the waste rock emplacement, without including the obstruction from the amenity bunds, for heights ranging from ground level to 70 metres.

The maximum TI of 1.0% is associated with Kyalite Road. The maximum TI for the Newell Highway is 0.018% when travelling north. This view of the lights would be obstructed by the amenity bund. The limit for non-curfew and curfew is 20%.

6.6.4.6 Impact on Observatories

Clause 2.4.4. of AS/NZS 4282:2019 states that where the installation is in close proximity of an observatory, then close consultation is required. The Standard then references the Astronomical Society of Australia's List of Designated Observatories [8].

Although these are referenced in AS/NZS 4248:2019 as observatories that have to be taken into account as part of an assessment. AS/NZS4282:2019 does not recommend additional parameters or limits that should be applied, but simply raises awareness of the observatories.

The nearest designated observatories on the list are listed on **Table 1**.

Table 10
Astronomical Observatories Considered in Lighting Assessment

Observatory	Distance from the Mine Site
Major Facilities	
Siding Spring Observatory	162km
University/Publicly funded facility	
UWS Penrith Observatory	272km
Significant Amateur Society/Private Observatories	
Bathurst Observatory (20km northeast of Bathurst NSW)	139km
Mt Tarana Observatory - Mr Colin Bembrick (25km east-southeast of Bathurst NSW)	140km
Wiruna Observatory, (Astronomical Society of NSW, Ilford)	160km
Grove Creek Observatory – (40km south of Bathurst NSW)	179km
Linden Observatory (Blue Mountains near Sydney)	249km
Crago Observatory - (Astronomical Society of NSW, Bowen Mountain NSW)	251km
Kirby Observatory - (UNE and Northern Tablelands Astronomical Society, Armidale NSW)	296km
Koolang Observatory (Bucketty, near Newcastle NSW)	328km

Other than the observatories in the vicinity of Bathurst the observatories are further from the Project Site than the SSO. While the SSO is a major facility that is protected, the Bathurst observatories are Amateur Society or Private facilities and are only marginally closer to the Project Site than SSO.

Although the term 'close proximity' is not defined in AS/NZS4282:2019 the distance that is used in the SEPP and the LEPs of the areas surrounding the SSO use 18km as the indicator of 'close proximity. None of the observatories fall within this distance. We have therefore assumed that if the Project is acceptable to the SSO then the impact on the other observatories would also be acceptable.

6.7 SUPPLEMENTARY CALCULATIONS

6.7.1 Light Colour

As we were not able to attend the site due to Covid-19 restrictions we were not able to measure the correlated colour temperature of the existing lighting towers. As the towers would be reused, this is not critical.

AS/NZS4282:2019 recommends that the CCT should avoid light at the blue end of the visual spectrum. This would mean that new light sources should have a CCT of less than 4000K, where possible.

The reason for the limit is that blue light scatters more in the atmosphere, increasing the stray light for astronomers and the general view of the light sky. In addition, much of the natural biota has increased sensitivity to blue light and it therefore the blue light has a relatively higher impact.

When we measured the reflectance of the rock samples, we also measured the shift in the CCT of the reflected light. This would indicate that the reflected light from the ground would be approximately 200K lower than the light source.

7. RECOMMENDED MITIGATION MEASURES

The calculations and modelling undertaken as part of this assessment indicate that the impact of the proposed lighting of the Project Site on the local environment and SSO would be significantly less than the limits contained in AS/NZS 4282:2019 and the SSO Dark Sky Planning Guidelines[2].

Provided that the detailed design and implementation of the lighting for the Project is in accordance with AS/NZS 4282:2019 *Control of obtrusive outdoor* lighting, and is consistent with the general design recommendations listed in Section 7.1, and the information on which this assessment is based, there would be no need for additional mitigation measures.

In addition to the requirements set out in Section 7.1, Section 7.2 presents further design criteria that could be considered by the Applicant to further reduce any potential impact of the Project Site lighting on the surrounding environment.

7.1 GENERAL DESIGN RECOMMENDATIONS

a) All new lighting within the Project Site should be designed to meet the criteria of Zone A2 in AS/NZS 4282:2019.

b) All new light sources should have CCT of 3000K.

c) All fixed floodlights should be forward throw luminaries with a maximum upcast of 10 degrees. Wherever possible the upcast should be zero.

d) Lights with diffusing covers or with visible bare lamps that emit light above the horizontal plane should not be used on the outside of buildings or structures

e) Where practical, floodlights on the mobile lighting towers should be aimed towards the centre of the Project Site or towards the surface of the SAR Amenity Bund.

f) Floodlights on the mobile lighting towers should be aimed with a maximum upcast of 49 degrees unless their beam if fully obstructed by a wall.

g) The floodlighting towers should not be used when the relevant activities are not operating.

7.2 OPTICAL MEASURES

The addition of eyelids shields over the lights on the towers would further reduce the upward light contribution and would improve the overall efficiency of the lighting as light that would normally be directed into the sky would be directed back to the ground.

It would also allow for the angle of upcast to be lightly increased if needed.

8. CONCLUSION

8.1 LOCAL ENVIRONMENT

The provisions of AS/NZS 4282:2019 are adequate to protect the amenity of the Residential Receivers in the area surrounding the Project Site.

8.1.1 Illuminance

The calculations indicate that, in both the pre-curfew and curfew periods, the Project would cause negligible increase in illuminance at the Project Site boundary.

