Snowdonia National Park – Dark Sky Reserve

External Lighting Master Plan

Contents

APPENDICES

1 Preamble

1.1.1 Introduction to Lighting Master Plans

The provision of a Lighting Master Plan, and its continued implementation, is an essential requirement of the International Dark Sky Association (IDA) when considering the initial merits of an application for a Dark Sky Award. The IDA has the option of withdrawing their support of any award if future sky measurements show a marked decrease in star visibility. The continued monitoring of the night sky quality is therefore essential.

The initial purpose of this external Lighting Master Plan (LMP) is therefore to provide a base document of lighting ordinance set within the lighting and planning framework of the UK for Snowdonia National Park Authority to mitigate the effects of stray and obtrusive light, often incorrectly referred to as 'light pollution', from all exterior lighting whether it is intended for domestic, public or commercial use. This document will use the words '**light obtrusion**' to include the outward and upward transmission of wasted light into the night sky unless referring to earlier documents produced by others.

The anti-social effects of obtrusive light is not limited to the vision of the night sky and obtrusive light was added to the list of "pollutants" in the UK's Clean Neighbourhood Act in 2005. In March 2012 the UK Government published the National Planning Policy Framework (NPPF) which contains provision for the control of obtrusive light through planning procedures. Although the document applies to the English planning framework, paragraph 125 can be equally applied across the UK and Europe as good planning practice. The paragraph states "***by encouraging good design, planning policies and decisions should limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation***."

Additionally an associated publication, National Planning Practice Guidance (2014), provides planning authorities with a defined link between planning and lighting - see http://planningguidance.planningportal.gov.uk/blog/guidance/light-pollution/

Of prime importance here is guidance for all planning authorities to set up their own night time environmental zones applicable to all new planning design work. Most National Parks in England and Wales have control over planning matters within the Park boundary except in the South Downs and the Cairngorms in Scotland.

In areas where there is a Dark Sky Award this task has already been fully outlined as a 'Lighting Ordinance' in the Lighting Master Plan associated with each award.

In the Welsh context, the publication of Planning Policy Wales, Edition 7 (2014) contains several references to lighting and in its Chapter 4 the promotion of sustainability through good design shows how design quality can enhance environmental quality. There is a reminder in Chapter 4.11.12 of the legal obligation to consider the need to prevent and reduce crime and disorder with other references linking the quality of external lighting in this objective. Additionally Chapter 4 (Planning Policy Wales) contains advice on the preparation of Local Development Plans assisted by Supplementary Planning Guidance with clear policies through the preparation of audits and appraisals.

The provision of this Lighting Master Plan has been based on external lighting audits and professionally assessed appraisals. It also contains policy objectives in the form of Plan Statements.

The detrimental effect of light and noise is contained in Chapter 13 (Planning Policy Wales) and 13.14 contains the necessity for developers to provide a technical noise assessment.

This LMP surpasses this by providing the methodology for a similar technical lighting impact assessment process for external lighting. (See Section 3)

This LMP relies on tables of technical parameters and lighting values contained in British Standards, the International Lighting Committee (CIE) and UK Lighting Institutions all of which have been used, at times, in the UK Judiciary.

This LMP also combines these lighting technical parameters to work within the framework of the International Dark Sky Association (IDA), the National Policy Planning Framework, Planning Policy Wales and the Eryri Local Development Plan Policy DP1 with strategies of best working lighting practice to follow in:-

- Planning for lighting with appropriate design and planning guidelines.
- Protecting the natural and historic environment including wildlife.
- Maintaining or improving the existing dark sky attributes.
- Reducing the carbon emissions associated with external lighting.
- Preventing glare to respect the amenity of neighbouring land uses through the appropriate choice of lighting fixtures and correct lighting installation practice.

This plan's principal aim is to provide sustainable policies to mitigate stray light, which astronomers and residential neighbourhoods may find obtrusive. Although the objectives given are relative to the National Park all the objectives can be equally followed in the other parts of the adjacent counties. This will help to protect, maintain or even, hopefully, improve the existing dark sky attributes and the rural environmental setting of intrinsic darkness, which is enjoyed by National Park residents and visitors.

All National Parks are administered by National Park Authorities which seek to achieve the two following statutory purposes of national park designation:-

- **To conserve and enhance the natural beauty, wildlife and cultural heritage of the National Park.**

  and

- **To promote opportunities for the understanding and enjoyment of the special qualities of the National Park by the public.**

  Additionally National Park Authorities have a duty under legislation to:-

- **To foster the economic and social well-being of local communities.**

The protection of the remaining dark night sky fulfils key elements in these National Park objectives.

Within the framework of the IDA guidelines for the submission application there are two issues of particular importance and they are:-

1. *"Includes a policy for determining whether an area should or should not be lighted, at what times an area should or should not be lighted, and appropriate illumination levels."*

The only areas within Snowdonia National Park where permanent illumination is explicitly forbidden are in the National Nature Reserves see Section 2.3 and Figure 1.2 for three of the boundaries. Beyond the National Nature Reserves the remainder can be illuminated, if required, within the concept of this LMP. Section 2.4 contains time limits to reduce energy of all night lighting or a switch off curfew.

Appropriate illumination for typical tasks, within the National Park is included in Section 3.2.1 (Table 3.3), however, the tasks tabled are limited for simplicity and reference is made to British Standard BSEN12462-2:2007 for other possible external tasks. Section 3.3 contains road lighting illumination values.

2. *"The LMP should conform to or surpass applicable policy in the appropriate local jurisdiction concerning lighting and dark sky protection as well as other applicable guidance and laws (e.g. environmental leadership programs, agency orders, wilderness act, energy management guidelines)."*

Within the environmental zone classification system this LMP surpasses current CIE/ILP guidance by introducing boundary illumination limits and also introduces distance points for viewed intensity evaluation. (See Section 2.3, Table 2.3)

The LMP also surpasses national planning guidance by introducing the need for professionally prepared lighting impact assessments as part of the planning stage.

1.1.2 Summary of Plan Policy Statements

Plan Statement Number 1 The boundary between the second and third core is provisional and will be increased with a view to joining the two into one after further additional public consultation. (see Section 2.2)
Plan Statement Number 2 Any new or replacement lighting within the Core Zone boundaries shown in Figure 2.3 should be "Fully Cut-Off" (Fully Shielded (IDA term)) regardless of light source lumen output. (see Section 2.3)
Plan Statement Number 3 Residents in the Core Zone are to be encouraged to limit the visual perception of light output at their property boundary by adapting or modifying existing units to this end. (see Section 2.3)
Plan Statement Number 4 Residential and business occupiers will be encouraged to recognise the benefits of switching off exterior lights after 22.00 hours. (see Section 2.4)
Plan Statement Number 5 The Authority will endeavour to ensure that no lighting will be allowed to be projected from the adjacent light permitted buffer zones into the Core Zones and any overspill lighting from lights in the Critical Buffer Zone to be no greater than 0.05 lux (horizontal) at ground level or 0.05 lux vertical at 1 metre (or higher) above ground on the Core Zone side of the property boundary. (see Section 2.5.1)
Plan Statement Number 6 Luminaires in the Buffer Zone using lamps greater than 500 lumens and operating continuously throughout the hours of darkness should be installed as a Fully Cut-Off (IDA "fully shielded") example. (see Section 2.5.1)
Plan Statement Number 7 Residents are to be encouraged to limit the overspill light at their property boundary to no more than 0.1 lux. (see Section 2.5.1)

Plan Statement Number 8
In Environmental Zone terms the residents round the Core Zone live with and enjoy intrinsic darkness and as shown in Table 1.1, equivalent to Environmental Zone E1. Towns within the Park boundary with a population greater than 1,000 may relax this Environmental Zone in the town centre where buildings provide natural screening but not in exposed locations. (see Section 2.5.2)

Plan Statement Number 9
All new street lighting design will be based on a Glare Limiting Index of G6 and a light source colour temperature of 4,000K or less. (see Section 2.6)

Plan Statement Number 10
All new lighting should be designed and installed to provide lower glare or intensity values, where possible, than that recommended by the ILP for night time Environmental Zones. (see Section 2.6)

Plan Statement Number 11
All design submissions and planning applications that include external lighting should show evidence of compliance with the zero candela intensity at 90^0 and above and encourage domestic luminaires to be selected from units having some form of upward light control. (see Section 2.6)

Plan Statement Number 12
Through this LMP it will be possible to encourage developers, when required, to adopt and provide a lighting industry professionally prepared submission for planning consideration. (see Section 3.1)

1.2 Introduction to Snowdonia National Park

There are 14 National Parks in Britain with three of those parks in Wales namely Snowdonia, in the north, Pembrokeshire, in the south west, and Brecon Beacons in the mid south of the country. Brecon Beacons achieved International Dark Sky Reserve status in 2011. The general location of Snowdonia, which is the second largest National Park in Great Britain, is in Figure 1.1.

Figure 1.1: General location of Snowdonia National Park

The Park has an area of 823 square miles (2,130 km^2 or 213,969 ha) and was the first of the three in Wales to be designated. When the park boundaries were being drawn up in 1951 the large slate quarries round Blaenau Ffestiniog and the town were excluded from the Park to allow, at that time, the development of light industry to replace the declining slate industry. **The National Park Authority therefore has no planning jurisdiction over this 'hole in the middle' and this feature plays an important role in the formation of more than one Core Zone within the proposed Dark Sky Reserve boundary** (see later explanation).

From the 2001 census there are about 26,000 people living within the Park and the area attracts about 6 million visitors annually. The area lies just over a one and a half hour drive from the large cities of Manchester and Birmingham. The Park lies within the counties of Gwynedd and Conwy respectively, from which each highway department maintains their respective street lighting infrastructure within the Park.

Figure 1.2 Snowdonia National Park Roadmap

Unlike National Parks in other countries all National Parks in the United Kingdom are made up of both public and private land ownership but all are under each Park's Authority which has jurisdiction for planning matters (Blaenau Ffestiniog excluded).

The split in Snowdonia land ownership is shown in the table below.

Ownership Type	**Land Share %**
Private	69.9
Natural Resources Wales	17.5
National Trust	8.9
National Park Authority	1.2
Water Companies	0.9
Other	1.6

The landscape of the 823 square miles has a high proportion of rural upland in the centre, rising to between 500m and 700m above sea level but dominated in the north by the Snowdon Massif, the most popular area for tourists, and in the south by the Cadair Idris/Aran mountain range with the highest point being Snowdon at 1,085m. Each of the ranges provide mountain walking and climbing for all grades. More importantly they also have various national and international nature conservation designations associated with them such as National Nature Reserves (NNR), Special Areas of Conservation (SAC), Special Protection Areas (SPA) and Sites of Special Scientific Interest (SSSI).

Within the Park boundary there are 21 NNRs, covering an area of approximately 5,650 ha of which at least five, namely Yr Wyddfa and Cwm Idwal near Snowdon, Rhinog and Coed Ganllwyd near Coed y Brenin Forest Park and Cadair Idris in the south could be included within the rural remoteness of future Core Zones (see Figure 1.2). These nature reserves contain some of the most important natural and semi-natural habitats in the UK.

In addition to the NNRs there are 104 Sites of Special Scientific Interest (SSSI's) covering an area of 62,446 hectares, where the very best examples of wildlife and geology can be found. Rhinog NNR is contained within an SSSI which is larger than 10 square miles. Additionally it has also a Biogenetic Reserve of 593.3 ha, the only one in Wales.

Figure 1.3: View eastwards from Bronaber towards Rhinog SSSI

The proposed core zones have been devised to partly or wholly contain at least 12 SSSI's and one Biosphere of 605 hectares.

In landscape classification terms a National Park has equivalent planning protection significance as that of an Area of Outstanding Natural Beauty (AONB) and the conservation of landscape and environment heritage is uppermost in the National Park. The entire coastline of the Park (37 miles) is a Special Area of Conservation containing, amongst other features, valuable sand dune systems.

Snowdonia National Park is home to a wide and diverse range of wildlife, much of which is nocturnal. Evidence suggests that artificial lighting can have a significant adverse impact of nocturnal wildlife, which is substantially greater than many people would believe (60% of vertebrates and 30% of invertebrates. In particular, it can impact on behaviour, reproduction, mortality rates, movement and foraging behaviour, and community structure of a range of species groups, particularly invertebrates and other pollinators, bats, fish and many species of birds. For example, inappropriate artificial lighting impacted on the daily commuting behaviour of lesser horseshoe bats *Rhinolophus hipposideros*, a species for which Snowdonia is a stronghold in the UK, and that disrupted migratory patterns were found in Atlantic Salmon *Salmo salar* for the same reasons.

By reducing inappropriate light fittings (either excessive, or of the wrong spectra) particularly in sensitive areas such as near watercourses, likely commuting lines (e.g. woodland, linear features), bat roosts and any other habitats likely to support a diverse range of wildlife, significant improvements could be made to improve these areas for a range of native, nocturnal species.

In addition to areas important for nature conservation there are 14 conservation areas in Snowdonia where repairs and reconstruction works on many buildings are carefully controlled by planning policies to confirm their unique character. Although there are conservation areas close to the proposed core zones, the **conservation of intrinsic darkness is uppermost in this document.**

There are approximately 2 million residents living within easy reach of these nature conservation habitats (1 hour drive) to people living in North Wales and the historic city of Chester. There are probably more than 5 million living within a 2 hour drive from the Midlands. Tranquillity is a special feature of National Parks and the Authority are encouraged to provide recreation that involves “quiet enjoyment”. It is estimated that more than 450,000 visitors each year reach the top of Snowdon. **The introduction of astronomy facilities fits into this tranquillity outreach. Amateur astronomers also form part of the tourism outreach to attract more winter visitors as is now recorded in other Dark Sky award areas.**

The Countryside and Rights of Way Act 2000 (often known as the CRoW Act) in England and Wales sets a legal duty on public bodies to have regard to conserve and enhance natural beauty and it updates the original law which created National Parks. The CRoW Act commons for "Open Access" are shaded yellow on Ordnance Survey "Explorer" maps. In addition to the many public highways, which pass through the park, there are 2,399 public rights of way (PRoW) with a total length of 2,761 Km accessible by cycle, horse or simply walking to appreciate the Park’s tranquil settings.

The protection of the existing dark night sky over the National Park is crucial in this tourist outreach objective.

This Lighting Master Plan (LMP) only uses the uniqueness relating to the exterior lighting issues and does not intend to diminish the importance of the many other unique issues in the National Park area.

Snowdonia National Park Authority (The Authority) is the planning authority within the park boundary and all planning applications require approval by The Authority. Therefore the adoption of this External Lighting Master Plan will ensure that there will be no further degradation in the quality of the night sky due to future developments within the Park boundary.

1.3 The Astronomers’ Point of View

More than 20 years ago the British Astronomical Association (BAA) forged links with the Institution of Lighting Engineers (ILE) (renamed in 2010 as the Institution of Lighting Professionals (ILP) to open

discussions on the plight of amateur astronomers. The problem was that views of the stars at night were being diminished by stray upward artificial light from outdoor lighting. This included elements such as old style street lighting and poorly installed floodlighting installations, as well as other commercial, advertising and domestic lighting.

There are many reasons why obtrusive light should be prevented but there are two prime objectives for adequate control and they are:

- **To minimise the problems it creates for human beings, plants and animals thereby improving amenity and biodiversity.**

- **Reduce unnecessary consumption of electricity and demands on fossil fuels thereby minimising carbon footprint and global obtrusion.**

Combating poor light control for astronomers assists in achieving both of these prime objectives but this is only part of an international obtrusive light control issue.

This document has been commissioned with the prime objective of promoting the use of the intrinsic darkness of the National Park to view the stars in the night sky. The document therefore concentrates on mitigating any obtrusive light elements which could cause a nuisance, from both the astronomers' and residents' viewpoint, by:

- Creating a benchmark to achieve International Dark Sky Reserve (IDSR) status from the International Dark-Sky Association (IDA);
- Maintaining or improving the night sky darkness as a background to view the star constellations;
- Providing a practical working document for commercial and agricultural use, and be accessible to residents, hoteliers and any other tourist related promotional material;
- Introducing the use of good quality lighting equipment with good light control;
- Adopting improvement, adaptation or changing outdated existing lighting equipment.

Unlike some other countries the UK has no regulatory governing body which provides exterior lighting, however, Professional Institutions such as the ILP, the Society of Light and Lighting (SLL), the Commission Internationale de l'Eclairage (CIE) and British Standards all provide illuminating engineering background advice and recommendations for engineers to follow and adapt to suit different geographic locations.

Likewise it is important to understand that apart from the Authority owned property it has no statutory powers to change or alter conditions or standards on existing private or commercial property. This role lies in the hands of local residents, farmers, commerce and local authority managers to work in partnership and adopt the good practice ordinance outlined herein. However through this LMP, the Authority has the power to deny permission to future developments within the National Park which includes external lighting which does not conform to the LMP and will empower developers to mitigate light obtrusion at the outset by adopting appropriate and suitable design.

1.4 Night Sky Quality Survey

The quality of the night sky was evaluated by volunteers from Snowdonia Society and staff from Snowdonia National Park Authority. This survey gives an assessment of night sky quality within the Park and establishes a benchmark that future surveys can be measured against.

1.4.1 Location of major sources of light presence within the National Park

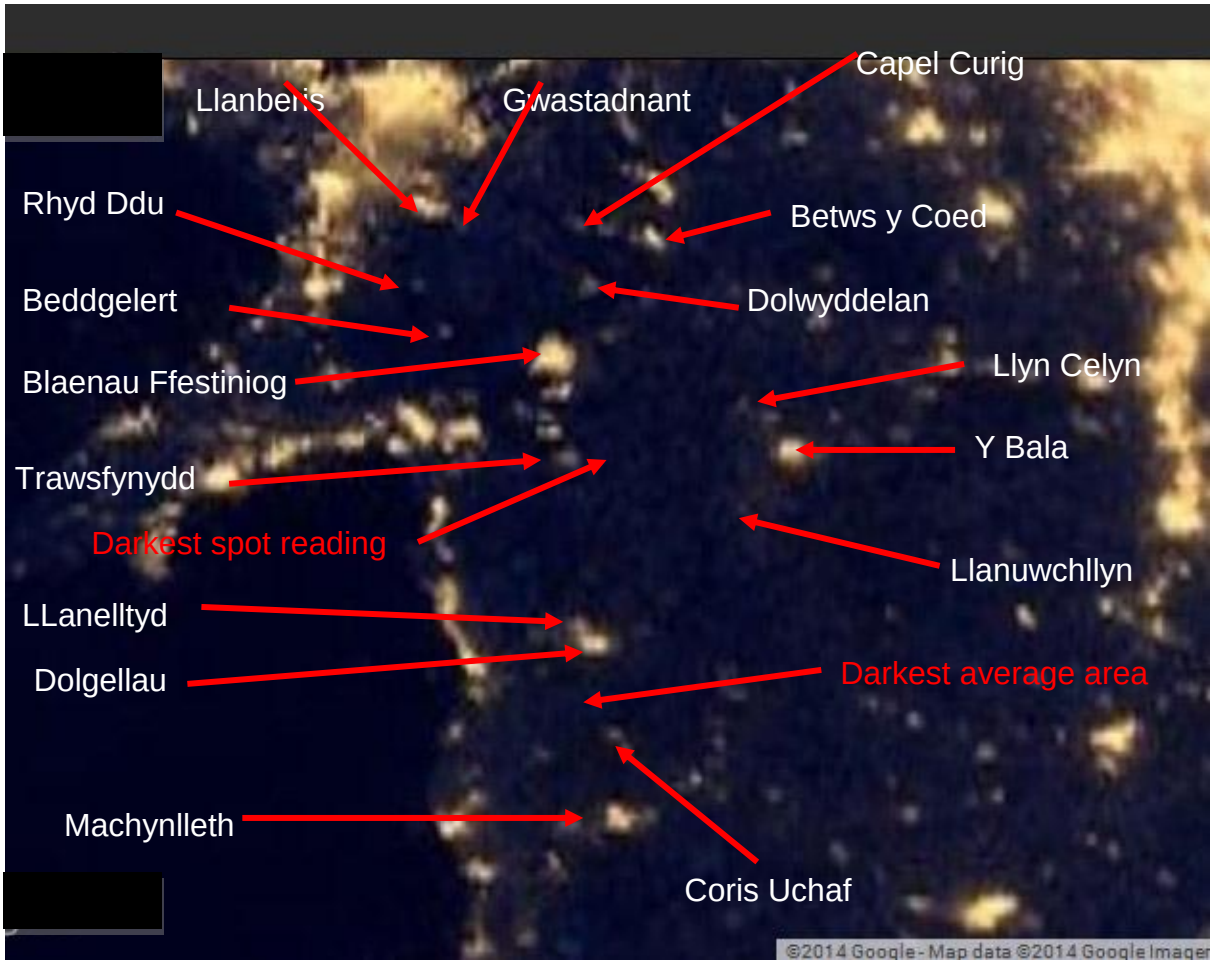


Figure 1.4: Snowdonia from Space (circa 2012)

Figure 1.4 is an extract from Google Earth by night where photographic images from several space station passes over the area have been assembled to show a graphic outline of the areas of earth illuminated at night. In the image there is a mixture of light reflected off the ground and light projected directly into the sky. It is only the light which is projected directly into the sky which is the cause for concern. However, figure 1.4 gives a good indication of possible high risk areas and town or village names, in or close to the Park boundary, that have been added as reference points.

Within the Park boundary Bala and the larger town of Dolgellau are close to a large central core of darkness. The image therefore acts as further evidence in the formulation of where possible core zones need to be established to protect the remaining dark areas.

Clear night sky measurement is the main method of establishing sky quality.

1.4.2 Measurement Methodology

To ascertain the darkness of the entire Park, 57 sites were located at convenient lay-bys or car parking points covering town, village and hamlet locations within the Park in addition to its uninhabited areas. The points chosen were included to give a balanced reading of the sky quality across the whole National Park and to identify areas of concern for the Authority. Measurements of the sky darkness were made at least 2 hours after local sunset on dates spread over a period of 15

months. They were taken with four separate Unihedron Sky Quality Meters (model SQM-L), which records the visual magnitudes per square arc-second over an area of approximately 42 degrees of sky.

All measurements were obtained by pointing the SQM at the zenith, then taking a minimum of three recordings before determining a mean reading.

Figure 1.5 : Dolgellau by night

1.4.3 Findings

The mean SQM value in different parts of the Park were -

Around Snowdon: 21.1 (average of 9 means)
A4212 and north: 21.3 (average of 8 means)
Area between Bala and Dolgellau: 21.34 (average of 7 means)
Area round Cadair Idris: 21.45 (average of 6 means) (see Figure 1.4)

(See Table 1.1 and 1.2 for the consolidated set of measurements)

The darkest SQM reading in the Snowdonia National Park = 21.67 is located near the village of Trawsfynydd (for location see Figure 1.4). A similar value was also found a few miles beyond the Park boundary.

