AUSTRALIAN ASTRONOMICAL OBSERVATORY	Australian Government Department of Innovation Industry, Science and Research	AAO

RESPONSE TO THE COBBORA COAL ENVIRONMENTAL ASSESSMENT BY SIDING SPRING OBSERVATORY, COONABARABRAN

1 BACKGROUND

Siding Spring Observatory (SSO) is a major scientific infrastructure facility operated by the Australian National University (ANU). Situated on a high ridge in the Warrumbungle Mountains, it hosts a range of telescopes operated both by ANU and other agencies, several of which are international collaborations. Among the various facilities are the two telescopes of the Australian Astronomical Observatory (AAO), a division of the Commonwealth Department of Industry, Innovation, Science, Research and Tertiary Education, and Australia's national optical observatory. One of the AAO's telescopes, the 3.9-metre Anglo-Australian Telescope, is the largest optical telescope on Australian soil, and is expected to remain so for at least the next two decades.

The Cobbora Coal project is sufficiently close to the Observatory as to raise concerns about the detrimental effects of light and dust pollution from the mine. Possible seismic disturbance is a further concern. The northern boundary of the project application area is less than 100km from Siding Spring and, although the mine will not be within line-of-sight visibility of the observatory due to intervening high ground, damaging light pollution from upward sky-glow is a very real prospect unless steps are taken to mitigate it.

This submission is a response to the exhibition of the Cobbora Coal project's environmental assessment made jointly by the Australian Astronomical Observatory and the Australian National University on behalf of all stakeholders on Siding Spring Mountain.

2 SKY BRIGHTNESS

Even in the absence of artificial light-sources, the night sky is naturally luminous, a phenomenon made more obvious in an unpolluted sky by the presence of clouds, which appear jet black against their background. They contrast strikingly with their illuminated counterparts in a city sky. Similarly, unilluminated foreground objects such as trees are silhouetted against the natural sky (Figure 1).

The natural sky-glow has several components, of which the brightest is due to auroral emissions in the upper atmosphere at specific wavelengths. In addition, there is a continuous-spectrum background whose sources include illuminated dust in the Solar System, faint stars within our own Milky Way Galaxy and, at the very faintest level, the light of distant galaxies that are indistinguishable from one another.

Any celestial object that an astronomer wishes to investigate is superimposed on this sky background, and usually the background dominates the observation. Often, astronomers are looking at faint objects whose brightness is less than *one percent* of the natural sky background. Any increase in the background glow due to artificial light simply renders these objects invisible. In that respect, there are few natural environments as sensitive to pollution as the night sky.

Figure 1. A 9.5-hour photographic exposure of the AAT dome at night showing star-trails and the natural luminosity of the sky. (David Malin)

Pierantonio Cinzano (University of Padua) has mapped the world's light pollution using night-time images from space (to show upward-pointing light sources) combined with the known propagation characteristics of the atmosphere by molecular and aerosol scattering (Cinzano, Falchi & Elvidge 2001). The process is highly refined, taking into account the curvature of the Earth, and shows that two-thirds of the world's population lives in light-polluted conditions. More dramatically, about one-fifth of the population can no longer see the Milky Way.

Cinzano's studies also show that light pollution is encroaching on many of the world's major observatory sites, including those in Australia (Figure 2). This leads to the conclusion that remoteness is not enough to protect an observatory, and steps have to be taken to reduce the spread of light pollution. The steps are both legislative and educational, and emphasize the message that light-pollution is detrimental to everyone. Not only are astronomers and nocturnal animal species directly affected, but the ill effects of obtrusive lighting on human circadian rhythms are also starting to be recognised (e.g. Smolensky 2007). The carbon footprint of wasted light, shining where it is not needed, is now of universal concern.