8.1.2 Luminous Intensity

The northern, southern and western sides of the SAR Mine Site would be protected by the SAR Amenity Bund; therefore, Residences in these directions would not be impacted from the luminous intensity of the lighting of the Project Site.

The Residences on the eastern side would have a view of the light sources if the lights are aimed in that direction. However, it is anticipated that the for the majority of the time the lights would be aimed into the operational surface areas of the Project Site or below ground level in the pit.

Notwithstanding the above, if lights are aimed towards Residences, the luminous intensity would still comply during the non-curfew times or if the angle of upcast exceeds 49 degrees in the curfew period.

8.1.3 Upward Light Ratio

The ULR would be achieved for all new and existing lighting that would be used for the Project if the angle of upcast is limited to 49 degrees. The addition of eyelid shields at the top of the fittings will further reduce the upward light and allow for an increase in upcast.

8.1.4 Summary

LAS considers that the proposed lighting of the Project Site, would have minimal impact on the surrounding environment in the pre-curfew and curfew periods.

8.2 IMPACT ON SIDING SPRING OBSERVATORY

LAS has calculated the Total Lumens into the sky.

SSO have confirmed that the Project would have negligible impact on their operation. Correspondence from the SSO presenting the results of the calculations relating to the Project is reproduced in **Annexure D**.

9. REFERENCES

1 *Environmental Planning and Assessment Regulation 2000.*

2 *Dark Sky Planning Guideline, Protecting the observing conditions at Siding Spring* — NSW Department of Planning and Environment, June 2016

3 *AS/NZS 4282:2019 Control of the obtrusive effects of outdoor lighting*

Standards Australia Feb 2019

4 CIE 126, *Guidelines for minimizing sky glow*

5 CIE 001-1980, *Guidelines for Minimizing Urban Sky Glow Near Astronomical Observatories* (Joint Publication IAU/CIE)

6 *Current List of Designated Observatories* The Astronomical Society of Australia. http://asa.astronomy.org.au/observatories.php

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Annexures

(Total No. of pages including blank pages = 30)

Annexure A Background Information provided by RWC (12 pages)

Annexure B Proposed Lighting Equipment (12 pages)

Annexure C Correspondence from SSO (4 pages)

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Annexure A

Background Information provided by RWC

(Total No. of pages including blank pages = 8)