The following readings are only included as a general comparison with other dark areas in the UK and should not be used as an absolute measurement value since the SQM meters used were not calibrated at the same time, the measurement methodology may have been different and the weather conditions will certainly have been different.

Darkest reading in Galloway Forest = 22.7 magnitudes per sq. arc second

Darkest reading on the Isle of Sark = 21.5
Darkest reading in Exmoor = 21.8
Darkest reading in Brecon Beacons = 21.5
Darkest reading in Northumberland = 21.8 magnitudes per sq. arc second

With a value of 21.67 Snowdonia National Park would appear to have the darkest sky measurement comparable to other areas in the UK recognised by the IDA.

1.4.4 Conclusions

With so many people with poor night sky quality in such close proximity, Snowdonia has considerable potential for dark sky tourism. The dark skies of the Park are of great value and well merit the protection by the Park Authority.

See Appendix B for a Nomogram comparing the various measures of sky darkness.

Startrails near Trawsfynydd

Table 1.1: Sky Quality measurement locations and results

Ranking	Location	Grid Ref	Average
1	Bryn Celynog, Cwm Prysor	SH753369	**21.67**
2	Efyrnwy (Pont Rhiwargor)	SH963244	**21.67**
3	Maestir	SH971332	**21.63**
4	Maes Parcio Bwlch Llyn Bach, Cross Foxes	SH753136	**21.63**
5	Cwm Hirnant, Bala	SH946273	**21.62**
6	Bwlch y Groes	SH914227	**21.62**
7	Llechwedd Hafod, Cwm Penmachno	SH774483	**21.51**
8	Argae Llyn Celyn, Frongoch	SH880403	**21.50**
9	i fyny o Pont Aber-Geirw	SH771287	**21.46**
10	Trac i fwrdd o Pont Fronwydd, A494	SH829245	**21.45**
11	Gwaith Dwr, ffordd Ysbyty Ifan	SH809453	**21.43**
12	Llyn Gwynant	SH648519	**21.42**
13	Llyn Dinas/Layby Hafod y Porth, Nant Gwynant	SH610493	**21.42**
14	Pen y Pass, Yr Wyddfa	SH647555	**21.41**
15	Y Ffynnon Arian	SH805539	**21.40**
16	Ffynnon Eidda, Migneint	SH762437	**21.39**
17	Hendre Isaf, A5	SH854512	**21.39**
18	Pont Gromlech	SH628567	**21.37**
19	Ffridd Uchaf, Rhyd Ddu	SH576514	**21.36**
20	Ty'n y Celyn, Dinas Mawddwy	SH842160	**21.34**
21	Cilfan, Ffordd osgoi Trawsfynydd	SH711352	**21.34**
22	Bwlch Oerddrws, Dinas Mawddwy	SH802170	**21.33**
23	Byrgoed, Llanddefel	SH989371	**21.32**
24	Maes Parcio, Cwm Cynfal	SH734417	**21.31**
25	Ystwmgwadnaeth	SH776217	**21.31**
26	Ffridd Dol y Moch, ffordd Bronaber/Llanuwchllyn	SH782334	**21.30**
27	Pont Llanelltyd, Dolgellau	SH717193	**21.29**
28	Groesffordd ffordd Aber-geirw, Bronaber	SH726318	**21.24**
29	Ty Hyll, Capel Curig	SH756575	**21.24**
30	Cadair Benllyn, Frongoch	SH906453	**21.23**
31	Hafotty-fach, Arthog	SH663135	**21.18**
32	Llyn Eigiau Resevoir, Dolgarrog	SH741672	**21.16**
33	Tal y Llyn, Minffordd	SH710094	**21.16**
34	Cae Coch, Rowen	SH731714	**21.11**
35	Cwm Maethlon, Machynlleth	SN658994	**21.08**
36	A470, turning for Capel Garmon	SH807585	**21.08**
37	Maes Parcio, Nant Peris	SH607581	**20.98**
38	Craig Isallt, Cwm Pennant	SH531453	**20.97**
39	Craflwyn, Rowen	SH762721	**20.96**
40	Eglwys Llanfihangel y Pennant, Cwm Pennant	SH526444	**20.92**
41	Pont Afon Dysynni, Castell y Bere	SH660086	**20.91**
42	Dafarn Faig, Pant Glas	SH479463	**20.88**

43	Pont Dysynni	SH599038	**20.78**
44	Llyn Tryweryn, Cwm Prysor	SH784387	**20.77**
45	Tal y Braich, Dyffryn Ogwen	SH699598	**20.72**
46	Pont yr Afon Taihirion, Migneint	SH804397	**20.70**
47	Llynnau Mymbyr, Dyffryn Mymbyr	SH706575	**20.67**
48	Bwthyn Idwal, Dyffryn Ogwen	SH647603	**20.67**
49	Chwarel Simdde-dylluan, Drws y Coed	SH536533	**20.53**
50	Sychnant Pass, Conwy	SH754768	**20.52**
51	Bryn Hall, Llanllechid	SH629691	**20.47**
52	Lon Eifion, Chwarel Bryncir	SH464482	**20.44**
53	Maes Parcio, Abergwyngregyn	SH675716	**20.32**
54	Tai Newyddion, Nant Ffrancon	SH629636	**20.01**
55	Gerlan, Bethesda	SH631664	**19.64**
56	Canolfan ymwelwyr Betws-y-Coed	SH794566	**17.82**
57	Blaenau Ffestiniog	SH700457	**17.80**

See Figure 1.6 on following page for map locations

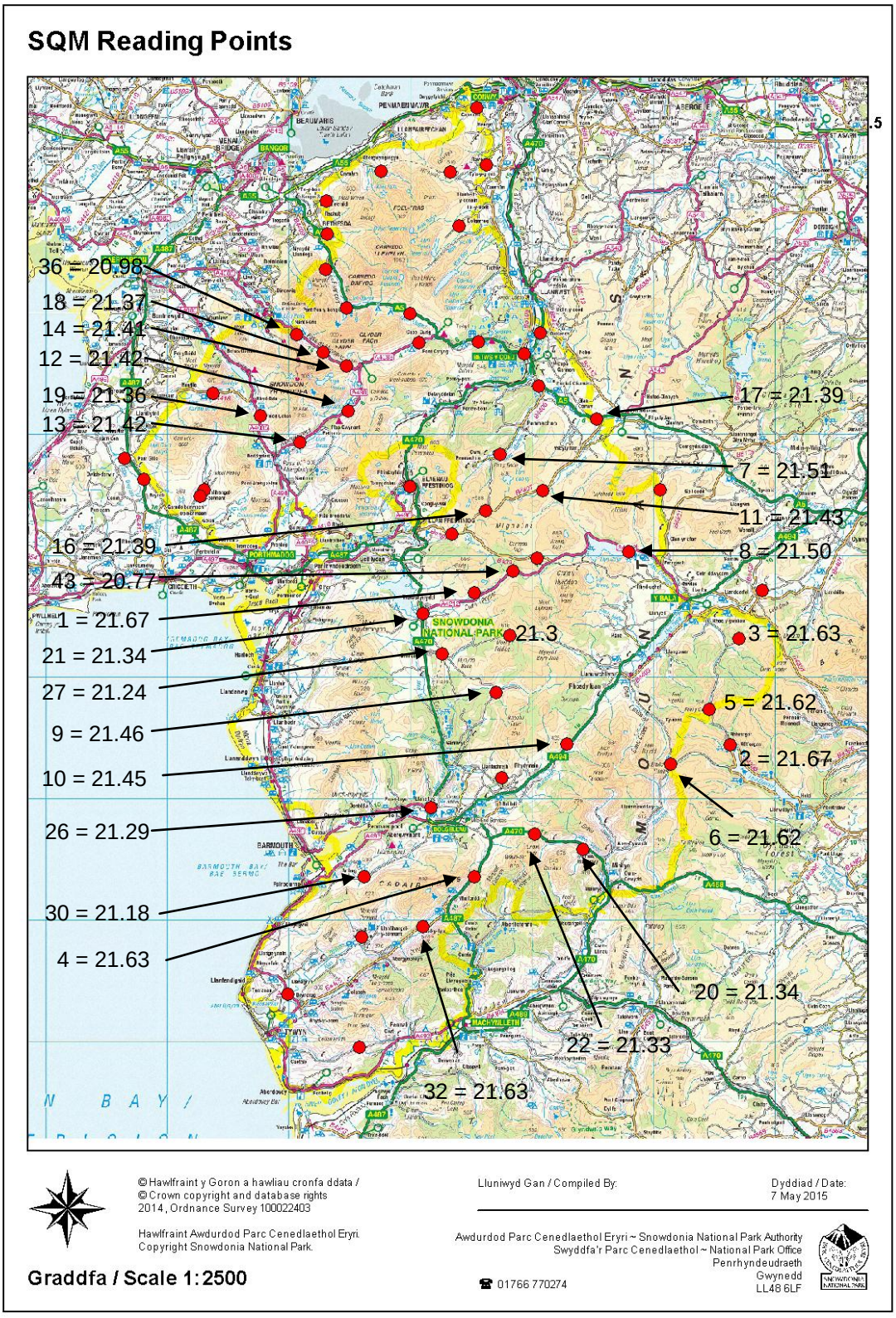


Figure 1.6: SQM reading and ranking close to prospective core zones

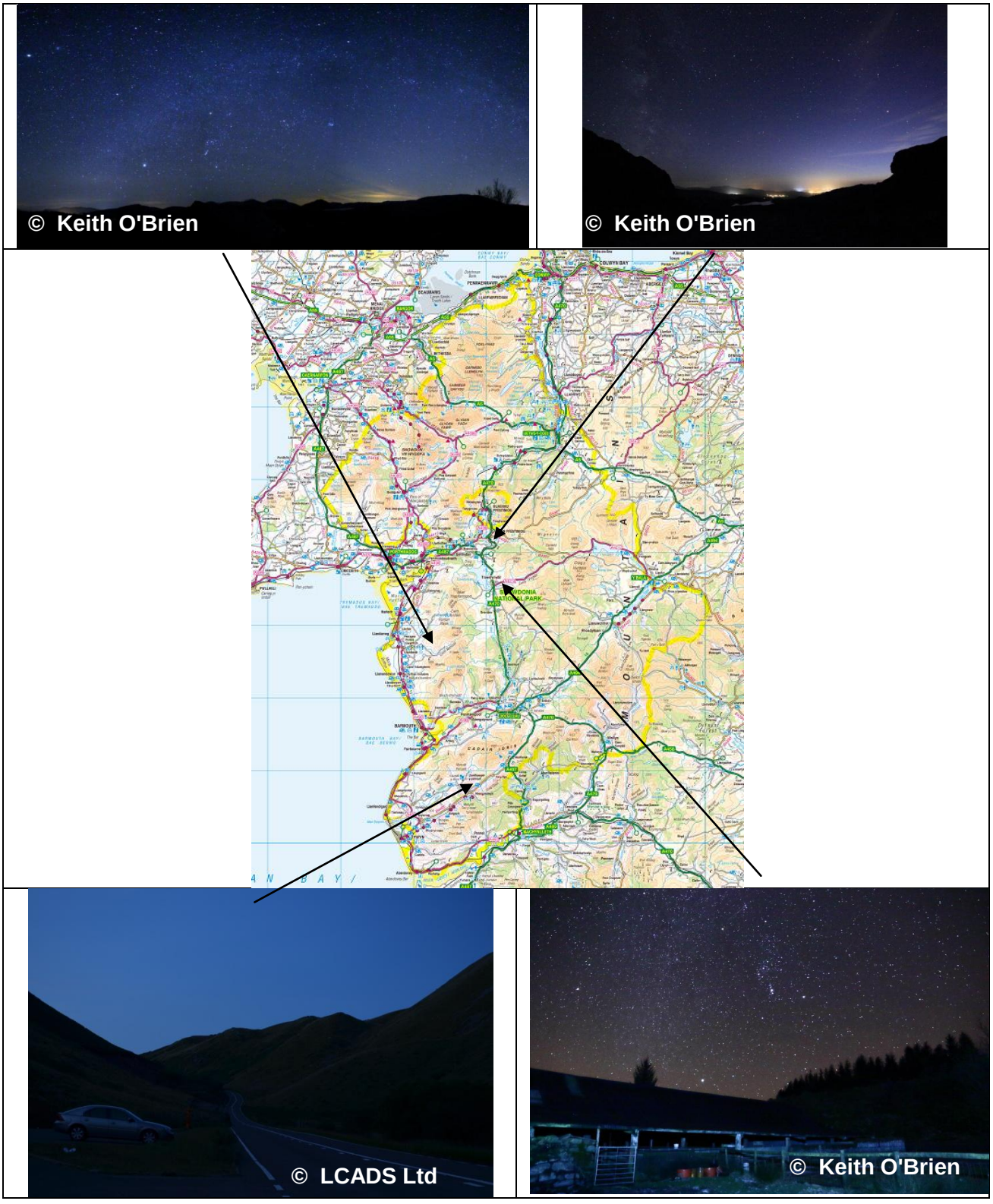


Figure 1.7: Sky Quality photographs within and near proposed Core Zones

1.5 Technical Lighting Data

It is not possible to produce a document on light control without introducing some light technical parameters and when used they will be defined as required with an appendix summary of technical definitions.

Basic Lighting Terms

Detailed explanations of basic lighting terms can be found in Appendix A but in this document the three lighting terms most commonly used for expressing values of light are:

Lumen: Describes the total amount of light given off by a bare lamp (abbreviation: lm (sometimes klm for 1,000lm))

Candela: Describes the intensity (I) of light in a particular direction (abbreviation: cd)

Illuminanc: Describes the amount of light falling on a surface area in lumens / square metre (abbreviation: lux)

This LMP has been devised, principally, to control different forms of stray light. First, and foremost, is upward light which can obscure night-time astronomical observations when it reflects off air-borne particles of water or dust. The effect is commonly known as **sky glow**. However, direct light sources close to any field of observation are also problematic and are discussed later.

In addition to sky glow, astronomers do not like to see a visible source of light either and luminaires with a light source larger than 600 lumens should be what the IDA call "**fully shielded**" from view, i.e. a completely flat glass window mounted horizontally, as shown in Figure 1.8 (right). Non-technical terms like this will be explained and mixed with technical descriptions later.

Figure 1.8: "Fully Shielded" luminaire

The IDA term of "fully shielded" and other non-technical terms like high beam, semi cut-off, cut-off, fully cut-off and aero-screened were formerly used in the UK to categorise a luminaire's light distribution. These luminaire category terms disappeared from the lighting industry usage in Europe and the UK some 30-40 years ago but sometimes still appear in UK planning publications. These old, non technical, terms have therefore been reinstated, in this LMP, but with more accurate technical descriptions with limitations on intensity values in Section 2.

The IDA term "**Fully Shielded**" is synonymous with the old UK term "Horizontal **Fully Cut-off**" and is the preferred term used in this LMP, (alternatively G6 glare rating see later).

Upward light and source intensity limitation are only two of four aspects of stray light control explained in two complementary technical publications on the limitation of obtrusive light namely:

- The Institution of Lighting Professionals (**ILP) (formerly ILE**) 'Guidelines for the Control of Obtrusive Light' (Undergoing continued revision), and
- The Commission Internationale de l'Eclairage (**CIE**) Technical Report 150:2003 'Guide on the limitation of the effects of obtrusive light from outdoor lighting installations'.

Both documents support the concept of setting out environmental zones based on the night time ambient light in the area. They then go on to recommend differing degrees of stray light control for each of 4 environmental zones. In previous years the most onerous limitations were in the zone of darkest ambience namely Environmental Zone E1 but the newest edition of the ILP guidelines (2011) includes an even more severe restriction in a new zone numbered “E0” where no new artificial light presence is permitted.

Snowdonia National Park has a total population of about 26,000 (2001) but there are no very large areas free of human habitation. However, a total non-cohesive area of 62,716.9 ha consist of nature reserves and other nature conservation related titles which warrants the application of "no new artificial lighting" regime. Section 2 therefore outlines a three tier approach to allow for the inclusion of existing farms and residences within the core areas. The remainder of the National Park does, however, fall into Environmental Zone E1 as outlined below in Table 1.2. Strict light control status in all UK National Parks has been recognised since the ILP first introduced the night time ambience zone classification in 1993 and a full description of light limiting factors for Core, Buffer and other adjacent environments will follow in Section 2.

Table 1.2: Environmental Zones in the UK

Zone Number	Surrounding	Night Environment	Typical examples
E0	Protected	Dark	Starlight Reserves, Dark Sky Parks or Islands, Typical of Core Zones
E1	Natural	Intrinsically dark	National Parks, Areas of Outstanding Natural Beauty or Dark Sky Core Buffer Zones
E2	Rural	Low district brightness	Village or relatively dark outer suburban locations
E3	Suburban	Medium district brightness	Suburban residential / commercial or small town centre locations
E4	Urban	High district brightness	Large town, commercial area or city centre with high levels of night time activity

In addition to direct upward light limitations Dr Christopher Baddiley has shown in ‘Towards Understanding Skyglow’ (ILE:2007) that obtrusive glare from street lighting units, at or near the luminaire horizontal axis, can also diminish the astronomers’ observations. Accordingly the source horizontal intensity is also used in this LMP as a further means of providing both public nuisance reduction and better astronomical observations.

Reference is therefore made to limiting intensity values emanating from lighting units. The traditional simplistic means of displaying intensity distribution information is by means of a polar diagram with angular intensity values.

The polar diagram in Figure 1.9 (following) is a traditional way of illustrating a line of maximum intensity through the major and minor axis of a street lighting luminaire. For clarity Figure 1.9 shows only the major axis distribution for a street lighting luminaire ie the intensity of light emitted out of each side of the luminaire together with three angles where intensity limitations will be later applied to control horizontal and upward light, and a further two downward angles which are used in BS 13201 to control disability glare on the public road network. However, recent research has shown that downward intensity values at an angle of 70 degrees has an effect on the amount of light

reflected upwards, off hard surfaces. **Therefore the lower the values at 70° and 80°, the lower the reflected upward light.**

Regardless of luminaire light distribution characteristics recent research has also, more importantly, shown that off highway light absorbing landscape such as natural grass can reduce, by half, the upward reflected light of the installation and the use of asphalt surface lowers by half the upward light reflected off concrete.

(Landscape note: Many rural commercial/industrial estates and car parks could be constructed, where appropriate, with asphalt surfaces rather than bare concrete if illumination is required or intended in the future)

Throughout this LMP Upward light control limitations are stated for the luminaire in its designed or 'as-installed' condition on site and is not a factory measured intensity.

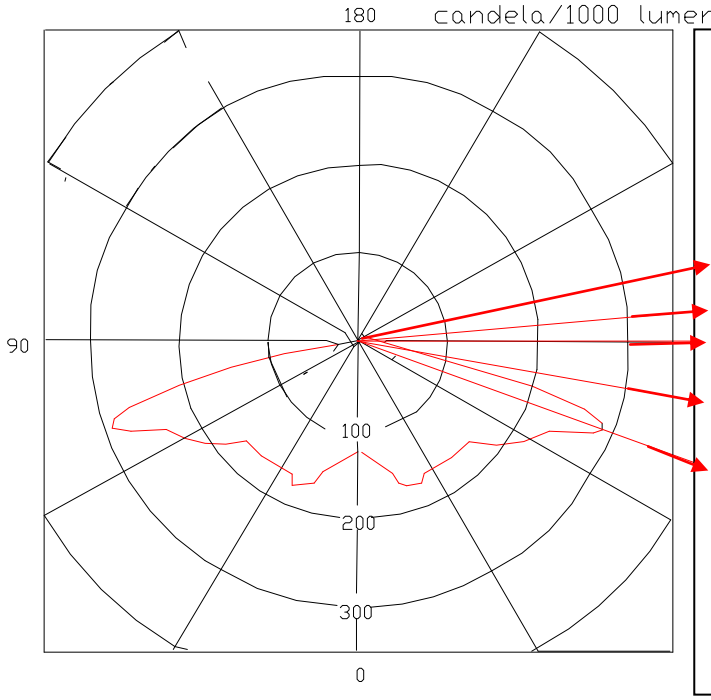


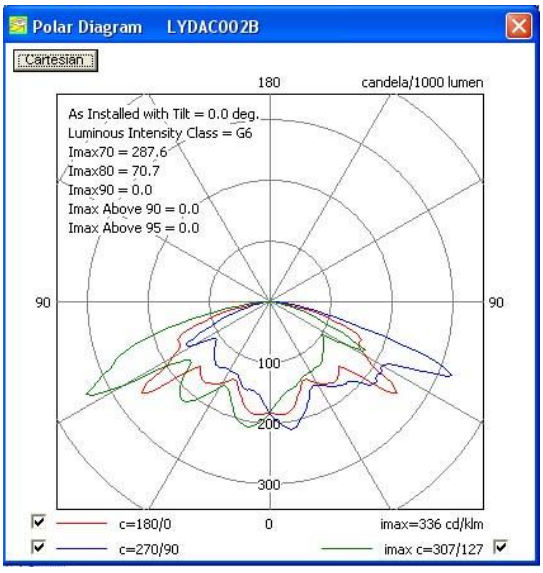
Figure 1.9: Polar Diagram of typical street lighting luminaire

Also shows the angles and maximum intensity values for a "fully shielded (cut-off)" luminaire
Imax above 95^0 = 0 candela
Imax above 90^0 = 0 candela
Imax at 90^0 = 0 candela

Imax at 80^0 = 100 cd/klm

Imax at 70^0 = 350 cd/k/lm

Tables extracted from BS publications will show all 5 angles with restrictions relative to glare control but in this LMP the important angles will be the intensity of **zero** at 90^0 and above.



Industry standard design software like 'Lighting Reality' can be used to check luminaire 'as installed' intensity values in a dynamic format as shown in Figure 1.10 at the design stage.

Another technical way of describing the limitation of upward light from luminaires is called the Upward Light Output Ratio and the ILP are currently considering the values, in percentage terms, of the zonal flux in 2 upward zones, namely between 90^0 and 100^0 and between 100^0 and 180^0.

Figure 1.10: Dynamic output from Lighting Reality showing results at installed tilt angle

1.6 Fully Shielded Concept Visualisation

The upward light limitations of a “fully shielded” / horizontal fully cut-off luminaire is outlined in technical detail in section 1.5. However, to display the effects, in a non technical format, an electronic model village was constructed and illuminated firstly with traditional low pressure sodium street lights which are not fully cut-off and Figure 1.11 shows house details up to and beyond chimney pots level.

Figure 1.11: Traditional Low Pressure Sodium distribution - the luminaire positions were then replaced by luminaires with flat glass and mounted horizontally with an equivalent wattage consumption using LED light sources.

Figure 1.12: Luminaires with fully cut-off distribution showing distinct lack of upward spill light detail.

Both figures 1.11 and 1.12 were created with AGI32 calculation software which uses mathematical light radiance calculations (and not by artistic artwork) to render all the model surfaces.