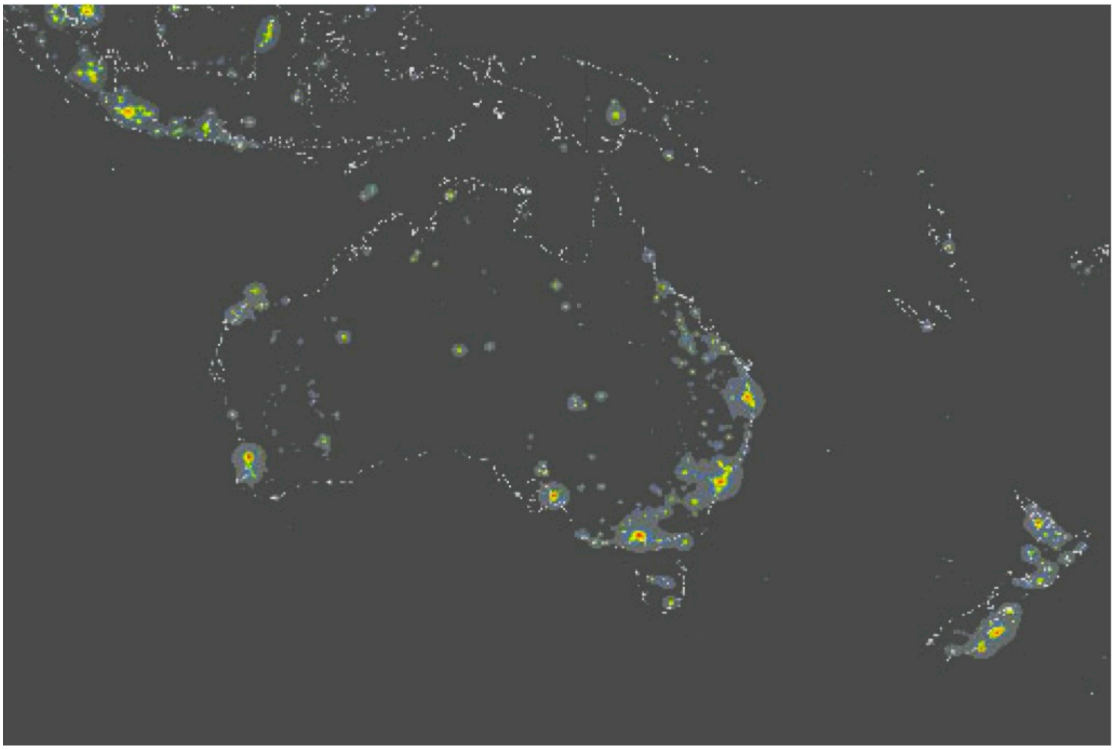

Figure 2. Light pollution in Australia and New Zealand, as modelled by Cinzano. The lowest gray contour denotes a level of sky illumination high enough to begin impacting the number of stars visible to the unaided eye.

3 NIGHT SKY PROTECTION AT SSO

At present, the three main sources contributing to artificial sky-glow at Siding Spring are Coonabarabran (population 3,000, distance 20 km), Dubbo (population 41,000, distance 100 km) and Sydney (population 4.5 million at 350 km).

Legislative efforts to safeguard SSO from the damaging effects of light pollution began in the late 1980s, but by 2000, it was clear that a wider approach was required, including a vigorous outreach campaign in the local area. Since then, AAO and ANU have maintained a watch on the protection of the Siding Spring site by means of a Dark-Sky Working Group (formally the Orana Regional Environmental Plan Revision Working Group), chaired by the AAO Astronomer-in-Charge. The Group draws its membership from AAO, ANU, Warrumbungle Shire Council, NSW Department of Planning and Infrastructure, and an independent lighting consultancy (Lighting Analysis and Design).

Local controls are covered by the Warrumbungle Shire Council Development Control Plan (DCP) No.1, and the Warrumbungle Shire Council formally refers any development applications requiring lighting assessment to the ANU at SSO. The principal legislative instrument covering lighting developments remains the Orana Regional Environmental Plan (REP) No.1. This covers an area of radius 100 km centred on the Anglo-Australian Telescope. In the central part of the REP zone, ‘full cut-off’ outdoor fixtures (which permit only illumination below the horizontal plane) are mandated within the Shire by the DCP. Beyond the REP zone, however, there is no overarching legislation to protect the skies of the observatory, and the night-time glow of the Sydney–Newcastle conurbation can be seen, as predicted by Cinzano’s model (Figure 3).

Figure 3. A 5-minute digital exposure from Siding Spring Observatory, showing the horizon illumination from Coonabarabran (far left), Newcastle (centre) and Sydney (right). (Bob Shobbrook)

The new State Environmental Planning Policy (SEPP) governing lighting developments around Siding Spring (which has evolved from the old Orana REP), is currently being prepared for public exhibition. When it is enacted into law, it will provide better protection for the Observatory by extending the REP zone to the boundaries of the affected Local Government Areas, and mandating full cut-off fittings throughout. Other controls, together with a clarification of the required consultation and concurrence procedures, are included. Fully-shielded lights have been included in the State Minister for Planning and Infrastructure’s conditions of consent for mines within 200 km of Siding Spring since a request for this was made by the Dark-Sky Working Group.

There are already several examples of state-of-the-art sky-friendly lighting installations within the Orana Region, including major sports grounds in Dubbo and Coonabarabran (Figure 4).