A1 Project Site Layout

A2 Land Ownership Plan

A3 Rock Samples

A4 Tower Lights

A5 Proposed Caloma Waste Rock Emplacement

A6 Proposed SAR Waste Rock Emplacement

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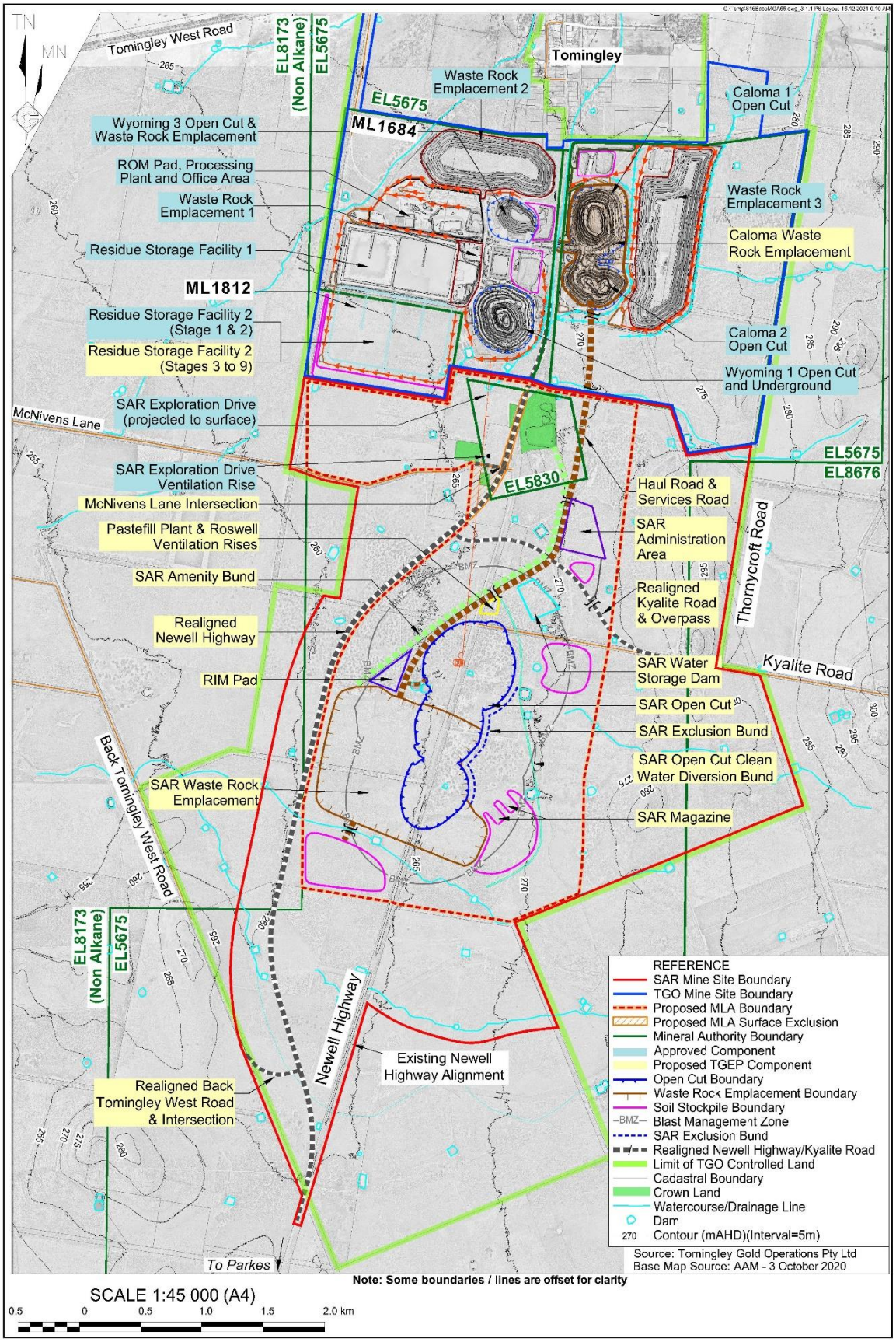
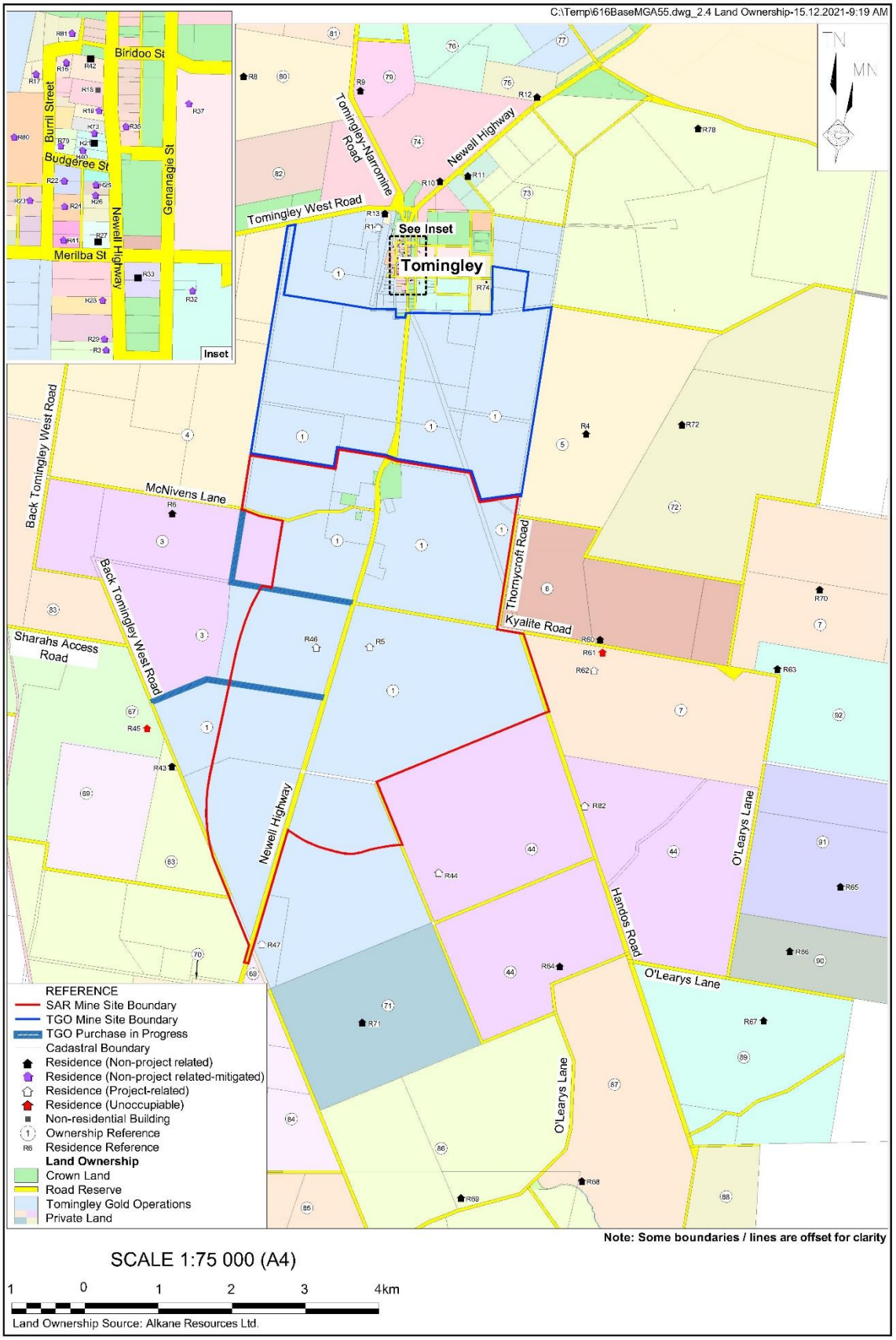
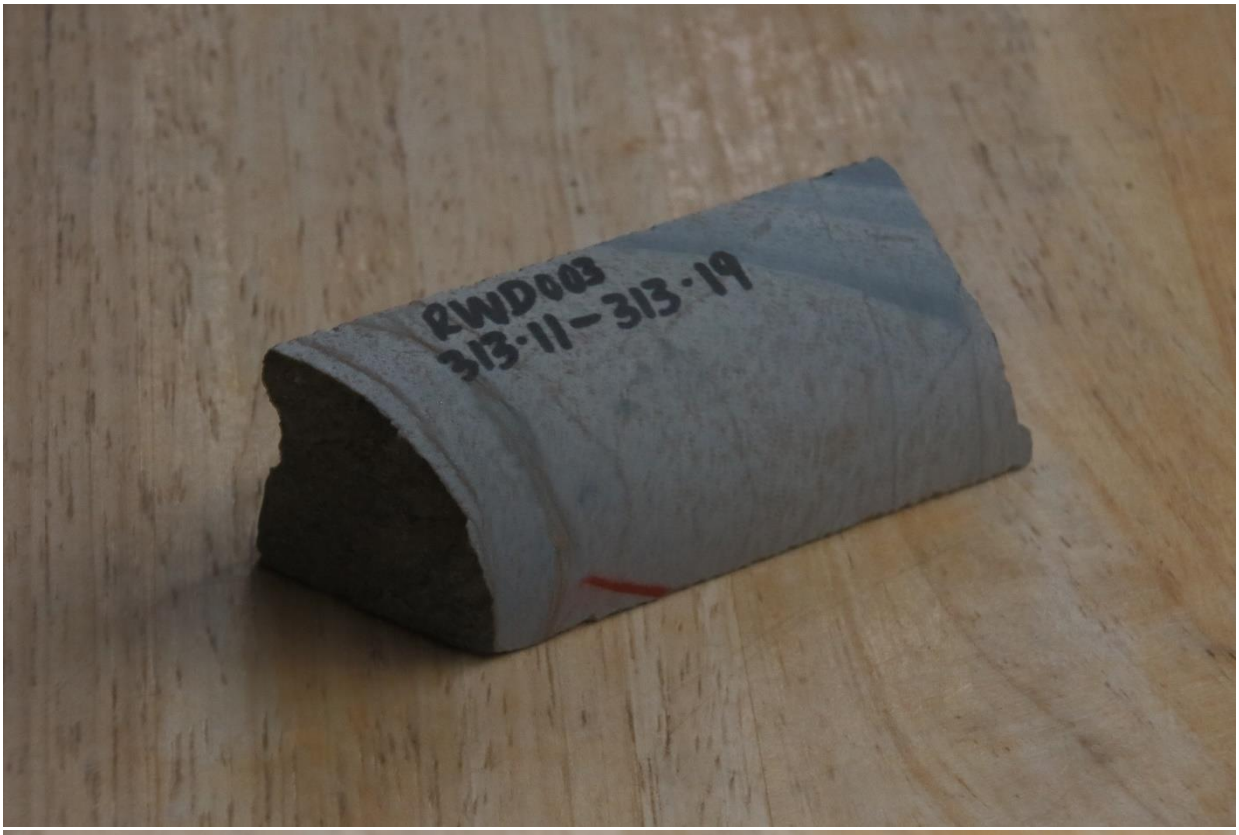
A1 -Project Site Layout