2 Dark Sky Reserve Boundaries and Light Limitation Policy

The International Dark Sky Association (IDA) promotes the concept of creating three zones to the dark sky area namely a Core Zone with no, or very few, external light sources, a Buffer Zone with strict stray light control to protect the Core and lastly an External Zone with slightly relaxed stray light control.

This section covers the boundary methodology for each of these zone areas and the associated stray light restriction recommendations for each area together with planning recommendations to mitigate problems with future applications containing external lighting.

2.1 Dark Sky Reserve - Core Zone Formation

As described in Section 1.2 there are three distinct sections to this National Park with each section containing National Nature Reserves, but separated by an area in the north around Blaenau Ffestiniog which is not in the National Park and in the south by Dolgellau. This separation created some difficulty in deciding which section had the best attributes to be selected as a cohesive single core zone as has been exercised in other UK Dark Sky Reserves. Since the central area between Bala and Dolgellau provided the darkest sky quality attributes this appeared to be the only initial option. Unlike other application core zones, however, this option is much more heavily populated and many more residents live in harmony with the wildlife than in other areas previously granted reserve status.

To help resolve the dilemma at an early stage an informal approach was made to the IDA and they produced four possible options for discussion.

Figure 2.1.1: IDA Option 1

Figure 2.1.2: IDA Option 2

The first IDA option equated to similar lines to the initial dilemma and the second included the towns of Bala and Dolgellau. However, the inclusion of Bala, within a core, would bring the core boundary too close or coincide with the Park boundary and thereby exclude the management of a buffer zone between the core and an external zone.

The inclusion of Bala and Dolgellau in a buffer zone situation was therefore set as an interim necessity as an opportunity for improvement with a possible core zone inclusion for Dolgellau in a future core zone expansion to the south following similar lines to that shown in IDA's Option 3.

Figure 2.1.3: IDA Option 3

Figure 2.1.4: IDA Option 4

In providing Option 3 the IDA suggested that the inclusion of Blaenau Ffestiniog was too great a challenge for improvement. As previously indicated in Section 1.2 the town and an area of countryside round it does not fall within the Park Authority jurisdiction. It could, however, be regarded as a possible objective for Gwynedd County Council to improve in line with the LMP light limitation principles.

Because of the perceived problem with Blaenau Ffestiniog the IDA Option 3 introduced a new concept. The idea of more than one core zone and the inclusion of the area round the mountain which gave its name to the National Park was therefore set as another essential element.

The boundaries of two core zones were devised to replicate option 3 but also include the best of nature's reserves, maximise on public access by using many of the "Open Access" boundary lines, shown on Ordnance Survey maps, and maximise on the best sky quality measurements. The initial draft boundaries were then subsequently extended to include another Nature Reserve, more sky quality measurements and a possible location for an observatory.

Figure 2.2: Dark area of Cadair Idris not included in original two core zone concept - in response to resident feedback from the area south of Dolgellau the area was visited during the two core lighting audit and in view of its lack of light obtrusion (see Figure 2.2) a third core, south of Dolgellau, was seen as another essential element.

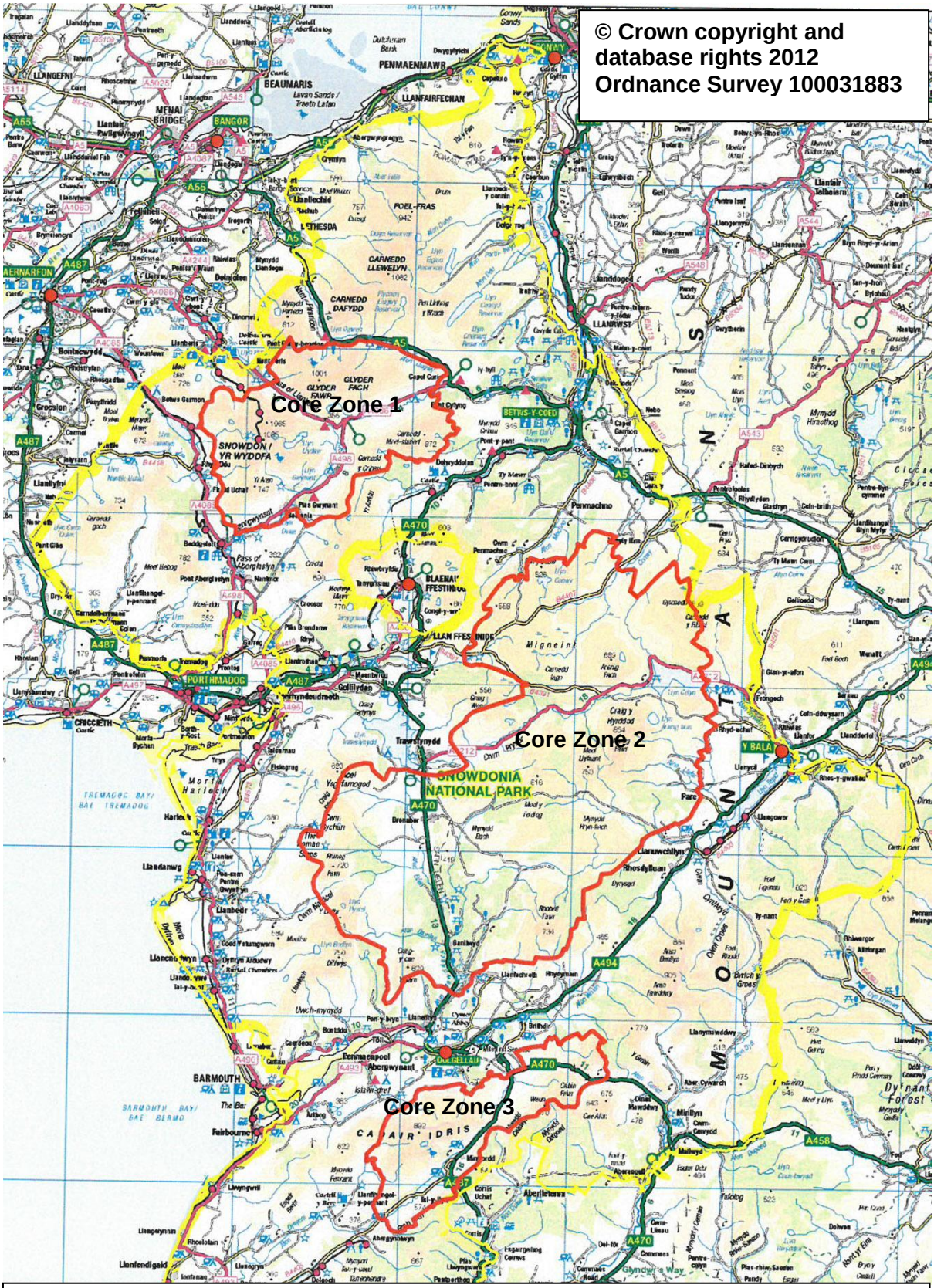


Figure 2.3: Boundary line of the three proposed Core Zones

2.2 Dark Sky Reserve - Core Zone Detail

After combining the best of the sky quality measurements, the property areas with the best IDA compliant external lighting results and the Authority outreach objectives the Core Zone boundaries, as shown in Figure 2.3, 2.4, 2.6 and 2.9 was devised to maximise on open land access by encompassing the following natural attributes of the National Park (see Table 2.1).

Table 2.1 Core Zone Protection Attributes

	Core Zone 1	Core Zone 2	Core Zone 3	Overall
Area of Core	44.6 Sq. Miles	144.4 Sq. Miles	25.6 Sq. Miles	214.6 Sq. Miles
Proportion of National Park	5.4%	17.6%	3.1%	26.1%
Number of National Nature Reserves	2	2	1	5
Number of Sites of Special Scientific Interest (SSSI's)	2	9	1	12
Number of Special Area of Conservation (SAC's)	2	4	1	7
Number of Special Protection Area (SPA's)		1		1
Number of Historic Landscapes	2	4	3	9
Number of Residential Hamlets	2	4	1	7
Core Property Density per Square Mile (excluding hamlet density)	0.7	0.9	1.3	
Average SQM Value	21.1	21.32	21.43	

Note: The overall area of the three proposed core zones is equivalent to the overall area of all the SSSIs.

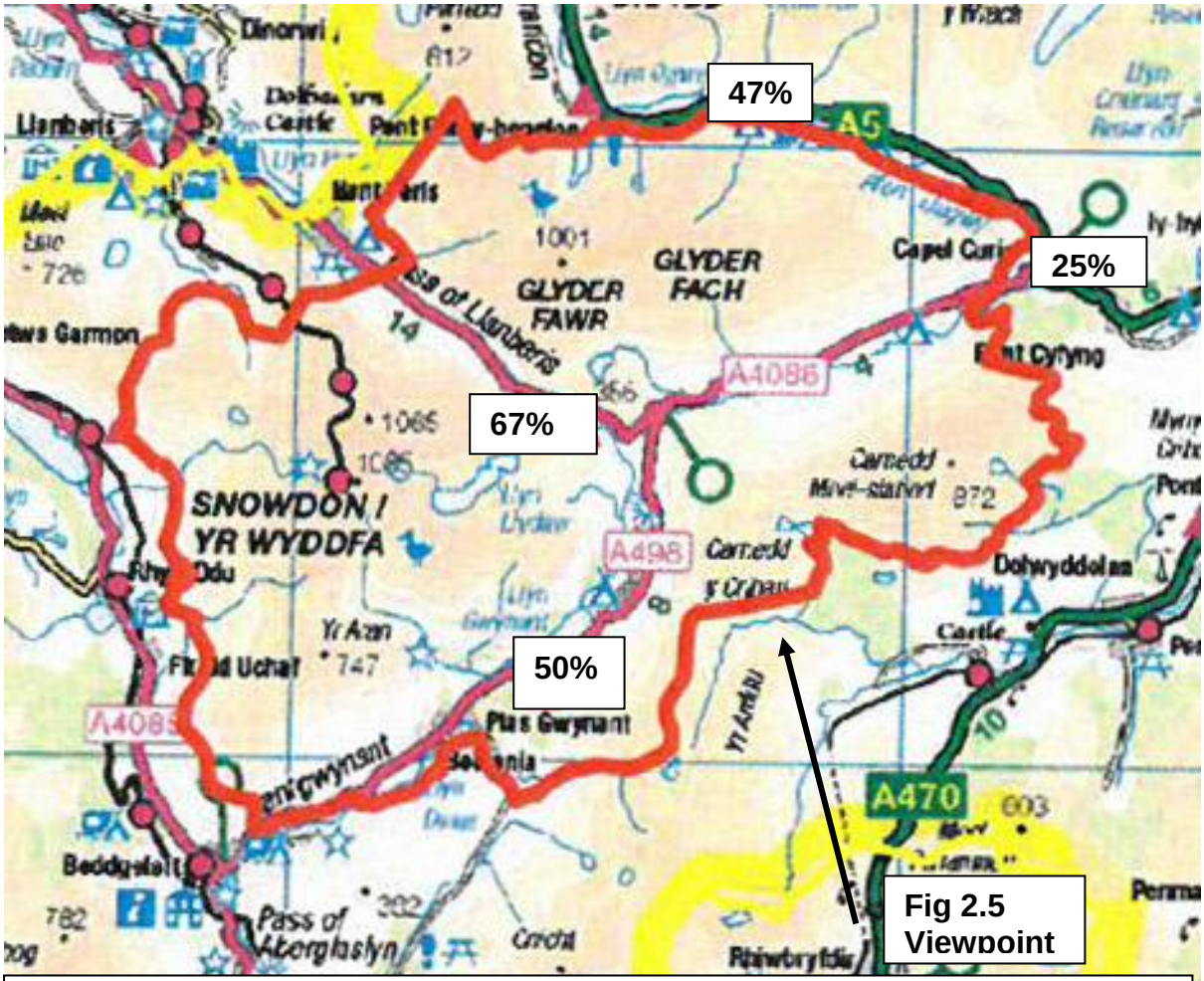
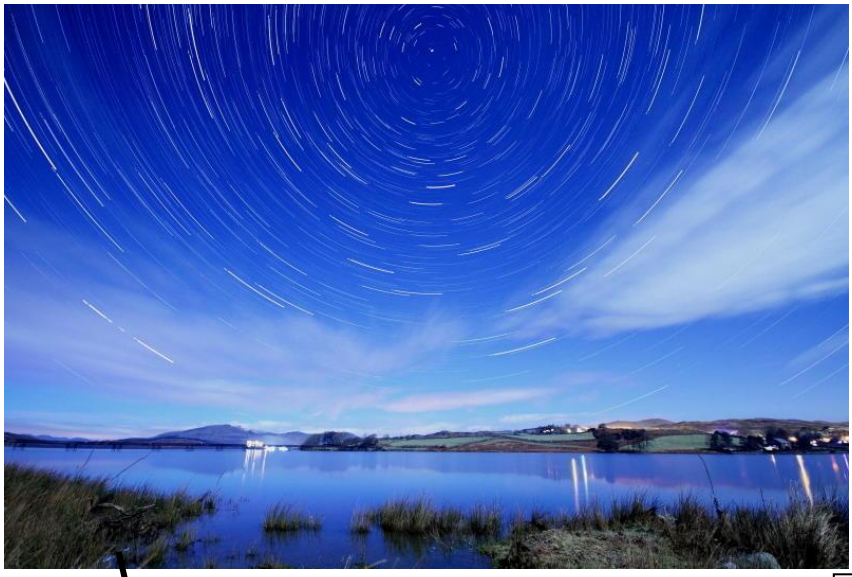


Figure 2.4: Core 1 boundary with audit compliance rate less than 70%

Figure 2.5: Core 1 Typical Landscape Character



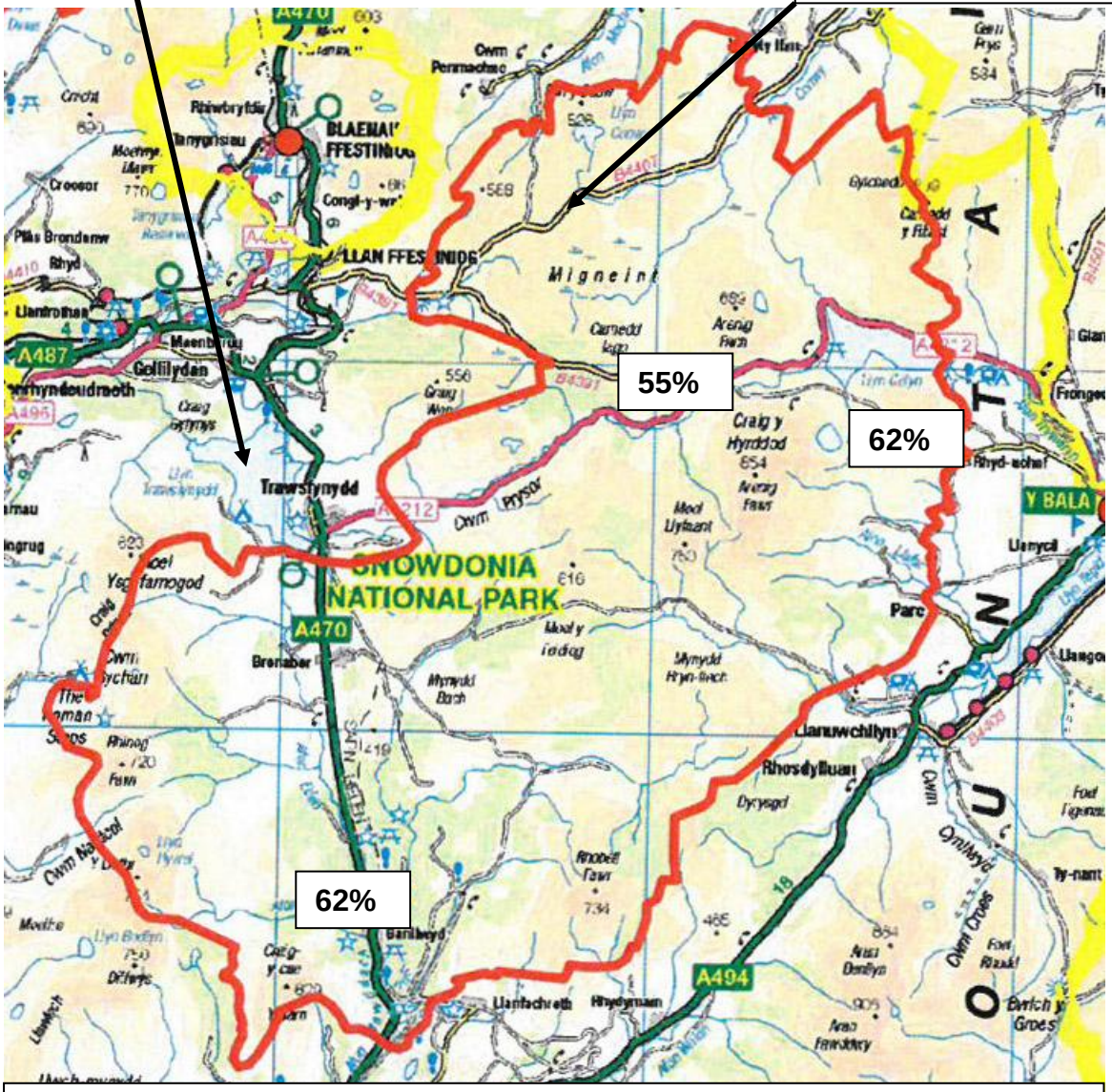


Figure 2.6: Core 2 boundary with audit compliance rate less than 70%

Figure 2.7: Typical landscape in North of Core 2 near possible Observatory

Figure 2.8: Typical landscape in south of Core 2

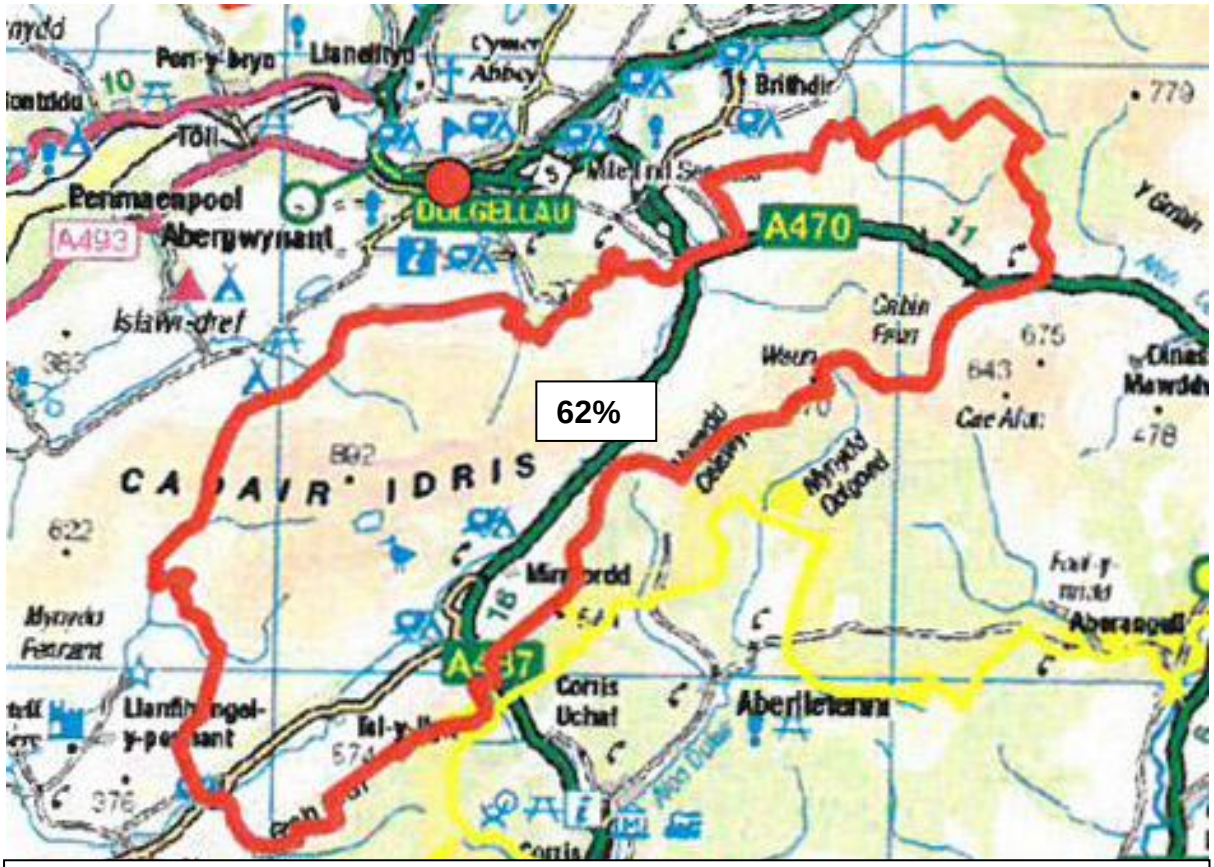


Figure 2.9: Core 3 boundary with audit compliance rate less than 70%

Figure 2.10: View looking South over Dolgellau with Core 3 beyond

Although the third core represents only 3% of the total Park area it carries just as important nature protection attributes as core 1 and also has a darker sky quality than Core 1. By including it at this stage will give it instant protection from possible future light obtrusion and amplify the need for improvement along the Bala/Dolgellau corridor.

Plan Statement Number 1: The boundary between the second and third core is provisional and will be increased with a view to joining the two into one after further additional public consultation.

2.3 Basic Light Limitation Plan - Environmental Zone E0's

The first UK application to the IDA was Galloway Forest Dark Sky Park and their Core Zone was an area of zero inhabitants and therefore within that Zone the concept of no new lighting was sustainable and that was described as a possible E0 in 2009, prior to the CIE/ILP recognition in 2011 as the values shown in table 2.2.

Table 2.2 E0 - CIE/ILP guidance

Environmental Zone	Sky Glow ULR %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)	
		Pre-10pm	Post-10pm	Pre-10pm	Post-10pm	Pre-10pm	
E0	0	0	0	0	0	0	-

There are now core zones in other Dark Sky Reserves where there are remote farms and residences within a core boundary where the "no new lighting" concept is not sustainable.

There are, however, areas like NNRs within the Snowdonia core zones where the requirement for no new lighting is essential.

For inhabited areas any new or existing lighting could be made sustainable if the visual perception of source intensity is limited to the immediate vicinity of the property or the property boundary.

Table 2.3 (following page) shows adaptations (added by this LMP author) to the CIE/ILP published values to replace core zone with three assessment notes below to identify where presence can be measured depending on the property density. Within a group of houses a distance limit of 50 meters is appropriate and in remote farm locations a measurement distance of 250 metres should be applied, assuming in both situations that the property boundary is more distant.