Figure 4. The head of one of four masts carrying full cut-off light fittings at the Victoria Oval in Dubbo. The illumination is of TV broadcast standard, but is confined entirely to the playing surface. (Wes Giddings)

4 SCALE OF INVESTMENT AT SSO

Like coal mines, observatories are long-lived infrastructure investments that cannot be moved. Sites are selected on the basis of prevailing natural conditions including sky darkness, absence of cloud cover, and freedom from atmospheric turbulence. Siding Spring Observatory was established by ANU in 1964 as the best optical observing site in Australia.

The largest facilities at SSO are the 3.9-metre Anglo-Australian Telescope (1974), the ANU 2.3-metre Telescope (1988), the 2-metre Faulkes Telescope South (2004, operated by Las Cumbres Observatory) and the 1.2-metre UK Schmidt Telescope (1973), which, like the AAT, is operated by the Australian Astronomical Observatory. The total replacement cost for these telescopes at current rates would be in excess of $100 million.

Wayne Rosing, President of the Las Cumbres Observatory Global Telescope Network (one of the largest independently-funded astronomical institutions in the world) has expressed particular concern about the possibility of mining developments in the vicinity of SSO. A comment from Rosing is presented in Appendix A.

ANU has recently completed another large-scale facility, the robotic 1.3-metre SkyMapper telescope under the leadership of Nobel prize-winner, Prof. Brian Schmidt; this represents a further investment of $15 million. Another major project currently in train is the Korea Microlensing Telescope, a remotely-operated 1.6-metre telescope facility with capital and implementation costs totalling $4.25 million. A number of other external institutions are at present in negotiation with ANU regarding the placement of telescopes with apertures up to 0.5 metres on the site (see Appendix B). These will represent a combined investment of $1.3 million. By the end of 2013, it is expected that the total number of operational telescopes at Siding Spring will be 20.

Siding Spring thus represents a major national and international resource for astronomy, with substantial investments by the Australian Federal government (through AAO), Australian universities (especially ANU), private enterprise (Las Cumbres Observatory, SLOOH, iTelescopes), and international groups from several nations.

5 IMPACT OF SSO ON THE LOCAL ECONOMY

The observatory makes a direct injection of funds into the local economy through the salaries of resident staff and the procurement of goods and services. In the case of the AAO, this amounts to approximately $3.5 million annually, while the ANU's component is about half this amount, representing a total direct spend of well over $5 million.

SSO also makes a significant contribution to local tourism. Because Coonabarabran is optimally placed on the Melbourne-Brisbane route, it is a natural overnight stopping point, and of the 32,000 tourists who visit the town's Visitor Centre annually, 94 percent stay for one or two nights in the district. Almost 24,000 make the trip to Siding Spring (usually in conjunction with a visit to the Warrumbungle National Park) to see the telescopes and Visitor Centre—the Siding Spring Exploratory. This is 74 percent of the total visitor numbers to Coonabarabran. It is estimated that the indirect contribution of SSO to the local economy is in excess of $10 million annually.

The presence of a cadre of observatory employees with high-level technical skills also feeds into the well-being of Coonabarabran via their partners and children, resulting in a community that has more in common with a small university town than a rural community. Once again, this contributes to Coonabarabran's role as a tourist destination rather than just another country stop-over.

6 NATURE OF THE THREAT FROM THE COBBORA MINE

Cobbora's threat to the Observatory arises principally from two components of the mine: the central infrastructure area, and the working coalface itself. These will be the biggest contributors in terms of upward light-spill, and the further scattering of light above the horizontal plane by raised dust.

AAO has already taken steps to begin benchmarking sky brightness and air quality (dust monitoring) in advance of any work at the mine site. The observatory operates a CCD-based night sky brightness monitor (NSBM), which has been installed on the AAT Utilities Building. This forms part of a global observatory network of NSBMs that are used to compare the relative darkness of the sites and the way this changes over time.

Less well-quantified is the threat from airborne dust, which is a particular concern in the case of the Cobbora Coal project. Although it is unlikely that dust ingress at the telescopes will be a major issue (since quite high levels of natural wind-borne dust are experienced from time to time at Siding Spring), there may be a requirement to enhance the dust-filtering equipment at the AAT and other telescopes in order to avoid any occurrence of problems. A more significant risk is that rising dust around the working face of the mine will be illuminated by the mine's lighting equipment, effectively increasing the light-flux from the mine.

There is some experience in dust monitoring among colleagues at the European Southern Observatory (ESO) sites in Chile, with nearby copper mines posing a similar threat. AAO is in consultation with ESO staff about this.

There is also a possible threat to the stability of SSO telescopes from seismic activity brought about by blasting at the coal face.