A2 Land Ownership Plan



A3 – Rock Samples

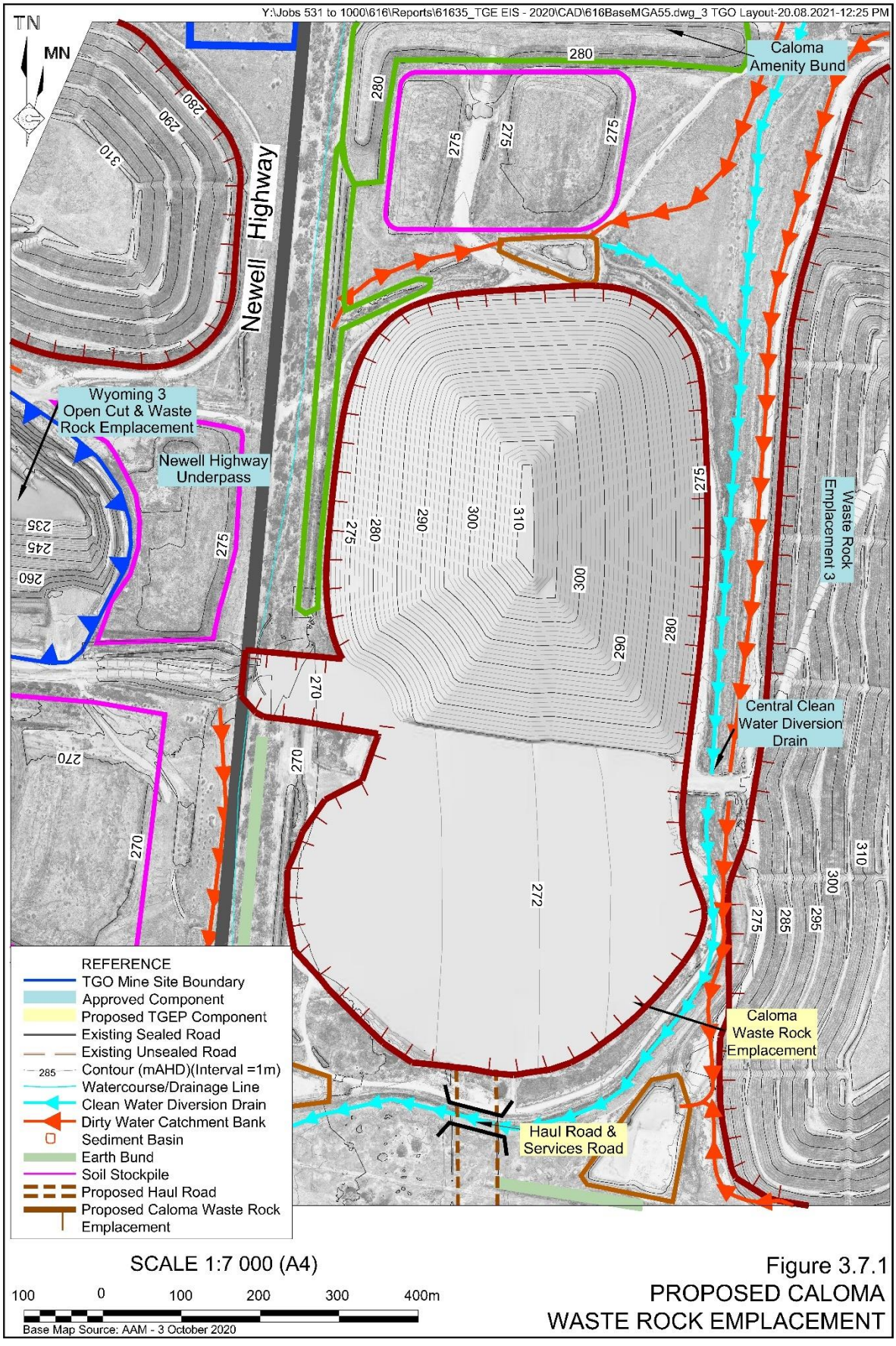

RWD003
313·11-313·19


RWD005
225·75-225·80

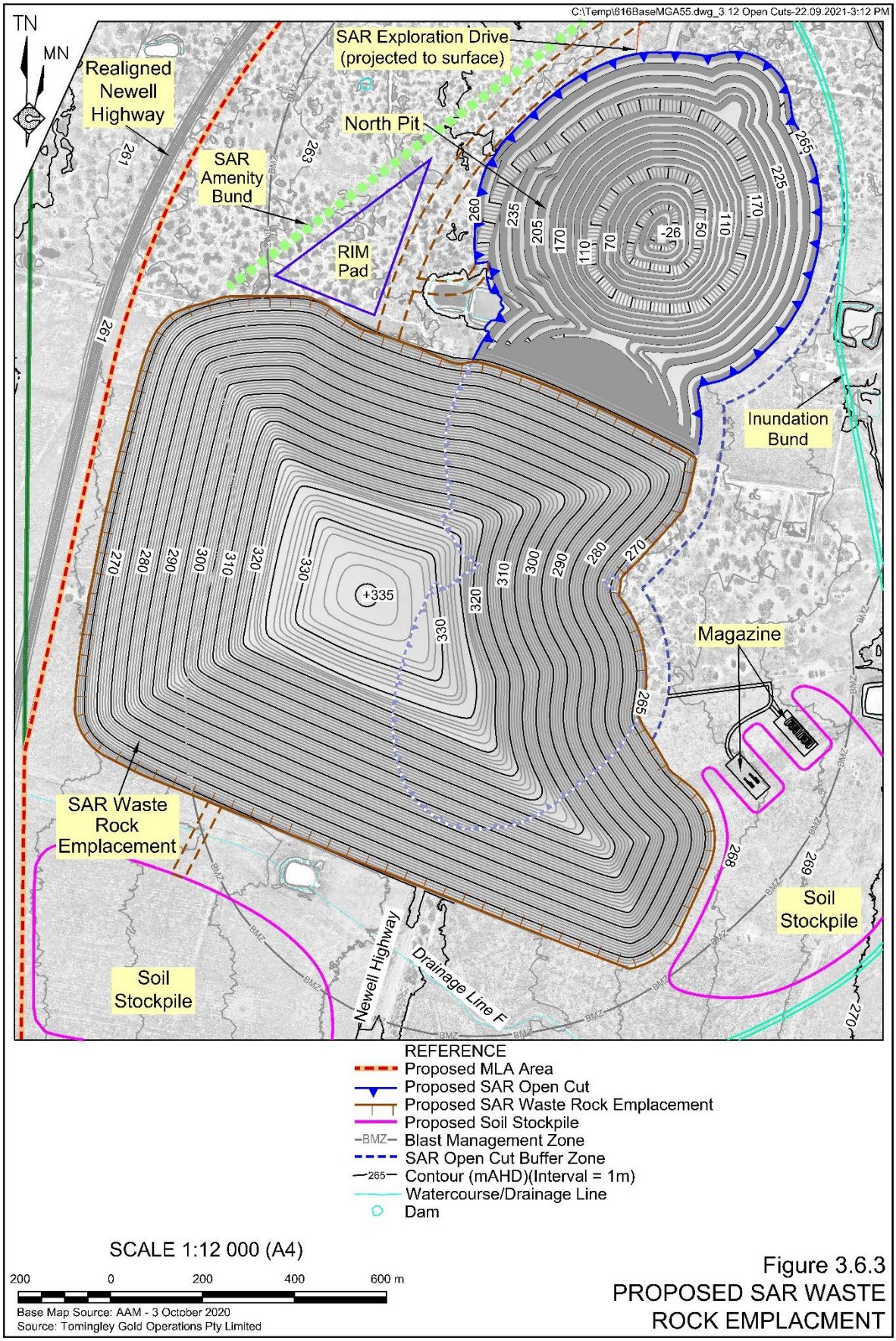
A4- Existing Tower Lights


PROMAC

A5 Proposed Caloma Waste Rock Emplacement



A6 Proposed SAR Waste Rock Emplacement



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Annexure B

Typical Lighting Equipment

(Total No. of pages including blank pages = 12)