Table 2.3: Stray light control recommendations in Typical E0 Zone

Night Time Environmental Zone	Sky Glow ULR %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)	Assessment Point Illuminance
		Pre-10pm	Post-10pm	Pre-10pm	Post-10pm	Pre & Post - 10pm	Ev or Eh (lux)
E0-0	No New External Lighting Units Permitted (excluding the need for red filtered navigation / marker lights)						
E0-250	0	0	0	0*	0*	0	0.10
E0-50	0	0	0	0**	0**	0	0.25
E0-SL***	0	0.25	0.1	0	0	0	
© LCADS Ltd 2013							(IESNA = 0.5 lux)

Assessment Note 1: Measurement or calculation of light intrusion should be in the vertical plane and parallel with the window pane in its centre.
***Assessment Note 2:** Measurement or calculation of the source intensity should be based on a 1.5 metre high visual receptor placed at any location on the property boundary or 250 meters beyond the new light source, **whichever is closer** (eg. remote farm).
****Assessment Note 3:** Measurement or calculation of the source intensity should be based on a 1.5 metre high visual receptor placed at any location on the property boundary or 50 meters beyond the new light source, **whichever is closer** (eg community within E0-250).

*** Note spill light from public street lighting unit only

Plan Statement Number 2: Any new or replacement lighting within the Core Zone boundaries shown in Figure 2.3 should be "Fully Cut-Off" (Fully Shielded (IDA term)) regardless of light source lumen output.

With the exception of the National Park Visitor Centre in Core Zone 1 all the other properties in the Core Zones are private, however, the summary in Table 2.4 shows that there are 74% compliant with the general IDA guidelines and over the next 5 years The Authority will encourage commerce and residents to adapt, adjust the tilt angle or retrofit at least 10% of the remaining which are not IDA compliant. As a visual assistance Figure 2.11 provides typical domestic luminaire profiles which comply with the recommendations in Plan Statement Number 2 and 4.

Table 2.4: Core Zone Lighting Summary

Core Section Audit Number	**Number of lights**	**Number IDA Compliant**		**Number Plan Statement 2 Compliant**
Core 1 Section 3	42	28		6
Core 1 Section 4	80	64		18
Core 1 Section 5	96	48		6
Core 2 Section 7	195	135		

Core 2 Section 8	379	352		5
Core 2 Section 9	55	34		1
Core 2 Section 10	55	25		2
Core 2 Section 12	89	49		
Core 2 Section 13	29	26		2
Core 2 Section 16	30	29		1
Core 3 Section 22	112	74		
Total in Core Zone	**1162**	**864**	**74%**	

Plan Statement Number 3: Residents in the Core Zone are to be encouraged to limit the visual perception of light output at their property boundary by adapting or modifying existing units to this end.

Deltalight

LED Deltalight

Zumtobel -

Kont Smide + others

Kont Smide - Torino

Kont Smide - Modena

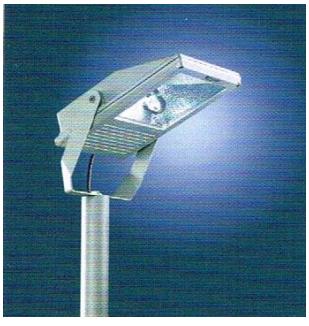
liteCraft Stainless Wall Light

liteCraft Dacu 2x1 watt LED

liteCraft Savona (shielded version)

Raytec

B&Q (above)
Norlys - Koster (right)



Sitco + Others - Double Asymmetric Mini Flood

All floodlights like this are designed to be mounted horizontally. Additional shielding as illustrated right can limit light at task area boundary

Figure 2.11: Typical external domestic fittings which can provide the fully cut-off objectives of Plan Statement Number 1 and 2 when mounted correctly

2.4 Energy Saving Switching Regime (Time Limited)

Many commercial premises have labels attached to light switches to say switch off lights when room is not in use and some buildings have energy management systems which automatically detect occupation and adjust accordingly. External lighting should be similarly treated, not only to limit energy usage but also to reduce the impact on the night sky.

Many domestic exterior luminaires can be purchased with a combined passive infra-red (PIR) presence detector and photoelectric switch unit (PECU) to do the same work as the commercial building management system. A time delay switch is just as good and it has the added advantage over PIR detection in that the luminaires will not be turned on by cats, dogs or other wildlife movement and will ensure that lights are not accidentally left on overnight.

All residential and business occupiers should be encouraged to recognise the benefits of switching off unwanted lights or adopt some form of light reduction after the time limitation of 22.00 hours. Even if the luminaire is not fitted with presence or darkness detection some DIY stores supply programmable light switches which are designed to replace existing internal manually operated switches.

In addition to applying time limitation benefits in the Core Zones the Environmental Zone tables in the Buffer Zone, which follow, gives intensity limitations for Pre and Post - 22.00 hours.

Some sports or other work related applications may have earlier time limitations included in their original planning approval. This LMP suggested time limitation target does not override any existing planning conditions, however, in some cases a voluntary earlier switch off time or later switch on time may be requested.

> **Plan Statement Number 4:** Residential and business occupiers will be encouraged to recognise the benefits of switching off exterior lights after 22.00 hours.

Within the boundary of the National Park it is important to note here that if there is "NO TASK" in operation there should be "NO LIGHT" and that the recommended values given could be reduced if "white" light sources are used (see technical reason later).

2.5 Dark Sky Reserve – Buffer Zone

It is a general recommendation that all Core Zones require an area of protection surrounding the very strict limit of no, or very little, artificial light with one of less severe limitations. As outlined in Section 1.5 the status of light control within any National Park has been recognised since the first publication of the ILP "Obtrusive Light Guidelines" in 1993 as being that of a night time environmental zone E1. As such this provides, for the remainder of the Park a general Buffer Zone limit of many miles distant round the three core zones. This LMP encourages continuance of this classification but proposes a two step audit approach within the Park boundary.

The IDA recommends that an external lighting audit is carried out on all lighting within the Buffer Zone but the quantity of lighting, within the Park boundary, would take too long to collect.

The concept of a Critical Buffer Zone beyond the core with a generalised edge (not a boundary limit) of about 1½ miles (about 2Km) area was established and a domestic lighting audit taken. For the first

time in any UK master plan two towns and two villages were included in the audit process due to their close proximity to the proposed core boundaries.

In this way the audited properties, in the form of remote residences, remote farms, grouped residential villages and towns can be presented as representative of the domestic scene elsewhere in the National Park Reserve. In the region of 1740 properties were audited and this yielded a total of more than 3,000 external lighting units and an overall average of 73% was found to be IDA compliant.

Section 5 contains a summary of compliance rates in the various areas audited. Areas with low compliance generally have one or two poorly lit commercial properties and an overall average of 73% does not reflect the generality of high domestic compliance when there are no commercial properties in the section total.

2.5.1 Critical Buffer Zone

Within the 2 mile area immediately surrounding the Core Zones there are 25 village settlements with two towns namely Bala and Dolgellau. While these residential areas are not contained within the concept of a habitation free core **they have not been excluded** from the concept of reducing light obtrusion throughout the future Dark Sky Reserve.

> **Plan Statement Number 5:** The Authority will endeavour to ensure that no lighting will be allowed to be projected from the adjacent light permitted buffer zones into the Core Zones and any overspill lighting from lights in the Critical Buffer Zone to be no greater than 0.05 lux (horizontal) at ground level or 0.05 lux vertical at 1 metre (or higher) above ground on the Core Zone side of the property boundary.

Although there are many lighting unit variations on a theme to be found in the Cores and Critical Buffer Zones there are principally 3 different luminaire styles, namely:

Heritage (Figure 2.12.1)

Figure 2.12.1

Bulkheads (Figure 2.12.2)

Figure 2.12.2

Floodlights (Figure 2.12.3)

Figure 2.12.3

A few other styles were also found but the important element is not the style of the luminaire but its associated lamp output and more importantly the distribution of light being emitted. Most of the tungsten halogen floodlights use lamps which have an output greater than 1,500 lumens. About 390 were found with an elevated angle as illustrated in Figure 2.12.3. To be fully compliant with the IDA recommendations, the glass window should be totally horizontal as shown previously in Section 1.5 (Figure 1.8). Included in this number at least 210 (about 54%) were controlled by presence detectors

and would probably not have been used continuously at night (see Appendix G for a future improvement process).

> **Plan Statement Number 6:** Luminaires in the Buffer Zone using lamps greater than 500 lumens and operating continuously throughout the hours of darkness should be installed as a Fully Cut-Off (IDA "fully shielded") example.

Bulkhead style luminaires should be fitted with lamps less than 500 lumens even although they may have an upper hood purportedly limiting upward light. A luminaire such as shown in Figure 2.12.2 with an 18watt compact fluorescent lamp ("energy saving light bulb") can provide a vertical illuminance value of 0.1 lux at least 22 metres from the source and also provide visual perception of light on tree tops some 150 metres distant. Although it may not be possible to measure the quantity of illumination at this distance it is the visual perception of the light reflecting effects, which causes concern for both astronomers and neighbours alike.

The IDA recommend that the spill light at a property boundary (excluding property in the Core Zone) is not greater than 0.1 lux, which is about 1/3 of the light from a full moon. Illuminance can be measured with a light meter but a rule of thumb guide which links the lamp lumen usage to property footprint size is included in Section 3.3.

As well as providing careful control of spill light it is equally important to avoid over-lighting an area. Where possible this LMP provides task illuminance objectives and some alternative solutions to address in the future.

> **Plan Statement Number 7:** Residents are to be encouraged to limit the overspill light at their property boundary to no more than 0.1 lux (residents within the Core Zones have stricter recommendations).

With the exception of the large pole mounted heritage style luminaires as shown in Figure 2.13 most domestic heritage style luminaires are designed and labelled with a maximum tungsten filament lamp wattage of 60 watts (11watts Compact fluorescent), both producing just over 600 lumens. Even at this wattage they have very little light control and a lumen output cap of 500 lumens is now generally accepted in the Buffer Zone as IDA compliant.

The lower the wattage the better the compliance.

In some residences the heritage style luminaires were found to be located in a door porch area. This approach provides a good method of limiting stray upward light. Additionally some residents have installed 8 watt, or less, compact fluorescent lamps, which are often all that is necessary to provide some light round a doorway in the intrinsic darkness of the Park.

Most domestic lamp cartons are now marked with the lamp lumens and colour temperature in addition to the lamp wattage, however, a lamp wattage and lumen output chart for domestic style lamps is given in Appendix F. Guidelines for an individual property self-assessment style audit with recommendations on what to do to better the existing conditions is given in Appendix G.

Figure 2.13: Good example of Heritage Luminaire with rear light limiter, lamp recessed in canopy hood and light distribution using pot-optic.

2.5.2 Remainder of Buffer Zone (extends to National Park Boundary)

Some of the hamlets have no street lighting system and some have two or three located at strategic locations in the village rather than providing a cohesive street lighting system. Since the old sodium street lighting is perceived as providing all the light obtrusion the two local authorities, who own and maintain the street lighting, have already started to change their own lighting policy plans to introduce part night dimming (ie on full light output at dusk but dimmed by 50% about midnight and back on full power again about 5.30am until dawn).

As outlined in Section 2.3 no audit was undertaken for domestic lighting units in the remainder of the Park Buffer Zone due to the quantities involved, however, as shown in Table 2.5 the surveyed quantity and the resulting compliance percentage is equivalent to other UK Dark Sky applications. The survey contained data from domestic and commercial properties and when analysed the combined compliance percentage equated to 69%.

Table 2.5 Comparison of Percentage Compliant with other Dark Sky audits

Dark Sky Application	Quantity Surveyed	Quantity Compliant	Percentage Compliant
This Application	3,499	2,410	69%
Northumberland & Kielder	2,375	1,786	75%
Brecon Beacons	964	681	70%
Exmoor National Park Reserve	693	539	77%
Isle of Sark Dark Sky Island	582	436	75%
Galloway Forest Park	374	263	70%

Due to the vast number of properties visited in the overall survey to find the best fit core zone boundary it was not necessary to test the domestic average in a different section of the Park. It could therefore be reasonable to assume that this percentage will be replicated throughout the National Park. See Table 5.3 for compliance summary in each section audited.

Where new or replacement external lighting is required the most onerous light control conditions should be applied to maintain and ultimately improve this condition. To assist in this objective, Section 2.4 contains recommendations on luminous intensity recommendations for new luminaires,

with a lamp output greater than 500 lumens. For domestic style luminaires with no intensity data Section 3.3 contains a lumen recipe (lumen cap) evaluation method.

Although the domestic lighting audit was limited to the Critical Buffer Zone a Public Lighting Audit was also collected and is displayed, together with typical luminaire profiles in Section 5.4 to 5.5.

Plan Statement Number 8: In Environmental Zone terms the residents round the Core Zone live with and enjoy intrinsic darkness and as shown in Table 1.1, equivalent to Environmental Zone E1. Towns within the Park boundary with a population greater than 1,000 may relax this Environmental Zone in the town centre where buildings provide natural screening but not in exposed locations.

2.6 Light Limitation Plan - Environmental Zone E1's

Luminous intensity from a luminaire is derived from photometric information, which has been measured under laboratory conditions. These measured values describe the luminaire's light distribution in numeric electronic format (commonly known as I-tables in IES, TM14 or ELUMDAT format).

As commented in Section 1.5 the ILP originally classified upward light as one segment above 90^0 but are now considering upward light ratios in two upward segments but the recommendations are not yet formulated sufficiently to include in this document and a modified derivative of the glare restriction table in BS13201 will be used in this LMP.

From the I-table for a particular luminaire and its installed angle of elevation the intensity of light at different elevation angles can be computed and classified in glare classes, namely G1 to G6. Classification G1 is the most relaxed and G6 is the most restrictive and this is the limiting index, with selective relaxation, which should be applied throughout Snowdonia National Park as shown in Table 2.4.

An example of many light emitting diode (LED) and discharge light source luminaires, with light sources greater than 500 lumens, which complying with the upper and lower intensity limits of table 2.6 (following page) are shown in Appendix D.

Plan Statement Number 9: All new street lighting design will be based on a Glare Limiting Index of G6 and a light source colour temperature of 4,000K or less.

See Section 3.2.1 and Appendix A for IDA concerns about light source colour temperature greater than 4,000K.

Table 2.6 - Intensity Recommendations (excluding Core Zone)

NP Zone Dark Sky Requirements	Glare Class	Maximum luminous intensity in cd/klm				Non technical description of luminaire light control in installed condition
		at $70^{0\ az}$	at $80^{0\ az}$	at $90^{0\ az}$	above $95^{0\ az}$	
Between Core Zone and nearest population cluster > 1,000	G6*	350	100	0	0	Fully cut-off installation in environmental zone E1
Residential buffer between town centre and rural remainder (or centre of town with < 1,000)	G5-derivative	350	100	5	0	Cut-off installation
Town Centre with population > 1,000 (excluding heritage style streets)	G4	500	100	10	0	Part Cut-off installation
Heritage bowl style	G4	500	100	10	0	
Heritage gas style	G4+	500	100	20	0	
External for 5 miles beyond Park boundary (lamps < 20,000 lumens)	G3	.	100	20	2.5%	Semi-Cut-off installation in environmental zone E2
All luminaires with lamps greater than 20,000 lumens between Core Zone boundary and 10 miles distant	G6**	350	100	0	0	Fully cut-off installation regardless of night time environmental zone

Note ^{az} Table 2.4 restrictions apply to the luminaire's installed angle of inclination (azimuth) which can be tested in UK industry standard design calculation software.

Note* For light source colour temperature less than 3,000K intensity relaxation may be appropriate at 70^0 and 80^0 depending on luminaire availability but the **values of zero intensity at 90^0, 95^0 and above are crucial**. Full G6 intensity control for all new white light sources.

Note** Requires discussions with adjacent land owners and local authorities to adopt similar controls in their individual environmental policy plan.

In addition to the intensity controls presented in table 2.6 further light limitation recommendations are contained in table 2.7, following, to mitigate any obtrusive light in an E1 Environmental Zone **and the two tables should be considered in tandem at the design stage for all new exterior lighting**.

The ILP and CIE use the word 'curfew' to define the energy saving time limitation after which stricter requirements (for the control of obtrusive light) will apply. After the time limits most lighting should be extinguished or reduced as activity levels either finish or decline.

Although very few residents leave external lighting on longer than presence detection there are a few situations where lights are left on all night, sometimes by accident. The time of 22.00 hours is suggested as exterior light curfew time at which point users will be encouraged to extinguish or reduce the quantity of lighting.

Table 2.7: Obtrusive Light Marker Points

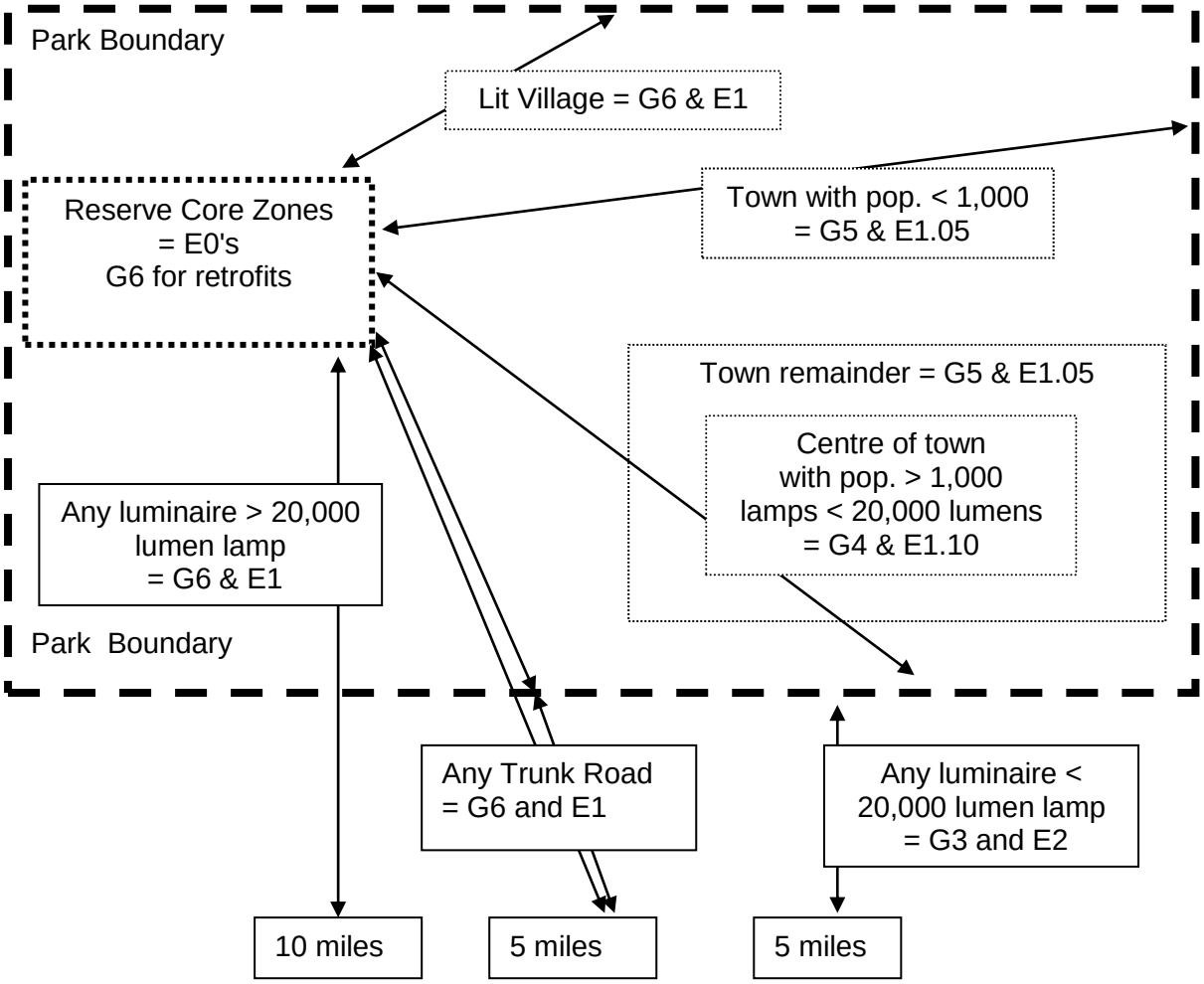
Light Limitations for Exterior Lighting Installations within the Park (excluding Core Zone)						
Night Time Environmental Zone	Sky Glow Upward Light Ratio %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)
		Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Pre-curfew
E1	0	2	0	2,500	0	0
E 1.05 (G5 areas)	1%	2	0	3,000	0	1
E 1.10 (G4 areas)	1%	2	0.5	4,000	100	2.5
Illuminated advertising signs	0	0	0	100	0	50

Refer to Section 3 for information on time switches and other switching regimes and also for local authorities commitment to converting most of the street lighting units to part night dimming.

Plan Statement Number 10: All new lighting should be designed and installed to provide lower glare or intensity values, where possible, than that recommended by the ILP for night time Environmental Zones.

In order to prevent medium district brightness from adjacent “non-national Park” lighting creeping closer to the Park's intrinsic darkness, table 2.6 and section 2.7, later, contains recommendations to reduce the elevation angle of existing or proposed high wattage/high output luminaires in the external zone. This requires discussions to encourage adjacent developers or Planning Committees to work towards adopting similar controls in their individual environmental policy plan.

Figure 2.14: Diagram showing combination of intensity and environment recommendations (refer to Table 2.3 and 2.4 for full descriptions)



Most domestic luminaires provide very little light control and very few are measured photometrically in the same manner as commercially available luminaires. Accurate intensity or illuminance values cannot therefore be predicted by computer calculations and a different method of calculation is required. Section 3.3 therefore contains a method recommended by the IDA which provides a guide to the number of lumens based on the footprint size of the property for all new domestic style lighting.

Care for the night time environmental control should be part of the process when selecting all new domestic equipment. Examples of domestic luminaires with good and poor light control can be found in Table 3.7 and Appendix D.

Plan Statement Number 11: All design submissions and planning applications that include external lighting should show evidence of compliance with the zero candela intensity at 90^0 and above and encourage domestic luminaires to be selected from units having some form of upward light control.