7 MITIGATION OF THE THREAT

SSO has endeavoured to play a proactive role in minimising the effects of light-spill and dust by engaging directly with the Cobbora Holding Company at an early stage. In support of this, the Dark-Sky Working Group has undertaken surveys of the available technology for night-sky friendly lighting suitable for use in open-cut coal mines, with at least one Australian manufacturer of such equipment being identified and consulted.

The use of full cut-off lighting fixtures is the first step towards mitigating the threat, so that shielded downward illumination is exclusively used (as in Figure 4). There is clearly an obligation for the mine lighting to be compliant with the requirements of Occupational Health and Safety, but this need not contradict the necessity of providing full cut-off illumination. Indeed, good lighting and effective OHS go hand-in-hand. The threat to SSO can be further mitigated by the use of low colour-temperature lamps, since the blue component of white light (which is minimised in these lamps) has a greater tendency to scatter over long distances.

While the use of full cut-off lighting will be a major step in reducing light-pollution from the mine, consideration also needs to be given to the upward scattering of light from the surfaces being illuminated, whether they are overburden, extracted coal, or roadways. Clearly, this is unavoidable at some level, but good lighting design can help to minimise its detrimental effects by limiting the intensity of illumination to only what is needed in any given situation.

A further consideration is that it may also be possible to design the layout of the Cobbora mine in such a way that access roads on the site are aligned away from the direction of SSO. This will reduce the amount of glare from vehicle headlights propagated by forward scattering.

It is expected that effective dust-minimisation procedures will be adopted at the Cobbora mine. The monitoring of dust levels both at the mine site and at Siding Spring is clearly an important requirement, and it is requested that Cobbora Coal contribute financially to the purchase of suitable equipment for this to proceed.

While the risk of seismic disturbance is low, Siding Spring is fortunate to have access to sensitive monitoring equipment operated privately by Dr Andre Philips within 15 km of the mountain. This is capable of detecting blasting activities at mines near Boggabri and in the Hunter Valley, but the tremors experienced are well below anything that would be of concern to the Observatory. Nevertheless, it is extremely valuable to have these data available in order to be able to monitor such tremors and determine the origin of significant seismic events.

As an adjunct to the strategy of benchmark monitoring for sky background, airborne dust and seismic activity, the resulting data can be made publicly available on a high-profile website. Thus, attention can be drawn to any activities likely to threaten the observatory's dark skies.

A final strategy that has worked well with other lighting developments in the Orana region (e.g. sports ground lighting) is to offer the services of Lighting Analysis and Design as consulting lighting engineers.

8 THE WAY FORWARD

Both AAO and ANU recognise that the current realities of energy production in Australia dictate that projects such as Cobbora are necessary, at least in the short to medium term. The challenge is to carry out these activities while, at the same time, preserving the near-pristine environment of Siding Spring so it can continue as a major contributor to the nation's scientific well-being. That being so, both institutions are keen to work with Cobbora Coal to minimise any detrimental impact on the observatory, and will make resources available to achieve that.

REFERENCES

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APPENDIX A – COMMENT FROM WAYNE ROSING, PRESIDENT OF LAS CUMBRES OBSERVATORY

Each and every activity that increases skylight (from lamps supporting night operations, particularly those that shine sideways or up into the sky) or particulate emissions (dust, blasting and even dust picked up from trucks) all contribute to the degradation of the night sky. As an example, over the past 20 years at McDonald Observatory in Texas, the night sky has brightened perceptibly. The reason is the extraordinary growth of industrial activity to the west of Fort Davis, Texas, in Northern Mexico. Dust is what makes sunsets red. Infrared radiation, the hardest to detect and the most powerful probe of the distant Universe, is affected by dust. Blue and ultraviolet light, used to probe and understand stellar astrophysics, is devastated by dust. For SSO, what matters is the general atmospheric circulation in the area: will dust from the mine tend to find its way back to SSO? Clearly light emissions will!

APPENDIX B – NEW FACILITIES AT SSO

Telescope(s)	Institution	Status	Approx. value
Solaris	Nicolaus Copernicus Astronomical Centre For The Polish Academy Of Sciences	Under construction	$400k
Korea Microlensing Telescope	Korea Astronomy & Space Science Institute	Site preparation	$4,250k
SLOOH Robotic Telescope	SLOOH Group, Canary Islands	Construction early 2013	$135k
PROMPT Telescopes	University of North Carolina	Under construction	$350k
Faulkes Telescopes	Las Cumbres Observatory Global Telescope Network	Under construction	$10,500k
iTelescopes	iTelescope Pty Ltd	Under construction	$350k
TMF Telescopes	Tzec Maun Foundation	Proposed	n/a