B1 Forward Throw Area Floodlight

B2 Mill catwalks

B3 30 degree beam width luminaire used for mobile lighting tower assessment

B4 30 degree beam width luminaire used for mobile lighting tower assessment

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B1 Forward Throw Floodlight – Philips Tango G3 series

Tango G3 - BVP38x

BVP381 LED60/NW 50W 220-240V AMB GM

-

The energy-saving Philips Tango G3 LED Floodlight is the ideal solution for a wide range of Area lighting applications. It incorporates the LED light source, optical system, heat sink and driver into one compact and robust housing that meets globally recognised safety standards. Its specially designed heat sink incorporates aesthetics and functionality to ensure excellent reliability. Powered by LED technology, this luminaire delivers superior performance and a longer lifetime, bringing area lighting to a whole new level.

Product data

General Information	
Lamp family code	-
Light source colour	Neutral white
Light source replaceable	Yes
Driver/power unit/transformer	PSU [Power supply unit]
Driver included	Yes
Optical cover/lens type	PC-MLO [Polycarbonate micro lens optic]
Luminaire light beam spread	40° x 80°
Control interface	-
Connection	Flying leads/wires
Cable	Cable 1.5 m without plug (C1K5)
Protection class IEC	Safety class I (I)
Flammability mark	NO [-]
CE mark	CE mark
ENEC mark	-
Warranty period	3 years
Outdoor optic type	Asymmetrical medium beam
RoHS mark	-

LED engine type	LED
Light Technical	
Standard tilt angle post-top	-
Standard tilt angle side entry	-
Operating and Electrical	
Input voltage	220-240 V
Input frequency	50 or 60 Hz
Power factor (min.)	0.95
Controls and Dimming	
Dimmable	No
Mechanical and Housing	
Housing material	Aluminum die-cast
Reflector material	-
Optic material	Polycarbonate

Datasheet, 2018, October 2

data subject to change

Figure 3

Tango G3 - BVP38x

Optical cover/lens material	Polycarbonate
Fixation material	Steel
Mounting device	MBA [Mounting bracket adjustable]
Optical cover/lens shape	-
Optical cover/lens finish	Frosted
Overall length	500 mm
Overall width	84 mm
Overall height	349 mm
Effective projected area	0.12 m²
Colour	Aluminum and gray

Approval and Application

Ingress protection code	IP66 [Dust penetration-protected, jet-proof]
Mech. impact protection code	IK08 [5 J vandal-protected]
Surge protection (common/differential)	Luminaire surge protection level up to 15 kV differential mode and 15 kV common mode

Initial Performance (IEC Compliant)

Initial luminous flux	6000 lm
Luminous flux tolerance	+/-10%
Initial LED luminaire efficacy	120 lm/W
Init. Corr. colour temperature	4000 K
Init. colour rendering index	>70
Initial chromaticity	SDCM< 7
Initial input power	50 W
Power consumption tolerance	+/-10%

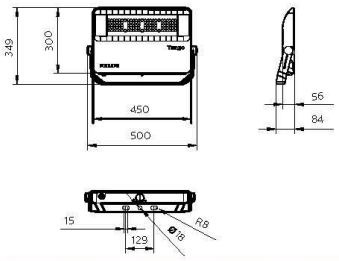
Application Conditions

Ambient temperature range	-40 to +50 °C

Product Data

Full product code	871016332846100
Order product name	BVP381 LED60/NW 50W 220-240V AMB GM
EAN/UPC – product	8710163328461
Order code	32846100
Numerator – quantity per pack	1
Numerator – packs per outer box	1
Material no. (12NC)	911401843298
Net weight (piece)	5.999 kg

Dimensional drawing



BVP38x Tango G3

B2 Mill Catwalks – Sylvania StreetLED

SYLVANIA

A SMART CITY SOLUTION

The smart choice for urban roads

STREETLED MK II

CATEGORY P LED LUMINAIRE

Engineered and crafted in Australia, the StreetLED MKII is a high performance luminaire designed specifically to meet Australian/New Zealand minor road lighting requirements.

The optical system with LED light source is optimised to provide the maximum spacing complying with AS1158-3.1 Category P.

The optical chamber sealed to IP66 ingress protection and the self-cleaning visor minimises light loss due to dirt accumulation, reducing maintenance and resulting in a highly energy efficient luminaire.

Perfect for one for one replacement for legacy fittings including 70W HPS, 80W MV, 32/42W CFL, 2 x 14W T5, 2 x 24W T5.

Self cleaning visor version

Aeroscreen visor version

Aeroscreen visor version with D2 PE Cell fitted

PERFORMANCE SUMMARY

- High performance street luminaire
- Designed specifically to meet Australian/New Zealand road lighting standards
- The optics and LED light source are optimised to provide the maximum spacings complying with AS1158-3.1 Category P
- Available with self-cleaning Standard or Aeroscreen visor
- The self-cleaning visor minimises light loss due to dirt accumulation, resulting in a highly energy efficient and low maintainence luminaire
- Downward facing PE Cell
- Optical chamber sealed to IP66 ingress protection
- Minimum 70 CRI
- CCT: 4000K and 3000K available

* See Gerard Lighting standard terms & conditions

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GERARD LIGHTING

SYLVANIA

A SMART CITY SOLUTION

STREETLED MKII (cont.)