2.7 Environmental Zone Roadmap in Core and Critical Buffer Zones

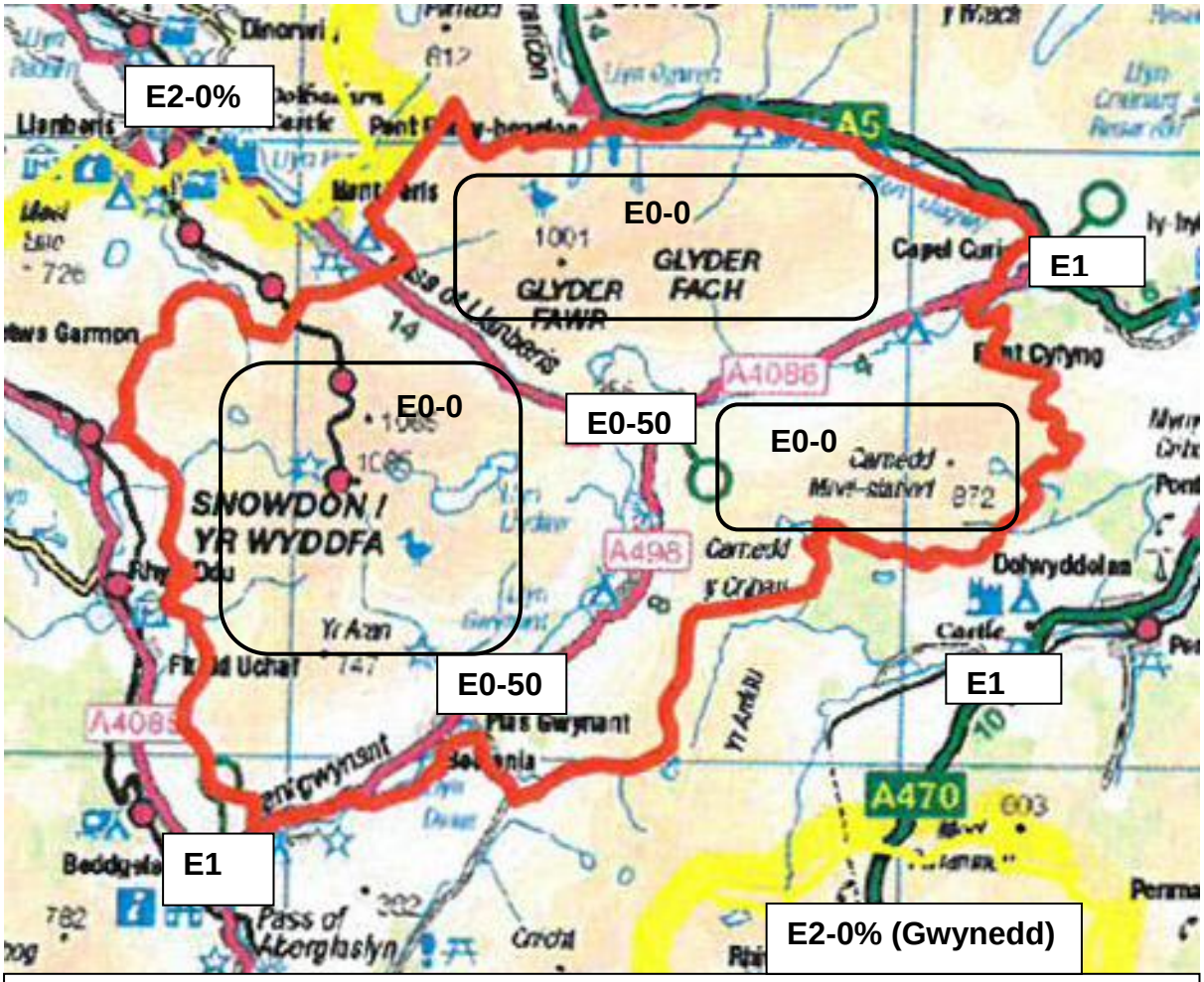


Figure 2.15 : Core Zone 1 internal and adjacent buffer Environmental Zones

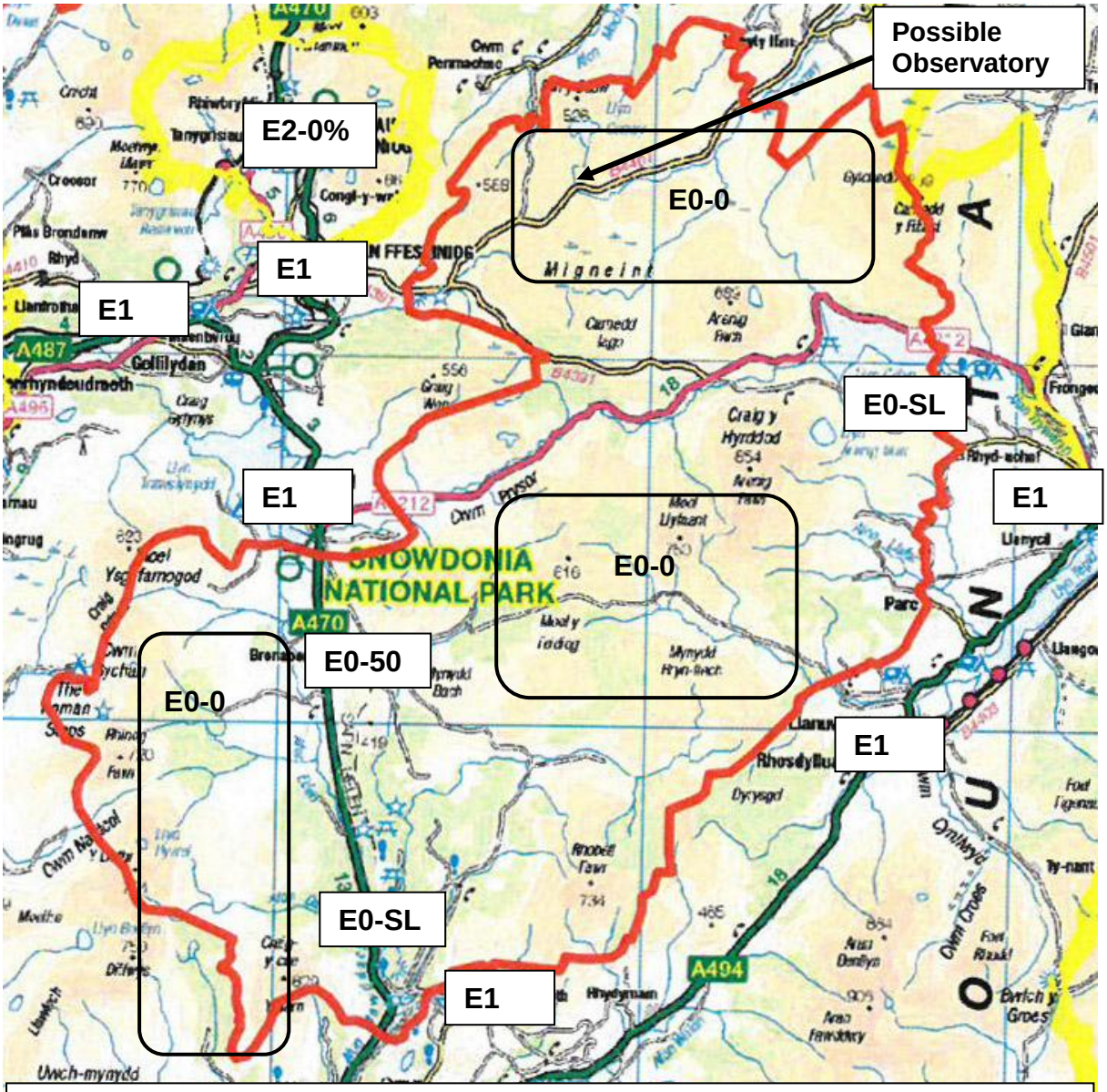


Figure 2.16 : Core Zone 2 internal and adjacent buffer Environmental Zones

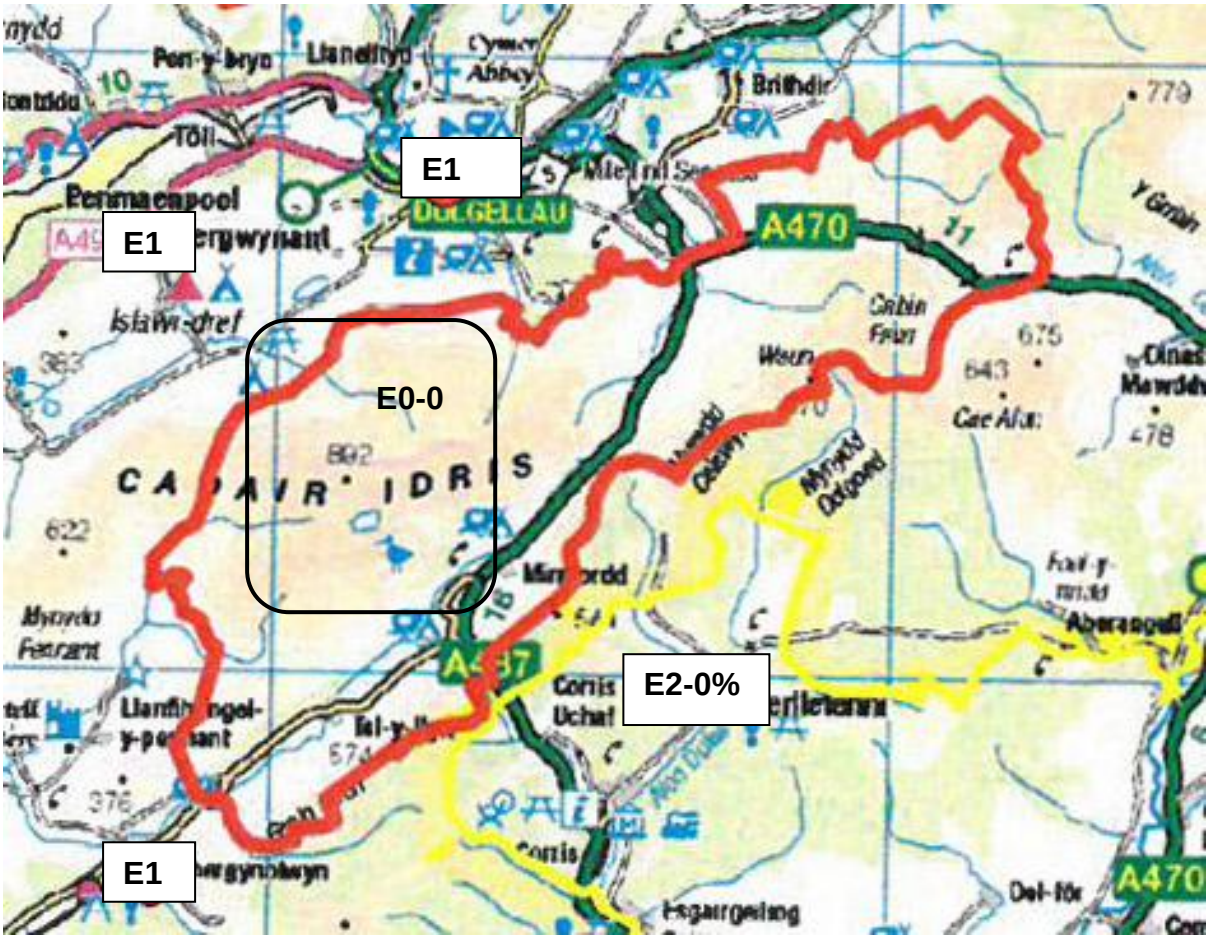


Figure 2.17: Core Zone 3 internal and adjacent buffer Environmental Zones

2.8 External Zone - General

Since the Authority has no jurisdiction in the area beyond their Park boundary this part contains numeric progression to the values already explained in the Core and Buffer Zones of the Park. Section 3, following, explains how planners and engineers need to work in partnership, both within and external to the Park, to help maintain or enhance the Dark Sky Reserve.

2.9 External Zone – Immediate Surrounds

No inventory was undertaken in the External Zone, however, as in section 2.3.3 if the following Tables 2.8 and 2.9 are used in tandem, at the design stage, they may mitigate obtrusive elements in new installations.

Table 2.8: Luminaire Intensity distribution recommendations in External Zone

Dark Sky Requirements	Glare Class	Maximum luminous intensity in cd/klm				Non technical description of luminaire light control in installed location
		at 70^{0} az	at 80^{0} az	at 90^{0} az	above 95^{0} az	
External for 5 miles beyond Park boundary (lamps < 20,000 lumens)	G3	.	100	20	2.5%	Semi-Cut-off installation in environmental zone E2
All luminaires with lamps greater than 20,000 lumens between Core Zone boundary and 10 miles distant	G6	350	100	0	0	Fully cut-off installation

The mileage limits shown in Table 2.8 assume that no other, more restrictive intensity limitation, external policy is in place.

Table 2.9: Typical Obtrusive Light Maker Points for External Environmental Zone

CIE / ILP Obtrusive Light Limitations for Exterior Lighting Installations						
Environmental Zone	Sky Glow Upward Light Ratio %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Building Luminance L (cd/m^2)
		Pre-curfew	Post-curfew	Pre-curfew	Post-curfew	Pre-curfew
E1 – for lamp lumens > 20,000	0	2	0	2,500	0	0
E2 - For 5 miles beyond Park boundary limit with rural setting	2.5**	5	1	7,500	500	5
E3 E.g. Caernarfon	5	10	2	10,000	1,000	10

** Upward Light Ratio for luminaires in External Zone using lamps less than 20,000 lumens otherwise 0% for lamps greater, up to a distance of 10 miles beyond Core Zone.

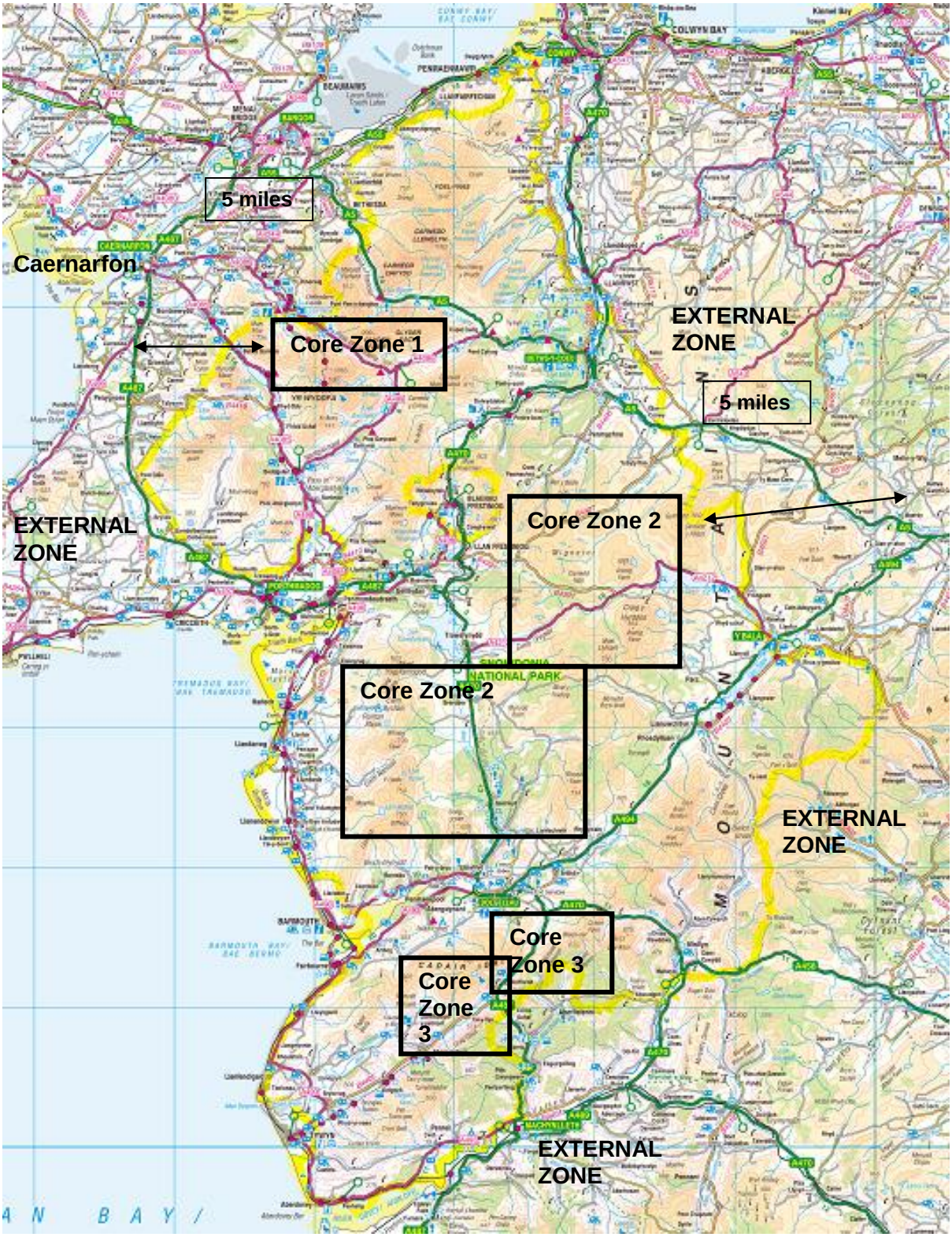

5 miles
Caernarfon
Core Zone 1
EXTERNAL ZONE
5 miles
EXTERNAL ZONE
Core Zone 2
Core Zone 2
EXTERNAL ZONE
Core Zone 3
Core Zone 3
EXTERNAL ZONE

Figure 2.18

Table 2.10: Summary of E0 / E1 zones

Zone	Definition	Typical Examples	Implications	Means to Achieve
E0-0	Dark	Typically uninhabited areas like :- National Nature Reserves 1 mile round Pont ar Gonwy Observatory	**No new external lighting units allowed and residents encouraged to modify existing units**	**Adapting or modifying existing units to this end.**
E0-250	Predominantly dark - Some light spill is inevitable up to **250 metres** beyond the new light source or up to property boundary whichever is nearer to property	All remote properties within boundary of application e.g. isolated farmsteads	**New units must be compliant and residents encouraged to modify existing units to prevent no more than 0.1 lux straying beyond their property boundary.**	**New units must be fully cut-off / shielded regardless of lumen output** **Encourage existing units to be modified or adapted to this end.**
E0-50	Predominantly dark - Some light spill is inevitable up to **50 metres** beyond the new light source or up to property boundary whichever is nearer to property	Limited or no street lighting system e.g.	**New units must be compliant and residents encouraged to modify existing units to prevent no more than 0.25 lux straying beyond their property boundary.**	**New units must be fully cut-off / shielded regardless of lumen output** **Encourage existing units to be modified or adapted to this end.**
E1 in Reserve	Intrinsically dark - Up to 0.5 lux light spill is inevitable at the property boundary		**New units must be compliant and residents encouraged to prevent any light straying into their neighbour's windows by adapting or modifying existing units to this end.**	**Residents encouraged to use bulbs with an output less than 600 lumens or ensure lighting unit is fully cut-off / shielded if greater than 1,000 lumens**
E1 Beyond Reserve Boundary	Up to 1 lux light spill is inevitable at the property boundary inclusive of any contribution from street lighting system		**Residents encouraged to prevent any light straying into their neighbour's windows by adapting or**	**Residents encouraged to use bulbs with an output less than 1,000 lumens and ensure lighting unit is fully cut-off /**

			modifying existing units to this end.	**shielded if greater than 3,000 lumens**

3 Design and Planning Requirements

3.1 General

In order to avoid a combination of light obtrusion into the night sky and also possible light nuisance problems into residential comfort zones Section 2 contains basic numeric objectives to this end, however, this section explains how planners and designers need to work in partnership, both within the Park and externally beyond the application boundary, to help maintain or enhance the sky darkness at night.

As indicated in the Preamble the objectives given in this document will assist in the defence of the existing night sky. However, there is a national problem with obtrusive light. Part of the problem emanates from the random standards of some planning applications containing external lighting proposals.

The previous lack of a published lighting design & assessment methodology has resulted in planning applications, being presented in a variety of formats, sometimes with a few extracts from manufacturers' catalogues and scant calculation techniques. This has created major difficulties for planners when appraising applications both subjectively and technically.

A new ILP document (PLG04:2013 "Guidance on Undertaking Environmental Impact Assessments") focuses on the lighting aspects of creating a Lighting Impact Assessment. Whilst most of these are effects on people and their perception of the surroundings, assessments must also include effects on flora and fauna. A summary of some of the sections covered are included below. Whilst an impact assessment may not be necessary for new residences it is certainly needed for sports complexes or container / warehouse distribution centres as examples but not limited to these two applications.

Table 3.1 Typical Lighting Impact Assessment Checklist

Lighting Impact Assessment - Checklist

Baseline Descriptions

- **Baseline Assessment Procedures**
- **Day time visit**
- **Night time visit**
- **Viewpoint Scheduling**
- **Baseline Assessment Layout**
- **Location Plan**
- **Brief Description**
- **Viewpoint Pages**
- **Baseline Summary**

Proposed Development – Lighting Design

- **Design – General**
- **Preliminary Assessment**
- **Provisional Design**
- **Final Design**
- **Maintenance Factors**

In addition to the ILP rational covering the process of carrying out Lighting Impact Assessments the Scottish Government (2007) published a complementary Planning Guidance Note (Controlling Light Pollution and Reducing Energy Consumption) which provides a rationale to all lighting design proposals. Reference to the full will provide the reasoning behind a 20 bullet point checklist. Although produced in Scotland the methodology fits national objectives.

An abbreviated 12 point summary checklist of the design methodology is shown in Table 3.2 below but reference to the full document will provide the reasoning behind a 20 bullet point checklist. (see www.scotland.gov.uk/Publications/2007/03/14164512/0). This LMP should encourage Development Control Committees, both within the National Park and adjacent Local Authorities, to insist on a thorough design process by the developer before submitting proposals. Although only 12 points are included in Table 3.2 these should be treated as an absolute minimum requirement and there are no reasons why the full 20 point plan is not set as a standard requirement.

Table 3.2: Design Methodology Checklist

Good External Lighting Design Practice

- **Survey of surrounding area environment**
- **Identification of critical viewpoints or receptors**
- **Analysis of task lighting level recommendations and game level if sports lighting application**
- **Establish environmental light control limits**
- **New lighting design quality objectives**
- **Calculated measurement of Task working area(s)**
  Overspill area(s)
- **Obtrusive light calculation of Property intrusion**
  Viewed source intensities
  Direct upward light output ratios
- **Compare design achievement with baseline values**
- **Schedule of luminaire types, mounting height and aiming angles**
- **Schedule of energy usage and lumens per square metre**
- **Schedule of luminaire profiles**
- **Layout plan with beam orientation indication and site relationship with surrounding residential and commercial properties**

Plan Statement Number 11: Through this LMP it will be possible to encourage developers, when required, to adopt and provide a lighting industry professionally prepared submission for planning consideration.

3.2 Design Stage

Luminaires are designed to have light distributions which are appropriate for specific applications. Even though a luminaire has a Dark Sky Fixture Award it can produce sky glow, light intrusion or

glare if it is installed incorrectly. By following the values relating to viewed intensity and vertical illuminance limits at lighting design stage should mitigate the potential obtrusive nature of stray light.

This assessment is not possible by inspecting luminaire catalogue information, however, industry standard software, complete with obtrusive light evaluation criteria, eg Philips Calculux, is essential and was until recently available as a free download from their web site. Some luminaire manufacturers also provide a design service but this may be limited in application and may not include obtrusive light analysis.

All planning applications involving external lighting should be encouraged to follow the 12 point plan outlined in Section 3.1 to ensure that viewed intensity and obtrusion are mitigated accordingly.

Over-lighting an area is just as obtrusive and wasteful as pushing light into the night sky. Designing for, and providing, the correct task illuminance on the ground is just as important as controlling stray light.

However, some luminaire manufacturers / suppliers, especially budget range DIY equipment, cannot provide photometric intensity tables. This precludes the use of computer algorithms to check either the essential information about fundamental illuminance values or check for obtrusive light situations.