SPECIFICATIONS

Electrical Characteristics:
- Input Voltage: 216V – 240V 50Hz/60Hz
- Power Factor: 0.9
- System watts: 17W-33W
- Class I

Optical Characteristics:
- CCT: Available in 4000K and 3000K
- CRI: > 70
- Optical chamber sealed to IP66

Mechanical Characteristics:
- Pressure die cast aluminium body
- Weight: 6.1kg
- Seld cleaning visor as standard
- Stainless steel fasteners, latches and clips
- Hinged access cover with quick access clips
- Easy to replace visor with quick access clips
- RAL 9006 finish as standard
- 27mm to 34mm spigot entry
- IP66
- 20 years design life

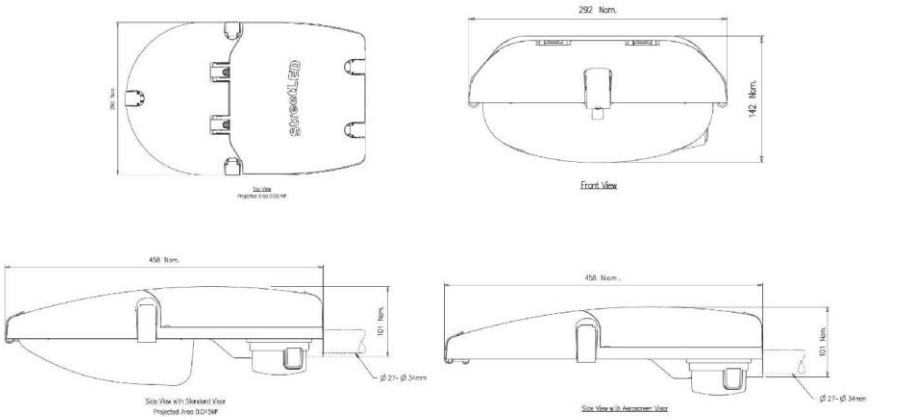
Control Characteristics:
- 1-10V Control
- NEMA 7
- Smart City ready

Environmental & Standards:
- Ambient Operation Temps: -10 to 40°C
- EMC compliant: AS/NZS CISPR15, AS/NZS 60598.1 & AS/NZS TS 1158.6: Luminaires - Performance
- IPART, VEET approved (applies to certain models)

Options: (MOQ and additional leadtime applies)
- Surge protection device (SPD)
- Fused terminal block
- Class II version (Double insulated)
- Visor options: Standard, Aeroscreen, Glare Shield, Louver
- D2 Cell

SMART CITY SOLUTIONS
- LOWPAN6, ZIGBEE, LORAWAN, NBIOT technologies
- Devices & sensors for smart city applications
- Customised platform integration

LINE DRAWINGS



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A SMART CITY SOLUTION

STREETLED MKII (cont.)

PHOTOMETRICS

Please contact your Roadway & Infrastructure Lighting representative for photometric information specific to your project.

ORDER CODES

Product Order Code	Name	Dimensions (mm) W x H x L	Mass (kg)	Beam Distribution	System Power (W)	Colour Temperature	Electrical Rating	Installation Type	Dimming Technology	PE Cell Base Type	PE Cell Type (if incl.)
JLB99Z1xL17	STLED2 14W 4K PESN7 CO 9006	290 x 110 x 458	6.1	Type 2/3M	17	4000	Class I	Side Entry	1-10Vdc	NEMA 7 pin	Shorting Cap
JLB99Z0xL17	STLED2 14W 4K PESN7 9006	290 x 157 x 458	6.1	Type 2/3M	17	4000	Class I	Side Entry	1-10Vdc	NEMA 7 pin	Shorting Cap
JLB99Z0xL33	STLED2 28W 4K PESN7 9006	290 x 157 x 458	6.1	Type 2/3M	33	4000	Class I	Side Entry	1-10Vdc	NEMA 7 pin	Shorting Cap
JLB99Z1xL33	STLED2 28W 4K PESN7 CO 9006	290 x 157 x 458	6.1	Type 2/3M	33	4000	Class I	Side Entry	1-10Vdc	NEMA 7 pin	Shorting Cap

The above codes are for standard offering only. For additional options or product configurations, please consult your Gerard Lighting consultant.

PUB DATE: DJS_06112018

Where innovation comes to light

GERARD LIGHTING

B3 30 degree beam width luminaire used for mobile lighting tower assessment

FLC230 LED

139-1843

1/16

we-ef

Description

IP66, Class I. IK07. Marine-grade, die-cast aluminium alloy. 5CE superior corrosion protection including PCS hardware. Silicone CCG® Controlled Compression Gasket. Safety glass lens. Two cable glands for improved wiring flexibility. Integral EC electronic converter, thermally separated. CAD-optimised optics for superior illumination and glare control. OLC® One LED Concept. Factory installed LED circuit board. 1-10V, DALI Interface or Eco Step Dim® on request. Maximum one internal optical accessory possible. Optional 2200 K version available, except version [EES]. To be specified at time of ordering.