At design and planning application stages the answer is simple, do not accept the use of such equipment and at installation stage do not substitute a non-photometrically measured equivalent look-a-like.

Although most of the commercial luminaires have photometric files many of the 1,000 lumen range of domestic residential exterior lighting does not have photometric files and therefore requires a non-photometric method. A lumen cap methodology is explained in the next section.

See Appendix H for a concise combination of the environmental zones, impact assessment and design methodology.

3.2.1 Typical Task Illuminance

Over a period of time most working tasks, and sports activities, have been analysed and researched. Recommendations have been relative to the quantity and quality of light required to carry out the task in comfort and safety. For task lighting illuminance value objectives for outdoor work places reference should be made to BSEN 12464-2:2007 – 'Light and Lighting – Lighting of work places' (Part 2: Outdoor work places) but a few of the typical Park tasks are contained below in Table 3.3.

Table 3.3: Illuminance for typical rural tasks (extract from BSEN 12464-2:2007)

Ref No.	Type of area, task or activity	Eav lux	Uo	GR_L	R_a	ELMP Remarks
	Farms					
5.5.1	Farm Yard	20	0.10	55	20	
5.5.1	Equipment Shed (Open)	50	0.20	55	20	
5.5.3	Animals sorting pen	50	0.20	50	40	
	Farmland Sport					
	Equestrian (outdoor event)	100	0.50	55	20	Time limited
	Harbours					
5.4.1	Waiting quays at canals and locks	10	0.25	50	20	
5.4.2	Gangways and passages exclusively for pedestrians	10	0.25	50	20	
5.4.6	Coupling of hoses, pipes and ropes	50	0.40	50	20	
	Power, electricity, gas and heat plants					
5.11.1	*Pedestrian movement within electrically safe area*	5	0.25	50	20	
5.11.3	Overall inspection	50	0.40	50	20	
5.11.6	Repair of electric devices	200	0.50	45	60	Not permanent
		Use local close up lighting				
	Industrial sites and Storage					
5.7.1	Short term handling of large units and raw material, loading and unloading of solid bulk goods	20	0.25	55	20	
5.7.2	Continuous handling of large units, lifting and descending location for cranes	50	0.40	50	20	
5.9.1	**Parking Areas – See Roadmap in section 1.7 following**				20	
	Simple Summary for safety and security when no equivalent task recommendation can be found	**Values during task operation time only No task – No Light**				
	Very low risk	5	0.25	55	20	
	Low Risk	10	0.40	50	20	

	Medium Risk	20	0.40	50	20	
	High Risk	50	0.4	45	20	

Key to table abbreviations
Eav = Maintained average illuminance
Uo = Overall uniformity
R_a = min. colour rendering index
GR_L = Glare Rating limit (for internal work visibility benefit and not a visibility measure from outside the site)

Within any new design it is important to:

- Provide the correct lighting levels for the task or sport game and grade playing level.
- Provide the lighting only when needed.
- **Recognise that providing light in excess of the recommendations not only increases an unnecessary addition to sky glow but it also wastes energy and increases the carbon footprint.**

If different tasks, from that shown in Table 3.3, are identified in individual communities the specific recommendations will be discussed and outlined in the Community Specific document later.

Most of the recommended values shown in Table 3.3 have been based on the premise that a lamp with a low colour rendering index will be used as shown in the column headed 'R_a'.

Although monochromatic low pressure sodium light is simple to filter out of astronomical observations a well controlled, zero upward light, white light source should be a more acceptable compromise with some energy saving advantages. **Filtering out certain wavelengths of artificial light has the effect of reducing the visibility of low magnitude stars by a factor of at least 4 (equivalent to 2 F-stops in a camera aperture).**

The colour rendering index (R_a) of a standard high pressure sodium lamp (SON) (yellow coloured light) is about 20 but the colour rendering index of ceramic metal discharge lamp (CMD) (true white light) is better than 65 and some newer light sources are achieving >80.

Various research projects, carried out over several years (see ILP PGN 03:2013), have proved that human vision works better with high order colour rendering and in some tasks the illuminance design target value can be reduced by the Photopic / Scotopic (S/P) ratio if 'white' light is used instead of 'yellow' light. This S/P ratio varies with different light sources and different colour temperatures. The proportional reductions for possible light sources in the Philips range are shown in Table 3.3. Different luminaire manufacturers publish their own S/P ratios and the values shown in Table 3.4 **should not be taken as generic**.

Table 3.4: Reduced Target Illuminance depending on S/P Ratio

Baseline Target Values in BS13201 $R_a < 60$		S/P = 1.15 Philips CPO-/728		S/P = 1.37 Philips Warm white		S/P = 1.43 Philips Warm white LED	
Eav (lux)	**Emin** (lux)	**Eav** (lux)	**Emin** (lux)	**Eav** (lux)	**Emin** (lux)	**Eav** (lux)	**Emin** (lux)
15.0	5.0	13.5	4.5	13.15	4.4	13.05	4.4
10.0	3.0	8.7	2.6	8.45	2.5	8.35	2.5
7.5	1.5	6.3	1.3	6.05	1.2	5.5	1.1
5.0	1.0	4.0	0.8	3.8	0.8	3.8	0.8
3.0	0.6	2.2	0.5	2.1	0.5	2.1	0.5
2.0	0.6	1.3	0.5	1.2	0.5	1.2	0.5
		Values above derived by linear interpolation from base values published in ILP PGN 03 by LCADS Ltd					

Illuminance objectives were originally based on a numeric system to replicate visually perceptible increasing steps as shown in Table 1.4. This table also shows possible future illuminance step difference between low colour rendering lamps and very high colour rendering lamps (eg 6000^0K).

Table 3.5 – Illuminance comparisons based on colour rendering index (R_a)

Colour Rendering Index	Task Maintained Average Illuminance Steps (lux)												
$R_a < 60$	2	3	5	7.5	10	15	20	30	50	75	100	200	300
$R_a > 80$		2	3	5	7.5	10	15	20	30	50	75	100	200
	© LCADS Ltd 2013												

Light sources achieving an $R_a > 80$ are often in the CCT range of 6000^0K and although ocular vision research has proved a case of improved visual acuity with “white light” current health research in the UK and the USA is studying the possible disturbing effect on the human circadian rhythm from “blue rich” white light and on the mental well being of humans and animals.

(See Appendix A for Warm or Neutral White LED light source recommendations)

Until more information is available the IDA are not encouraging the use of $6{,}000^0$K colour temperature and 3,000-$4{,}000^0$K is more appropriate.

Although BSEN 13201 recommends that average values should not be reduced lower than 2 lux there is no visual reason why 1 lux cannot be used on private paths or roads in rural locations, where appropriate, **and only if lighting is found to be necessary.**

Within the boundary of any Dark Sky application it is important to note here that if there is “NO TASK” in operation there should be “NO LIGHT” and that the objective values given could be reduced if “white” light sources are used.

The Roadmap shown on the following page of this LMP was compiled from information in BSEN13201-2:2003 - 'Code of practice for the design of road lighting' (parts 1 and 2) and the European CEN Standards. It has been designed to provide a simple selection process for light levels and quality criteria, including obtrusive light controls. The road lighting solution is derived from assessment of environmental zones, user types, user volume and crime volume via a flowchart.

Although BSEN13201-2:2003 has recently undergone revision with changes in the Class numbers (ME to M, S to P et all), this LMP Roadmap does not use this Class selection process. However, some previously recognised step values in the 2003 edition have been removed to allow individual S/P ratio information to determine the proportional reduction.

3.2 Requirements for Traffic and Residential Area Lighting

Selection Matrix Starter

Main User Type	Typical Speed of Main User	Excluded UserType	Situation Set
Pedestrian & Cyclist	Walking Speed	Motors, Slow Vehicles & Motor Cycles	Remote Path - Set 8 "Shops" - Set 7
Vehicle conftict and shop users	10-30 MPH		"Streets" - Set 7 Car Parks - Set 6
Residential vehicles, Cycles & Pedestrians	10-30 MPH	Heavy goods vehicles	Set 5
Motorised traffic & Slow vehicles	20-40 MPH		Minor / Rural- Set 4 Secondary - Set 3
Motorised Traffic	30-70 MPH	None	Set 2
Motorway Regulations	70+	Slow vehicles, cycles & pedestrians	Set 1

Set 1 - Luminance Design Objectives

Typical Network:- Motorway&Motorway Link Roads

Traffic Flow ADT		<40,000					>40,000				
		Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR
Complex Interchange		2.0	0.4	0.7	10%	0.5	2.0	0.4	0.7	10%	0.5
Junction Spacing	<= 3Km	1.5	0.4	0.7	10%	0.5	2.0	0.4	0.7	10%	0.5
	> 3Km	1.5	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5
Hard Shoulder		0.75	0.4	0.6	10%	0.5	0.75	0.4	0.7	10%	0.5

Set 2 - Luminance Design Objectives

Typical Network:- Strategic Routes, Trunk and some Principal "A" roads
Main Distributor Routes or
Routes between Strategic routes with peak time parking restrictions

Traffic Flow ADT		<15,000					>15,000					*>25,000*				
		Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR
Single Carriage-way	Normally	1.0	0.4	0.7	15%	0.5	1.5	0.4	0.7	10%	0.5	*2.0*	*0.4*	*0.7*	*10%*	*0.5*
	>10,000 & E3 or E4	1.5	0.4	0.7	10%	0.5						*Above only with on street parking, otherwise as below*				
Dual Carriageway		1.0	0.4	0.7	15%	0.5	1.5	0.4	0.7	10%	0.5	*1.5*	*0.4*	*0.7*	*10%*	*0.5*

Set 3 - Luminance Design Objectives

Typical Network:- Secondary Distributor ("A,B & C" Classified)
Unclassified Urban Bus Routes
Urban Collector Road

Traffic Flow ADT	Low District Brightness					Medium District (E3)					High District Bright. E4				
	Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR
< 7,000	0.75	0.4	0.6	10%	0.5	1.0	0.4	0.5	15%	0.5	1.0	0.4	0.7	15%	0.5
7,000 - 15,000	1.0	0.4	0.6	10%	0.5	1.0	0.4	0.6	15%	0.5	1.5	0.4	0.7	10%	0.5
> 15,000	1.0	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5
> 25,000	*1.5*	*0.4*	*0.7*	*10%*	*0.5*	*1.5*	*0.4*	*0.7*	*10%*	*0.5*	*2.0*	*0.4*	*0.7*	*10%*	*0.5*

Set 4 - Luminance Design Objectives

Typical Network:- Local Rural Roads & Rural Bus Routes = 40MPH or less
Residential or Industrial Interconnecting Roads
Minor single carriageway & Link Roads between Secondary Distributors

	Traffic Flow ADT	Low District Brightness					Medium District (E3)				
		Lav	Uo	UI	TI	SR	Lav	Uo	UI	TI	SR
No Parking	< 7,000	0.5	0.4	0.4	10%	0.5	0.75	0.4	0.5	15%	0.5
Parking	<7,000 + high cycle	0.75	0.4	0.5	10%	0.5	0.75	0.4	0.6	15%	0.5
Parking	< 7,000	0.75	0.4	0.5	10%	0.5	0.75	0.4	0.6	15%	0.5
	7,000 to 9,000	0.75	0.4	0.5	10%	0.5	*1.0*	*0.4*	*0.5*	*15%*	*0.5*
> 9,000 use Set 3											

Set 8 - illuminance Design Objectives

Typical Network:- Footpath, cycle way and non-town centre pedestrian area

Pedestrian Flow		Normal			High		
Environmental Zone		E1/2	E3	E4	E1/2	E3	E4
Normal Crime	Eav	2	3	5	3	5	7.5
	Emin	0.6	0.6	1	0.6	1	1.5
High Crime	Eav	7.5	10	15	10	15	20
	Emin	1.5	3	5	3	5	8

Pedestrian Flow
Measurement from IESNA
in 1st hour of darkness
Low = 10 or less
Medium = 11 to 100
High = over 100

Where a light source with Ra>60 is used, the lighting level can be reduced by 1 class except 2 lux should not be reduced further.

Set 7 - illuminance Design Objective

Typically:- City & Town Centre Shopping Streets

Pedestrian / traffic flow		Medium		High	
Environmental Zone		E3	E4	E3	E4
Pedestrian Only	Eav	15	20	20	30
	Uo	0.4	0.4	0.4	0.4
Mixed on separate surface	Eav	20	30	30	30
	Uo	0.4	0.4	0.4	0.4
Mixed on shared surface	Eav	20	30	30	30
	Uo	0.4	0.4	0.4	0.4

Values in Set 6, 7 and 8 are based on a light source with Ra < 60

Set 6 - illuminance Design Objectives

Typical Network:- Car Parks & Motorway Rest Area

	Zone	Eav	Uo	GRL
Major shopping centre, sports & major multi purpose building complex		20	0.25	50
Small town shops, Department store office building, small sports complex		10	0.25	50
Village shops, schools, churches, terraced and apartment houses		5	0.25	50
See BSEN12464-2:2007 for other external work task illuminance				

Set 5 - illuminance Design Objectives

Typical Network:- Local Access Roads & roads serving limited number of properties
Urban Residential Loop Roads

Residential Traffic		Low traffic flow with pedestrians and cyclists				Normal traffic flow with pedestrians and cyclists				Normal traffic flow with pedestrians and cyclists			
Env. Zone		E1/E2		E3/E4		E1/E2		E3/E4		E1/E2		E3/E4	
Crime rate	Ra value	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin
Low	<60	3	0.6	5	1	5	1	7.5	1.5	7.5	1.5	10	3
	~~>60~~	~~2~~	~~0.6~~	~~3~~	~~0.6~~	~~3~~	~~0.6~~	~~5~~	~~1~~	~~5~~	~~1~~	~~7.5~~	~~1.5~~
Med	<60	5	1	7.5	1.5	7.5	1.5	10	3			15	5
	>60	3	0.6	5	1	5	1	7.5	1.5			10	3
High	<60	10	3	10	3	10	3	15	5			15	5
	~~>60~~	~~7.5~~	~~1.5~~	~~7.5~~	~~1.5~~	~~7.5~~	~~1.5~~	~~10~~	~~3~~			~~10~~	~~3~~

LIGHTING DESIGN ROADMAP - Devised and Designed by
LCADS Ltd, Moffat : Tel 01683 220 299
Values in RED italics are additional CEN values to BSEN 5489 Recommendations

3.3 Sports Lighting

With a growth in leisure pursuit comes a growth in the need to extend the hours that play areas can be used and there are several game areas adjacent to this application with floodlighting facilities but some have poor light control. Nationally some sports areas contain some of the worst cases of over-lighting and it is essential that this does not happen in or around this application.

BS EN 12193:2007 "Light and Lighting. Sports Lighting" contains both indoor and exterior lighting recommendations for not just the players but also the audience, the referees, the cameras and last but not least the neighbours. It also contains recommendations for lighting designers in the form of typical calculation areas and the number of calculation points to include in any assessment.

The illuminance recommendations are based on the quality of the game. There are 5 levels of competition from National to Recreational, all with different illuminance requirements. Table 3.6 shows some of these extremes.

Some manufacturers provide free design outlines as shown in Figure 3.1 but that is only a very small part of sports lighting design considerations. It is also essential to consider light overspill and intrusion, especially when the sports field is close to residential property.

In order to protect the existing dark sky it is essential to ensure the playing surface of any new sports facilities requesting floodlighting is not over lit.

Double asymmetric flat glass luminaires should be used with the luminaire window completely horizontal as shown in Figure 1.8 and Figure 3.2.

It may also be necessary to limit the average illuminance to that of recreational level depending on the distance the sports facility is from the Core Zones. (see Appendix A for the definition of 'average').

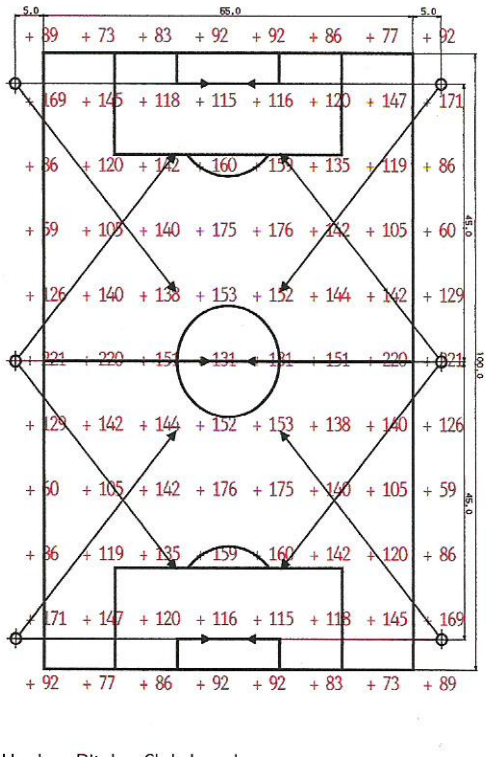


Figure 3.1 – Typical Football Area - Free Design
Note:- Free Design like this never includes an impact assessment on the surrounding landscape.

Table 3.6: Game maintained average illuminance extremes

Game	National			Recreational
Football, Rugby, Basketball, Netball, Volleyball	500 lux			75 lux
Equestrian and Cycle Racing	500 lux			100 lux
Hockey and Tennis	500 lux			200 lux

Figure 3.2: Tennis Court lighting good example

This is a pictorial example of a fully cut-off luminaire installation.

The IDA term for this installation is “fully shielded” without applying additional external screens, hoods or louvers on the luminaire.

3.4 Non-photometric Lumen Cap method for domestic exterior lighting

Budget range DIY equipment usually takes the form of a simple area floodlight with a high wattage tungsten halogen lamp. They are popular because they are cheap, easy to install, and are often combined with photo-electric (PECU) switches to prevent daytime operation and with passive infra red (PIR) detectors to switch on and off automatically during the hours of darkness.

In the majority of cases these fittings, or luminaires, are installed typically on garage or porch fascias at about 2-3 metres above ground level, and arranged to direct their main beams towards the property boundary to operate as vehicles or people enter. This high beam arrangement can result in disability glare for the user and to other road users, light intrusion into adjacent property and a source of possible complaint.

This type of installation is not in keeping with the light control required in a rural setting and as from the effective date of implementation of this LMP no new floodlights of this type will meet the IDA Dark Sky requirements unless they are installed with the glass face horizontal.

As described previously a light source output limit of 500 lumens in luminaires with poor light control is considered to be a generalised rule of thumb marker. Table 3.7 provides a more accurate lumen and wattage prescription, which is based on the overall area of the building structures on each residential plot of land.

Appendix E contains examples of exterior lighting equipment which should be considered when purchasing new exterior lighting. This Appendix could be made available to all the residents within each participating community.

Lamp lumens is a consistent value and although difficult to find on some lamp packaging it will gradually superseding the lamp wattage. Lamp watts can vary with the efficacy of the lamp. Table 3.7 (following page) has therefore been constructed using the lamp lumens as the base from which to start followed by tables which show the equivalent lamp wattages for different lamp types.

Table 3.7: Total Lumen Limit for each residence

	Environmental Zone				
	E0-50 / E0-250 and E1		E2	E3***	E4***
Total Lumens for domestic Exterior Lighting	750 lm plus 4.5 lm / m^2 of site structures*		2250 lm plus 4.5 lm / m^2 of site structures*	4500 lm plus 4.5 lm / m^2 of site structures*	6000 lm plus 4.5 lm / m^2 of site structures*
Fully cut-off luminaires each lamp lumen maximum	1200 lm		1650 lm	2400 lm	3200 lm
Part cut-off luminaires each lamp lumen maximum	E0's none	E1 500 lm	1200 lm	1650 lm	2400 lm
No light control luminaires each lamp lumen maximum	E0's none	E1 500 lm**	600 lm**	750 lm	750 lm
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* Site structures is the sum of the land area of residential buildings, habitable structures, garages, recreational buildings and storage structures on each property plot.

** The maximum watts or lumens for each lamp in this section relates to replacing lamps in existing lighting units only. No new luminaires with little or no light control should be considered, especially in environmental zones E0's and are shown in Table 3.3 as not allowed.

***** Environmental zones E3 and E4 do not relate to any conditions in or near Dark Sky Parks, Reserves or Community living and should be excluded from any considerations within the application boundary.**

They are shown here as an example for external zone large town centres to follow if appropriate.

From table 3.7 a total site structure in the Zone E1 with say 255 m^2 would provide for a total of 1,897 lumens which can be distributed as 1 or more luminaires up to the total allowance. (see Appendix F for list of lower lumen and wattage lamps)

Table 3.8 - Lamp watts for each luminaire with Compact Fluorescent

	Environmental Zone				
	E0's	E1	E2	E3***	E4***
Fully cut-off luminaires each lamp watts maximum	13w.	20 watts	24 watts	32 watts	42 watts
Part cut off luminaires each lamp watts maximum	0	11 watts	20 watts	24 watts	32 watts
No light control luminaires each lamp watts maximum	0	9 watts**	12 watts**	12 watts	12 watts
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Table 3.9: Lamp watts for each luminaire with Tungsten Halogen

	Environmental Zone				
	E0-50 / 250	E1	E2	E3***	E4***
Fully cut-off luminaires each lamp watts maximum	60 w.	100 watt	120 watts	150 watts	200 watts
Part cut off luminaires each lamp watts maximum	none	none	60 watts	100 watts	150 watts
No light control luminaires each lamp watts maximum	none	none	none	none	none
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Table 3.10: Lamp watts for each luminaire with Incandescent / Candle / Capsule Lamp

	Environmental Zone				
	E0-50 / 250	E1	E2	E3***	E4***
Fully cut-off luminaires each lamp watts maximum	2x35 w. halostar	2x35w. halostar	2x60 watt Capsule	See 3.4	See 3.4
Part cut off luminaires each lamp watts max.	none	60 watts	See 3.4	See 3.4	See 3.4
No light control luminaires each lamp watts max.	none	40w candle	40w candle	60w candle	60w candle
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Table 3.11: Lumen and Watts exception for Ceramic / Metal Halide discharge lamps

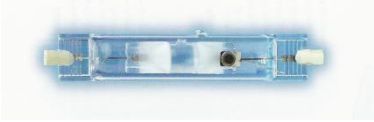	Environmental Zone				
	E0-50 / 250	E1	E2	E3***	E4***
Fully shielded luminaires each lamp lumen maximum each lamp watts maximum	none	1500 lm 20w	2400 lm 35w	5500 lm 70w	5500 lm 70w
Part or No light control luminaires are not allowed with this light source					
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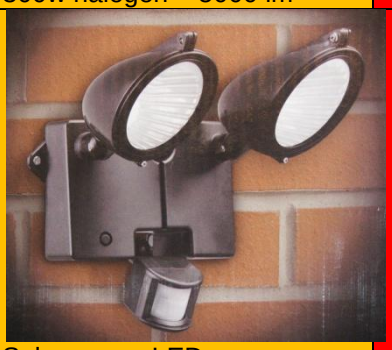
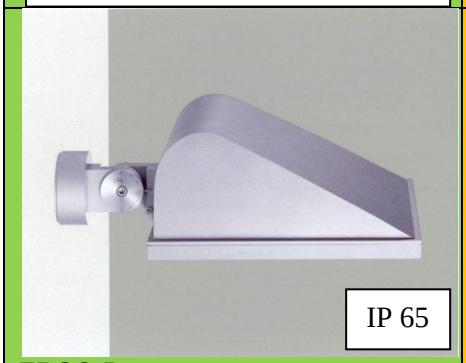
Table 3.12 on following page contains pictorial examples of fully cut-off (fully shielded), part cut-off (part shielded) and no light control luminaires.

Table 3.12: Light Control Examples

Fully Cut-off Examples	Partly Cut-off Examples	No light Control Examples
 SILL 420 Full range of compact fluorescent and low wattage metal halide	 100w halogen = 1650 lm 150w halogen = 2200 lm 300w halogen = 5000 lm	 no new units
 Zumtobel Bega 2489 18w PLC	 Solar power LED	 no new units
 ERCO Parscoop 42w fluorescent = 3200 lm 70w metal halide = 5000 lm Acceptable substitute for 300 or 500 watt tungsten halogen replacement	 limit to 40 watt tungsten or 6 watt compact fluorescent	 limit to 40 watt candle or 6 watt compact fluorescent
		 18 watts = 1200 lm and too large for E0's & E1 Dark Sky
Fully Cut-off Examples	**Partly Cut-off Examples**	**No light Control Examples**

4 Special Lighting Application Considerations

4.1 Excluded Applications

The following applications will be prohibited from any part of rural landscape and other areas that are not designated as Environmental Zone E3 or E4:

- Aerial Laser Shows
- Sky Tracking Searchlights
- High intensity light sources greater than 200,000 lumens
- Sports complexes requiring an average playing surface greater than 100 lux.

4.2 Temporary Applications

Typical lighting applications not excluded but requiring Short Time Planning Permission - but not limited to the following applications:

- Sports facilities with column mounted luminaires.
- Construction site lighting.
- Churches, public monuments or buildings.
- Travelling Fair Grounds - theme and amusement parks.

4.3 Planning Application

The **Light Control Zone** will be deemed to include the Dark Sky Reserve.
To obtain planning permission, applicants shall demonstrate that the proposed lighting installation application:

- (a) Contains an analysis of at least 12 essentials in the 20 point Good Design Practice Checklist (see Section 3.1)

- (b) An Environmental Impact Statement that shows every reasonable effort to mitigate Sky Glow and Light Intrusion has been addressed and accompanied by a computer calculation indicating average task illuminance, uniformity, horizontal values of overspill beyond the property line and vertical illuminance values of light intrusion on adjacent property windows.

- (c) Employs lighting controls to reduce the quantity of lighting at the project specific 'switch-off' time which has been established in the LMP.

- (d) Complies with all light limitation factors outlined in this LMP.

4.4 Lighting Applications Excluded from the Objectives of this LMP

- Temporary festive Christmas lighting switched on between the last weekend in November and the following year's January 6th only.

5 Existing Lighting

5.1 Lighting Audit - General

In order to evaluate the potential for light pollution beyond the obvious town locations like Bala and Dolgellau a domestic lighting audit was undertaken for properties within the three core areas and in the immediately surrounding critical buffer area which includes Bala, Dolgellau and other small towns or villages. The resulting compliance percentage is equivalent to other UK Dark Sky applications even although there were many more lighting units included than in any other dark sky lighting audits.

The survey contained data from domestic and commercial properties and when analysed, the combined compliance percentage equated to 69%. However at least 210 (over 6%) of the non-compliant floodlights are connected to presence detection devices and may not therefore be providing continuous illumination.

Figure 5.1 (following page) contains an overall picture of the compliance variations for each of the survey sections. Each section contains, generally, about 20 to 30 properties and has been devised this way to provide an early indication of where future action should be targeted to increase the compliance level in progressive years. The lowest compliance (25%) is in Capel Curig where the Park Authority is already in discussion with one commercial property which has a large quantity of outdated external lighting.

Where new or replacement external lighting is required the most onerous light control conditions should be applied to improve this condition. To assist in this objective, Section 2.4 contains recommendations on luminous intensity recommendations for new luminaires, with a lamp output greater than 500 lumens. For domestic style luminaires (less than 500 lumens) with no photometric intensity data Section 3.4 contains a lumen cap evaluation method.

A Public Lighting Audit within the National Park was also collected and is displayed, together with typical luminaire profiles shown in Section 5.4. The quantities shown are based on a visual count using the Google Street View images taken in 2009 and this has resulted in a low percentage of flat glass luminaires. Both Conwy and Gwynedd local authority highway departments have since then started a street lighting programme to replace many of the old units with flat glass equivalents and will provide a more accurate figure for the final version of this LMP.

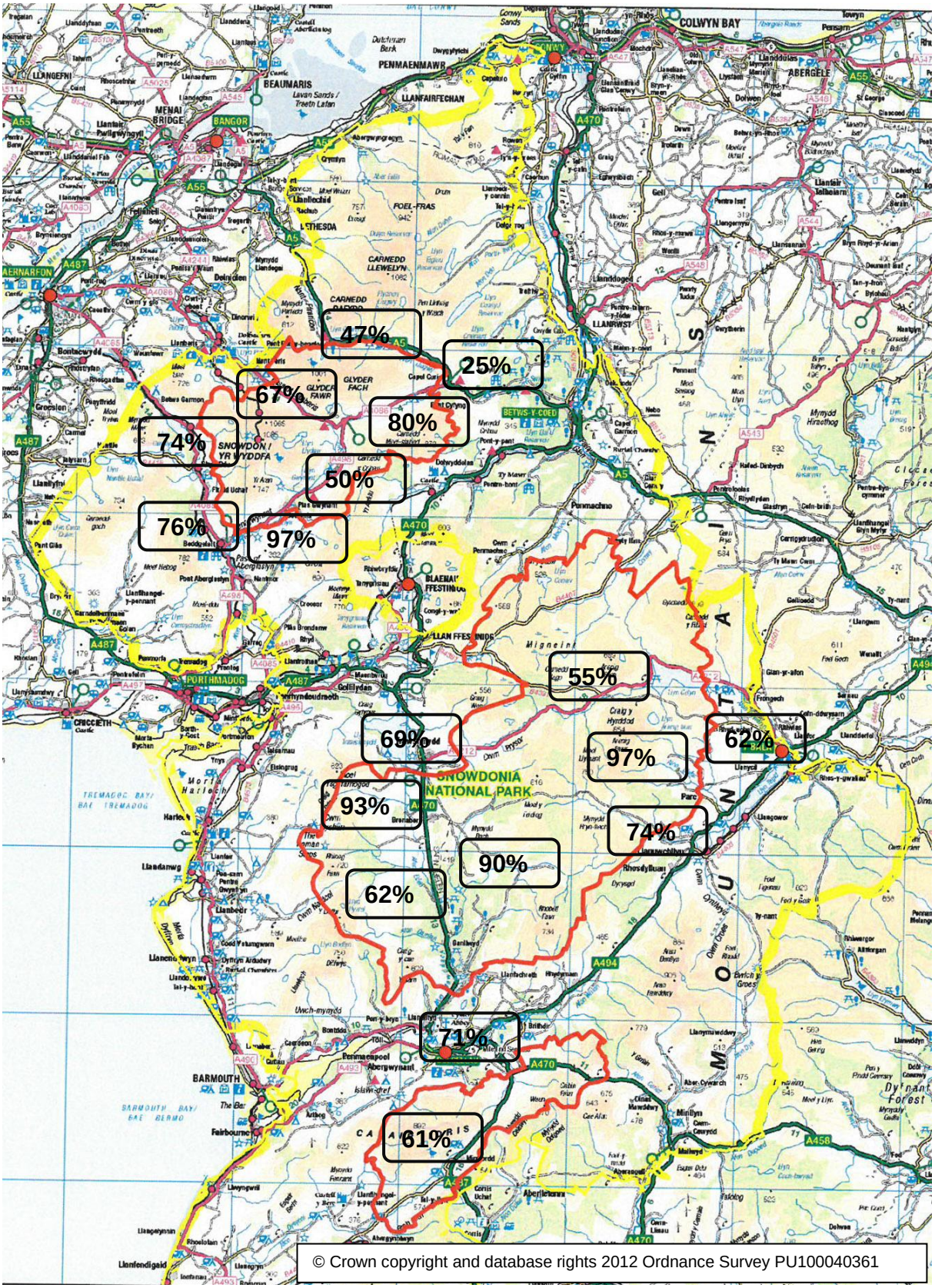


Figure 5.1: Showing the private lighting percentage compliance variation in different areas

5.2 Recommended Changes

Table 5.2 is typical of the standard data collected during the lighting audit at each property surveyed, however, due to the size of the audit only a single page is shown here as an indicative depth of detail included in the survey. The National Park Authority have a complete dossier which includes the property name where possible future improvement work is required.

Guide to Table 5.2 "Compliant" column

The last column contains 3 grades of luminaires namely:-

(1) Those which are "fully or part shielded" regardless of their lumen output (shown as 1 or more in clear cells) and are not at issue.

(2) Those with lamps less than the lumens cap although they are not "fully shielded" (shown as 1 or more in clear cells) and are also not at issue.

(3) Those with lamps greater than the lumens cap and not "fully shielded" (shown as red cells) in the table.

Although priority should be given to modifying the over 500 lumen units, in the red cells, over the next 5 years, greater priority must be given to improve locations where "Red Bars" occur (eg. record 1.01 in Table 5.2).

A "Red Bar" across the complete record should be treated as top priority since some are technically incorrectly installed, regardless of the dark sky application eg elevated double asymmetric floodlights , and some have incorrect luminaires to suit the lighting application.

Table 5.3: contains a summary of quantities in each section surveyed.

All existing street lighting within the application core zones should be changed to horizontal "flat glass" within the next 12 months and at least 10% should be completed before the application is appraised by the IDA. The remainder in the Buffer Zone shall remain as installed until the luminaires require to be replaced through the Carbon Reduction programme. As local authority improvement budgets permit, each street will be equipped with new luminaires and bracket arms, where necessary, to meet zero light intensity limitation at 90^0 and above as recommended in this LMP. Additionally all new street developments using LED light sources will be designed to accommodate a glare limiting index of G6 for the complete installation.

Table 5.2: Typical Domestic Lighting Audit Details

Total Number of lighting units = **3316** Total Compliant = **2410** = **73%**

Ref No.	Type of fitting	Qty.	Building Type	Elevation Angle	Adaptable	Wattage	Duty Cycle	Application	Fully Shielded	Qty. Compliant
1.01	asymmetric	1	hostel	45	yes	70	pecu	car park	no	0
1.01	spotlight	2	hostel	90	yes	120	pir	access	no	0
1.01	bulkhead	4	hostel	90	no	8	pir	toilet	no	4
1.01	floodlight	1	hostel	45	yes	100	pir	path	no	0
1.01	wellglass	1	hostel	0	no	8	switch	path	no	1
1.01	spotlight	2	cottage	10	yes	35	pir	steps	part	2
1.02	wellglass	1	cottage	90	no	20	switch	access	no	1
1.02	bulkhead	1	cottage	90	no	8	switch	access	no	1
1.03	wellglass	4	hall	90	no	60	switch	access	no	4
1.03	bulkhead	4	hall	90	no	8	switch	doors	no	4
1.04	floodlight	3	cottage	30	yes	100	switch	path	no	0
1.04	floodlight	1	cottage	30	yes	100	pir	path	no	0
1.04	wellglass	1	cottage	90	no	60	switch	path	no	1
1.05	bulkhead	1	cottage	90	no	8	switch	door	part	1
1.06	floodlight	2	farmhouse	45	yes	300	switch	yard	part	1
1.06	floodlight	1	cottage	45	yes	150	pir	garden	no	0
1.06	bulkhead	1	cottage	90	no	60	switch	path	no	1
1.07	bulkhead	1	cottage	90	no	8	swith	door	part	1
1.08	bulkhead	2	farmhouse	90	no	60	switch	door	part	2
1.08	wellglass	1	farmhouse	0	no	8	switch	door	no	1
1.08	floodlight	1	farmhouse	45	yes	150	pir	access	no	0

1.09	floodlight	1	farmhouse	45	yes	300	switch	drive	no	0
1.09	bulkhead	2	farmhouse	90	no	40	switch	door	no	2

5.3 Sectional Compliance Summary

Table 5.3: Summary of Lighting Audit Details

Section Number	Remote Properties	Qty of Luminaires	Qty. < 600 lumens	Qty. Compliant	% Compliant	Additional Comments
1	16+	86		64	74%	includes Rhyd Ddu village
2		217		164	76%	Buffer includes Beddgelert
3	4	42		28	67%	Core 1
4	15+	80		64	80%	Core 1 & includes Nant Gwynant
5	13+	96		48	50%	Core 1 & includes Bethania hamlet
6	7	32		31	97%	Buffer
19A	18	91		43	47%	Buffer
19B		88		22	25%	Capel Curig & Plas-y-Brenin Mountain Centre (Buffer)
Area 1 Totals		**732**	**323**	**464**	**63%**	
7	9+	195		135	69%	Buffer includes Trawsfynydd
8	7+	379		352	93%	Core 2 includes holiday village
9	16	55		34	62%	Core 2
10	2+	55		25	45%	Core 2 includes Ganllwyd village
11	4				0%	Buffer
12	36	89		49	55%	Core 2
13	19	29		26	90%	Core 2
14	20+	37		27	73%	Buffer includes Llanfachreth
15	15+	192		142	74%	Buffer includes Llanuwchllyn
16	38+	30		29	97%	Parc hamlet in Core 2
17	23				0%	Core 2
18	28	5		4	0%	Core 2
20	380	848		529	62%	Bala town in Critical Buffer
Area 2 Totals		**1914**	**894**	**1353**	**71%**	
21	1070	731		519	71%	Dolgellau town in Critical Buffer
22	31	122		74	61%	Core 3

Area 3 Totals	**853**		**593**	**70%**	

Figure 5.2: View overlooking Dolgellau lowest Compliance

The area in the distance is the section with the 83% compliance label.

The dots of light in the distance emanate purely from the presence of street lighting.

Figure 5.3: Dolgellau Area Compliance

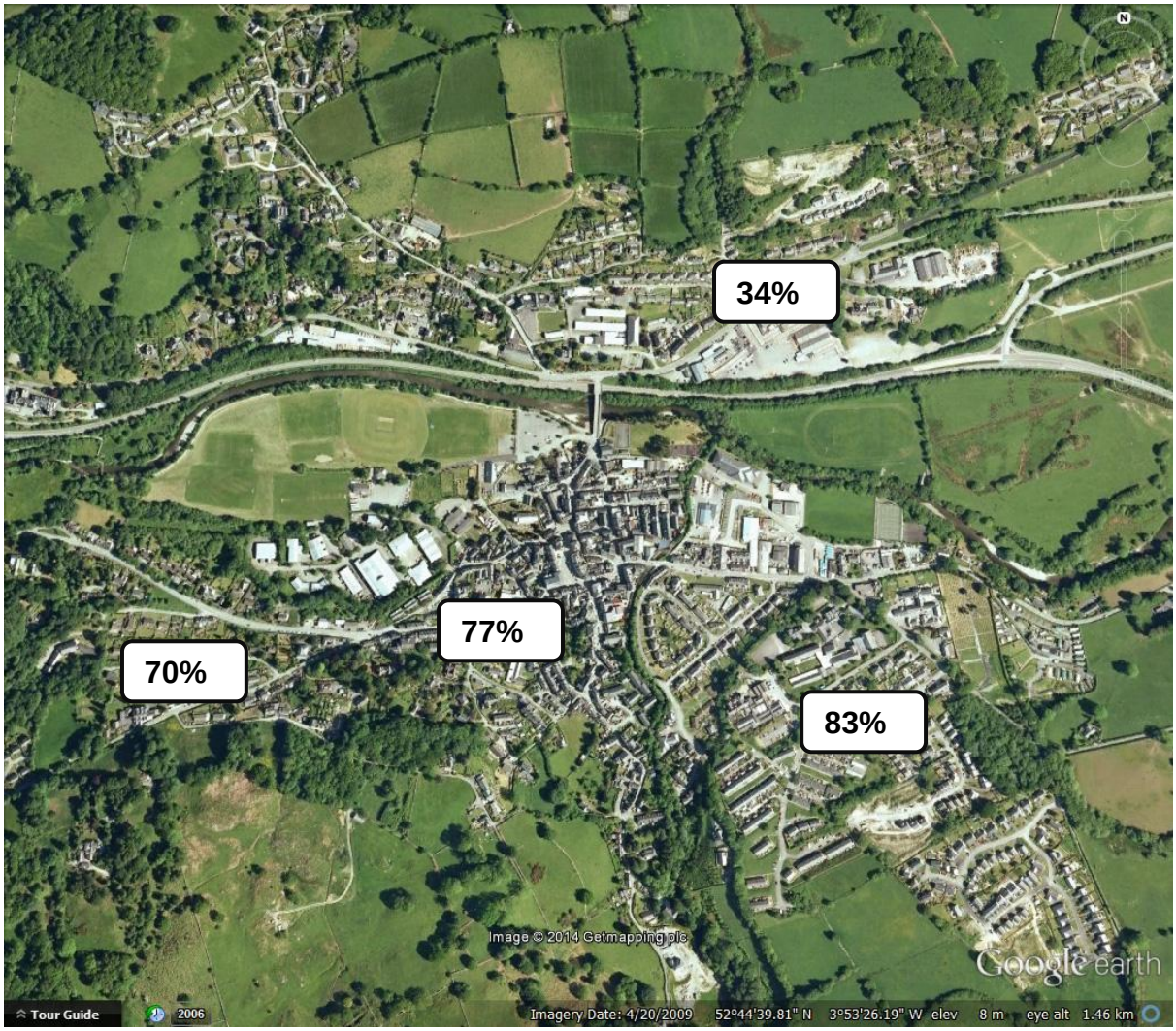

34%
77%
70%
83%
Image © 2014 Getmapping plc
Google earth
Tour Guide
2006
Imagery Date: 4/20/2009 52°44'39.81" N 3°53'26.19" W elev 8 m eye alt 1.46 km

Table 5.4: Bala Summary and typical of audit for properties in groups

Type of Luminaire	Quantity	> 600 lumens	Quantity Compliant	Quantity Non-Compliant
bulkhead	197	197	197	
heritage	159	159	159	
wellglass	85	85	85	
square bulk'd	97			97
circular bulk'd	15			15
flood @45 pir	42			42
flood @45 sw	43			43
flood @dsf 0	20		20	
dsf sports flood	57		57	
large eyelid	15			15
small eyelid	5	5	5	
Flat glass eyelid	1	1	1	
plaza	17			17
bollard	7			7
opal sphere	57			57
bi-symmetric	17			17
double asymmetric	4			4
par38 @45	5			5
par38 @0	2		2	
wall wash	3		3	
Bala Totals	**848**	**447**	**529 = 62%**	**319**

Red Bar assistance: Potential upgrade of red bar units to compliant version provides 85% compliance

The large quantity of Opal Spheres were found in the leisure complex in the South West outskirts of the town and this would be the first area to target improvements.

Change of property size

If a major addition occurs on a property, or street, lighting for the entire property, or street, shall comply with the recommendations in this LMP. The following are considered major additions:

- An addition of 50% or more in terms of residential houses, gross floor area, seating capacity, parking space or street length.

- Single or cumulative additions, modifications or replacement of 50% or more of installed exterior lighting luminaires.

Change of Property Ownership

If a property, with non-conforming lighting, changes ownership or usage a new external lighting application must be made. The application must include a complete lighting inventory and site plan

detailing all existing and proposed new exterior lighting. If the existing exterior lighting is no longer required all non-conforming lighting should be disconnected and removed.