Beam Type	symmetric, medium beam [M]
Light Source	LED-12/52W / 1400 mA - 4000 K
CRI	80
Gear Type	EC

Nominal Luminous Flux (lm)

LED Lumens	575.6 lm
LEDs	12
Total Lumens	6907 lm
Tj	85 °C

Rated Luminous Flux (lm)

LED Lumens	501.3 lm
Total Lumens	6016.2 lm
Ta	25 °C

Rated Input Power	56 W

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FLC230 LED

139-1843

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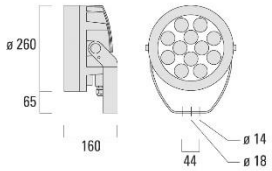
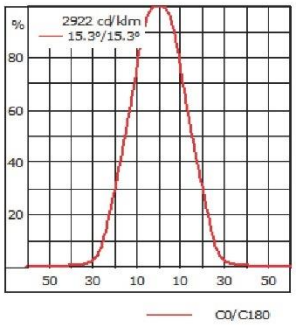
we-ef





Material Specification

Body:	Marine-grade, die-cast aluminium alloy
Weight (kg):	7.60
Lens:	Safety glass lens
Colours:	RAL9004 Signal black RAL9006 White aluminium RAL9007 Grey aluminium RAL9016 Traffic white
Gasket:	Silicone CCG® Controlled Compression Gasket
Fasteners:	PCS Polymer Coated Stainless Steel Hardware (unpainted)
Ingress protection:	IP66
Impact protection:	IK07
Corrosion protection:	5CE. 5CE+Primer optional
Surge protection:	6/6 kV (optional SP10)
Windage (EPA):	0.054 m²

Electrical Specification

Power supply:	220-240V / 50-60 Hz
Power factor:	> 0.9
Driver / Ballast:	DALI
Cable:	Two cable glands for improved wiring flexibility

Lifetime
Ta=40° L90B10 > 90000h

Warranty
The product is supplied with 10-year warranty. Please refer to the LED Warranty Statement located on www.we-ef.com for further details.

Mounting Accessories

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B3 60 degree beam width luminaire used for mobile lighting tower assessment

FLC230 LED

139-1912

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we-ef

Description
IP66, Class I. IK07. Marine-grade, die-cast aluminium alloy. 5CE superior corrosion protection including PCS hardware. Silicone CCG® Controlled Compression Gasket. Safety glass lens. Two cable glands for improved wiring flexibility. Integral EC electronic converter, thermally separated. CAD-optimised optics for superior illumination and glare control. OLC® One LED Concept. Factory installed LED circuit board. 1-10V, DALI Interface or Eco Step Dim® on request. Maximum one internal optical accessory possible. Optional 2200 K version available, except version [EES]. To be specified at time of ordering.

Beam Type	symmetric, wide beam [B]
Light Source	LED-12/52W / 1400 mA - 4000 K
CRI	80
Gear Type	EC

Nominal Luminous Flux (lm)

LED Lumens	575.6 lm
LEDs	12
Total Lumens	6907 lm
Tj	85 °C

Rated Luminous Flux (lm)

LED Lumens	477.9 lm
Total Lumens	5735.3 lm
Ta	25 °C

Rated Input Power	56 W

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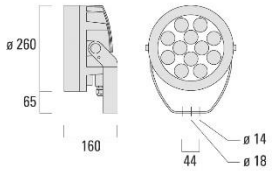
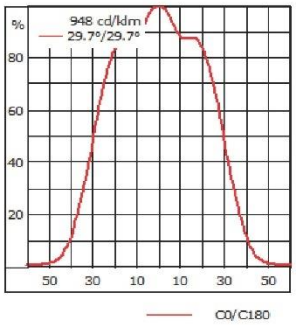
FLC230 LED

139-1912

2/16





Material Specification

Body:	Marine-grade, die-cast aluminium alloy
Weight (kg):	7.60
Lens:	Safety glass lens
Colours:	RAL9004 Signal black RAL9006 White aluminium RAL9007 Grey aluminium RAL9016 Traffic white
Gasket:	Silicone CCG® Controlled Compression Gasket
Fasteners:	PCS Polymer Coated Stainless Steel Hardware (unpainted)
Ingress protection:	IP66
Impact protection:	IK07
Corrosion protection:	5CE. 5CE+Primer optional
Surge protection:	6/6 kV (optional SP10)
Windage (EPA):	0.054 m²

Electrical Specification

Power supply:	220-240V / 50-60 Hz
Power factor:	> 0.9
Driver / Ballast:	DALI
Cable:	Two cable glands for improved wiring flexibility

Lifetime
Ta=40° L90B10 > 90000h

Warranty
The product is supplied with 10-year warranty. Please refer to the LED Warranty Statement located on www.we-ef.com for further details.

Mounting Accessories

WE-EF LIGHTING Pty Ltd
6/13 Downard Street | 3195 Braeside, Victoria | Australia | Tel +61 3 8587 0444 | Fax +61 3 8587 0499 | info.australia@we-ef.com | www.we-ef.com | 13-09-2021 04:04

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Annexure C

Correspondence from Siding Spring Observatory

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From: Christopher Lidman <christopher.lidman@anu.edu.au>
Sent: Tuesday, 21 September 2021 8:54 PM
To: Michael Fake
Cc: Peter McLean; Mitchell Bland; Christopher Lidman
Subject: Re: 616_TGEP Siding Spring Observatory Consultation

Dear Michael,
Thank you for contacting the Observatory and for providing a draft report for us to comment on.

While no detailed calculation on the impact on SSO is provided in the report, there is sufficient detail in the report for the Observatory to make it's own assessment. Using the 202,300 lm of luminous flux (consisting of direct and scattered light) quoted in section 6.5 of the report, the Observatory believes that the lighting used at the project will have negligible impact on the brightness of the night sky above the Observatory.

Kind Regards,

Chris Lidman

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