5.4 Public Lighting Audit

Table 5.4: Listing of towns and villages

Town / Hamlet	Miles	Authority	Total	Flat Glass		Population
Trunk Road Network (generally 150 - 250 watts)						
Llanelltyd	A470		35	35		
	A496		23	23		
Betws-y-Coed	A5		44	44		
Trunk Roads Total (within National Park Reserve)			102	102		
Community within Core Zone No1						
Nantgwynant	0.0	Gwynedd	3	3		< 200
Bethnia	0.0	Gwynedd	2	2		
Community < 2 miles from Core Zone No.1						
Capel Curig	0.2	Conwy	11			206
Dolwyddelan	1.5	Conwy				474
Beddgelert	1.0	Gwynedd	94			617
Nantmor	2.0	Gwynedd	2			< 100
Rhyd-Ddu	1.0	Gwynedd	20	20		37
Betws Garmon	2.0	Gwynedd	2			216
Community within Core Zone No2						
Llidiardau	0.0	Gwynedd	6			< 200
Parc	0.0	Gwynedd	12			< 200
Ganllwyd	0.0	Gwynedd	20	18		< 200
Bronaber	0.0	Gwynedd	5	3		< 100
Bronaber Holiday Village	0.0	Private	0			
Community > 2 miles from Core Zone No.2						
Penmachno	1.5	Conwy	34	2		< 400
Cwm Penmachno	0.5	Conwy	21			< 200
Ysbyty Ifan	1.0	Conwy	12			221
Frongoch	1.5	Gwynedd	34	20		< 100
Rhyd-uchaf	1.0	Gwynedd	6			< 200
Ty Gwy		Gwynedd	4			
Bala	2.0	Gwynedd				1,980
Llangower	2.0	Gwynedd	2			< 200
Llanuwchllyn	1.5	Gwynedd	53			834
Rhosdylluan	1.5	Gwynedd	0			
Pont Fronwydd	1.5	Gwynedd	3			
Rhydymain	1.5	Gwynedd	17			< 100
Llanfachreth	0.5	Gwynedd	17			200

Birthdir	2.0	Gwynedd	8+	no Street View		< 100
Llanelltyd	1.5	Gwynedd	10+	no Street View		< 200
Penmayenpool	1.5	Gwynedd	16			< 500
Bontddu	2.0	Gwynedd	34			< 500
Trawsfynydd	0.5	Gwynedd	94	15		1,000
Community within Core Zone No3						
Minffordd	**0.0**		0			< 600
Community > 2 miles from Core No.3						
Dolgellau	0.5	Gwynedd				2,678
Dinas Mawddwy	2.0	Gwynedd	27			622
Minllyn	2.0	Gwynedd	?	No Street View		
Abergynolwyn	0.5	Gwynedd	35			< 300
Other Towns Within Snowdonia National Park Boundary (Remainder of Buffer Zone)						
Betws-y-coed			68			564
Llan Ffestiniog						< 1,000
Dinas Mawddwy						
Mallwyd						< 200
Aberangell						< 200
Aberdifi						878
Tywyn						3,264
Fairbourne						1,058
Dyffryn Ardudwy						1,540
Llanbedr						645
Llandanwg						< 500
Harlech						1,950
Gellilydan						< 500
Talsarnau						< 300

Table 5.5: Listing of all towns less than 5 miles from Application boundary

Town Name	Miles	Authority	Total	Flat Glass		Population
Towns < 5 miles beyond National Park boundary (External Zone)						
Conwy	0.5	Conwy				564
Llandudno	1.0	Conwy				20,710
Conwyn Bay	5.0	Conwy				30,742
Conwyn	0.25	Conwy				14,723
Abergele	9.0	Conwy				10,577
Blaenau Ffestineog	0.0	Gwynedd				4,875
Machynlleth	0.5	Gwynedd				2,147
Barmouth	0.5	Gwynedd				2,522
Lanaber	0.5	Gwynedd				1,672
Penrhyndeudraeth	0.5	Gwynedd				2,031
Porthmadog	0.5	Gwynedd				4,185
Llandwrog	4.0	Gwynedd				2,466
Caernarfon	5.0	Gwynedd				9,615
Llanberis	2.0	Gwynedd				1,954
Llandderfel	1.0	Gwynedd				955
Bethesda	1.0	Gwynedd				4,327
Bangor	3.0	Gwynedd				13,725
Llanfairfechan	0.5	Conwy				3,755
Penmaenmawr	0.5	Conwy				4,353

5.6 Luminaire Profiles

Typical Road Lighting Luminaire Profiles with typical intensity distribution of light emerging near the horizontal axis

Typical 35 or 55w SOX Refractor bowl

35w luminaire elevated 5^0

I max	Cd/klm
Above 95	43
Above 90	62
90^0	62
80^0	115
70^0	163

Refractor Bowl

55w luminaire elevated 5^0

I max	Cd/klm
Above 95	30
Above 90	70
90^0	70
80^0	294
70^0	304

Typical 70w SON – Polycarbonate Bowl

luminaire elevated 10^0

I max	Cd/klm
70^0	251
80^0	204
90^0	66
Above 90	66
Above 95	18

luminaire elevated 15^0

I max	Cd/klm
70^0	242
80^0	236
90^0	96
Above 90	96
Above 95	25

Typical 50 - 70w SON – Refractor Bowl

luminaire elevated 5^0

I max	Cd/klm
Above 95	27
Above 90	38
90^0	38
80^0	195
70^0	493

Typical Post Top 70w SON

luminaire elevated 0^0

I max	Cd/klm
Above 95	40
Above 90	64
90^0	64
80^0	278
70^0	284

5.6: Public Lighting Inventory - Detail Synopsis

Town / Village Name: Bala
Location: East of Core No. 2
Distance from core boundary: 2 miles
Population: 1,980

Local Authority Street Lighting

Lamp Type	Watts	Quantity	Duty Cycle	Bowl Type	I_{90}
SOX	35/55	128	Dusk/Dawn	refractor	
SON	50/70	19	Dusk/Dawn	clear	
SON	50/70	7	Dusk/Dawn	low profile	
SON	100/150	7	Dusk/Dawn	deep bowl	
SON	100/150	35	Dusk/Dawn	low profile	
SON	100/150	35	Dusk/Dawn	flat glass	0%
Google Street View estimate by JP					

Other Exterior Lighting in Bala (eg sports, school, community)

Location : Ysgol y Berwyn - School Sports Ground

Fixture	Elevation	Lamp/Watts	Duty Cycle	Application	Compliance
Cowl Shielded Double Asymmetric	5	2 kw MBI	10pm limited	Multi sport	Fully

Location : Bala Football Club

Fixture	Elevation	Lamp/Watts	Duty Cycle	Application	Compliance
Dbl. Asymmet.	0	?	??	Football	fully

Location: Playing Field

Fixture	Elevation	Lamp/Watts	Duty Cycle	Application	Compliance
By-symmetric.	70	?	??	Training ?	failure

Location: Other Club Sports Ground

Fixture	Elevation	Lamp/Watts	Duty Cycle	Application	Compliance
Shielded	9 @ 0	2 kw MBI	??	Playing field	Fully
Dbl. Asymmet	6 @ 45				Fully
Bi-symmetric	4 @ 90				failure

Duty Cycle Options: Dusk/Dawn

Half Night	= Midnight or 1am Off
Part Night	= On for Evening and Morning, Off between
Dimmed	= On for Evening and Morning, Dimmed between
PIR	= Presence Detection

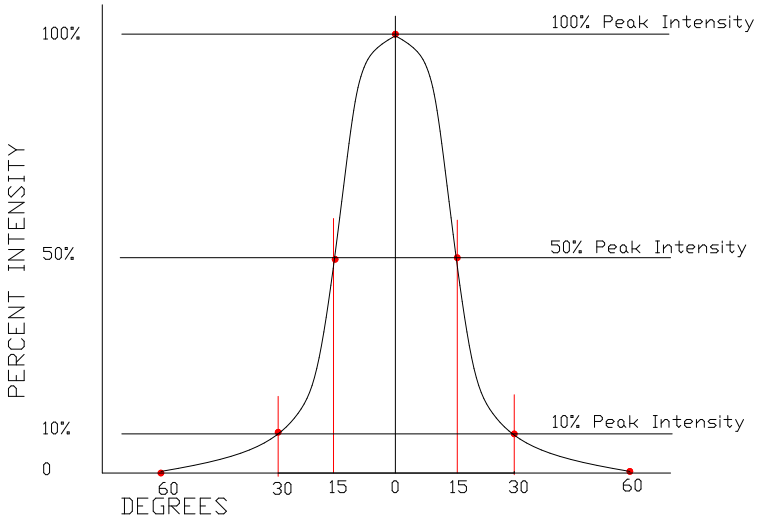
Appendix A – Definitions

Unit/Term	
lumen	A unit of light (luminous flux) emitted from a point source of one candela intensity, sometimes expressed in kilolumens - **(klm**)
candela	A unit of luminous intensity
illuminance	The quantity of luminous flux incident upon a unit area, expressed as lumens per square metre or **lux**
luminance	The luminous intensity (or brightness) of a surface or source expressed in terms of surface area i.e. **candelas per square metre (cd/m^2)** To convert dark sky 'brightness' to luminance Use the formula: [value in cd/m^2] = $10.8\times10^4 \times 10^{(-0.4*[\text{value in visual magnitudes/arcsec squared}])}$
reflectance	The reflection factor (or index) of a surface or material
inter-reflection	The result of various reflections
efficacy	In lighting terms - the value of light obtained per unit of electrical energy input i.e. **lumens per watt**
wattage	The nominal load rating of a lamp (excludes any allowances for associated operating gear losses usually taken as averaging10% of the nominal wattage value(lower for electronic control gear))
luminaire	The total package of lantern, lamp and all associated integral items of operating control and switch gear
projector	A special luminaire designed to provide a concentrated pattern of light
skylight	The variable brightness value of daytime sky caused by sunlight scattered by particles of dust and vapour in the earth's atmosphere (skylight can reach values in excess of 2,000 candelas per square metre)
moonlight	The luminous flux emitted by the moon received at the earth's surface at an average value of between 0.3 and 0.5 lux (a rural surface under moonlight conditions will have an average brightness of about 0.002 candelas per square metre i.e. 1/500 cd/m^2)
sky glow	The variable brightness value of night-time sky caused by upward components of light from direct and inter-reflected light off the earth's surface (the brightness of sky glow is dependent on the amount of upward light and the presence and density of atmospheric particles and their distance above ground level)

aura The hemisphere of light rising up from ground level encircling a light source or lighting array caused by low level mist and fog particles

Disability glare This is glare from a lamp or luminaire which prevents a visual task from being carried out by obscuring ones vision. It is sometimes associated with visual pain.

Cartesian diagram



IES, TM14, & Elumdat Are different electronic formats of luminaire intensity distribution. They are not a meaningful representation in hard copy printed format, like a Cartesian or polar diagram, however, as numeric data input for a computer algorithm they represent a 3-dimentional array. Some computer algorithms recognise all three different formats whilst other algorithms only recognise one format.

Light intrusion Is light entering or illuminating windows beyond the intended area requiring illumination. Sometimes referred to incorrectly as 'light trespass' since the word 'trespass' has different legal implications in the UK.

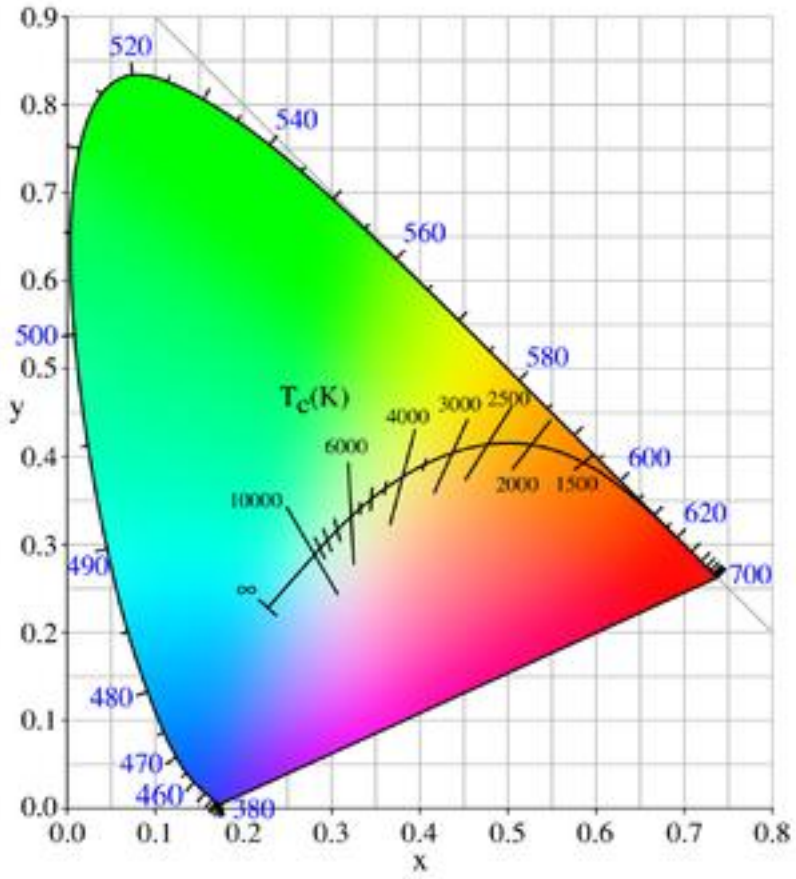
Average luminance or average illuminance Are all based on a maintained average which means the lowest average value to which the installation will fall before lamp replacing and luminaire cleaning takes place as part of a maintenance regime cycle.

Light Source Temperature, Colour, and Appearance

Colour Temperature

The **colour temperature** of a light source is the temperature of an ideal black-body radiator that radiates light of comparable hue to that of the light source. Colour temperature is a characteristic of visible light that has important applications in lighting,

astrophysics, horticulture, and other fields. In practice, colour temperature is only meaningful for light sources that do in fact correspond somewhat closely to the radiation of some black body, i.e., those on a line from reddish/orange via yellow and more or less white to blueish white; it does not make sense to speak of the colour temperature of, e.g., a green or a purple light. Colour temperature is conventionally stated in the unit of absolute temperature, the Kelvin, having the unit symbol K.



The CIE (1931) x,y chromaticity space

also showing the chromaticities of black-body light sources of various temperatures (Planckian locus), and lines of constant correlated colour temperature.

Source Wikipedia

The "Correlated Colour Temperature" (CCT / Tcp)** provides guidance of the colour appearance of lamps whether or not their chromaticity point (from the x & y values) is on the black body locus line.

BS 5489-1:2013 and BSEN 12665:2002 use the abbreviation of Tcp to replace CCT. The abbreviation CCT is still used in American documents.

Colour Appearance

The colour appearance of a light source can be defined objectively in terms of the temperature, in degrees Kelvin, to which a thermal radiator (e.g. a black body) would have to be heated to have the same colour appearance as that of the light source being assessed. A GLS tungsten filament lamp (traditional domestic light bulb) has a colour temperature of c.2700° Kelvin (usually written as 2700K).

The CIE categories of "Warm", "Intermediate" and "Cool" relate to CCTs as follows:

Below 3300K - WARM

3300K to 5300K - INTERMEDIATE or NEUTRAL
Above 5300K - COOL

Dark Sky Light Source Colour Issues

In 2010 the International Dark-Sky Association (IDA) produced a paper "**Visibility, Environmental and Astronomical Issues Associated with Blue-Rich White Outdoor Lighting**" which is a compilation of various research abstracts available at that time. All the research abstracts chosen relate to the possible 'harmful' effects of the blue content in most 'white' light sources. The IDA terminology of 'blue-rich white' includes metal halide, fluorescent, induction and **all CCT versions of LED** light sources. The following pages show the various spectral power radiation of these and other light sources which have no or very little blue content in their spectrum (ie below 500 nanometers).

Four years later when exterior lighting, especially highway lighting in the UK, was undergoing a substantial light source change from yellow sodium to various forms of white light the IDA reviewed their dark sky friendly fixtures approval process. In addition to their 'fully shielded' requirements they will now limit approval to luminaires which use a light source CCT of 3,000K or less. **This may not be a sustainable decision in the UK.**

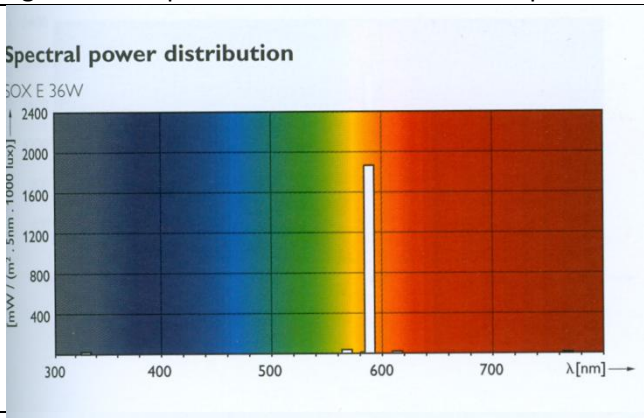
There are two issues in the 2010 paper which point towards limiting astronomy and also general vision 'glare'. Both of the main issues and also secondary ecology issues are linked to the blue content of white light. The paper supports continued use of yellow light which as shown in the following spectral analysis are deficient in blue spectral content. The paper cites the Rayleigh Scatter Index effect of the blue radiation appearing to be greater than yellow radiation.

In the UK yellow low pressure sodium lamps are regarded as "grand-fathered" old technology and the overwhelming majority of UK local authorities have a policy of not installing any more new low pressure sodium street lighting installations. While this lamp has been the mainstay of many street lighting installations for more than 50 years it is now scheduled to be phased out shortly in the UK and there is also growing evidence that the high pressure sodium lamp may also follow. Maintaining these two yellow sources is becoming increasingly more expensive and this will only add to their eventual extinction. It is therefore difficult to promote their continued use and a sustainable white light compromise is required for dark sky preservation.

'Glare' results from the quantity and quality of light distribution from a luminaire and not solely from the colour of the light source. BSEN13201-2 use technical metrics to define limits of 'glare' in street lighting and the **full distribution of G6 for neutral white LED sources should be applied** in preference to limiting the colour temperature of the light source in dark sky places.

The use of light sources with a CCT / Tcp greater than 4,000K is therefore not permitted in any UK Dark Sky Places.

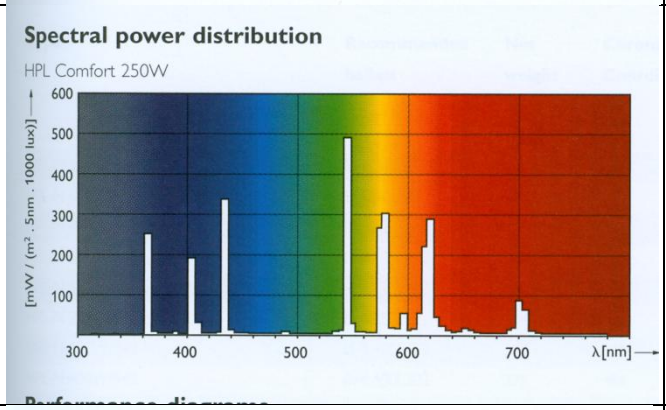
Light source Spectral Power and Colour Temperature Analysis



Low pressure sodium (SOX)
Colour Temperature CCT = 1800K
Colour rendering index Ra = minus 40

No radiation below 500nm

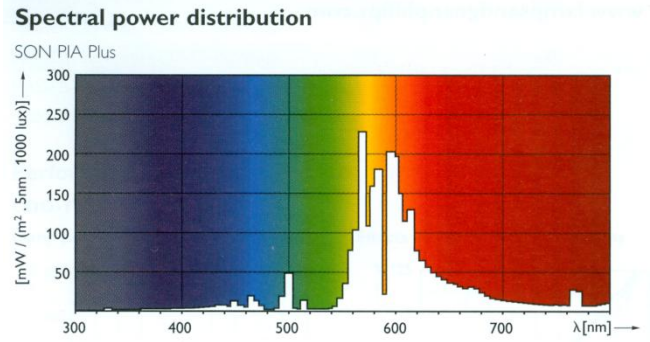
nm = wavelength in nanometers



High pressure mercury with fluorescent coating to convert UV radiation into visible light. (MBF/U)
CCT = 3300K, Ra = 52 (Comfort version)

More than 50% radiation below 500nm

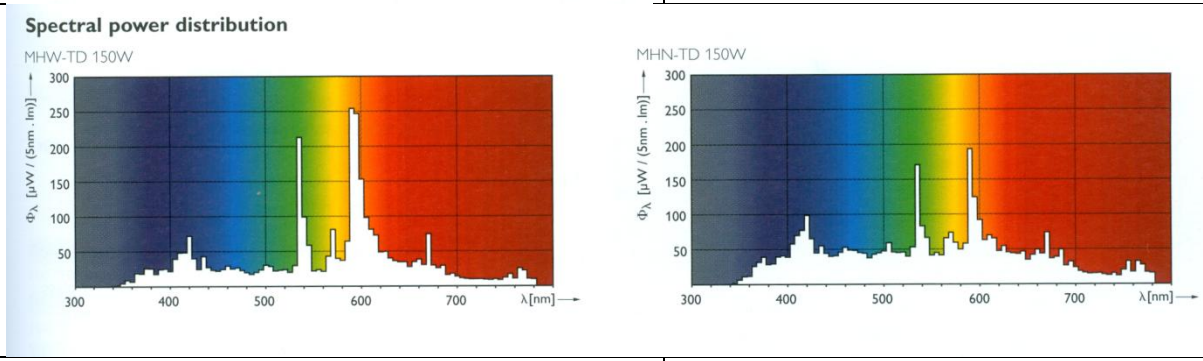
Some MBF/U still exists in some National Parks



High pressure sodium (SON/T plus)
CCT = 2000^0 K, Ra = 22 to 25

25% radiation below 500nm
but no radiation in UV range

"White SON" CCT = 2500K, Ra = 83

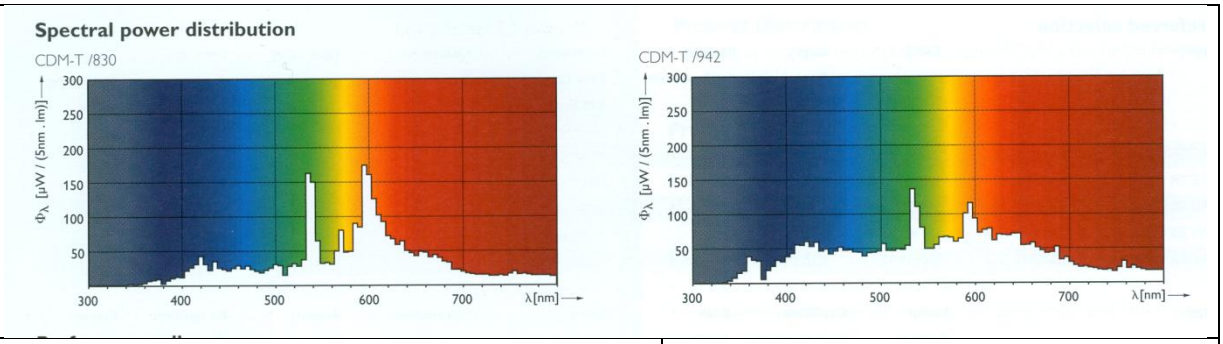


Metal halide warm white
CCT= 3300K, Ra = 52

Less than 25% radiation below 500nm

Metal halide cool white
CCT= 4000K, Ra = 65

About 50% radiation below 500nm

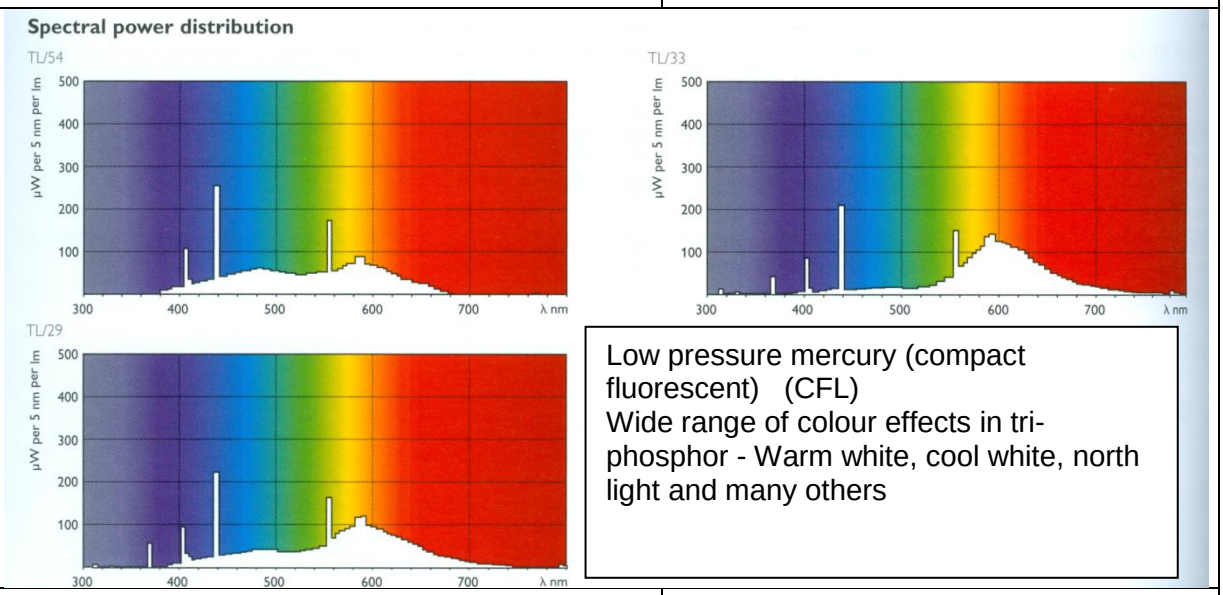


CDM-T warm white CCT = 3000K, Ra = 85

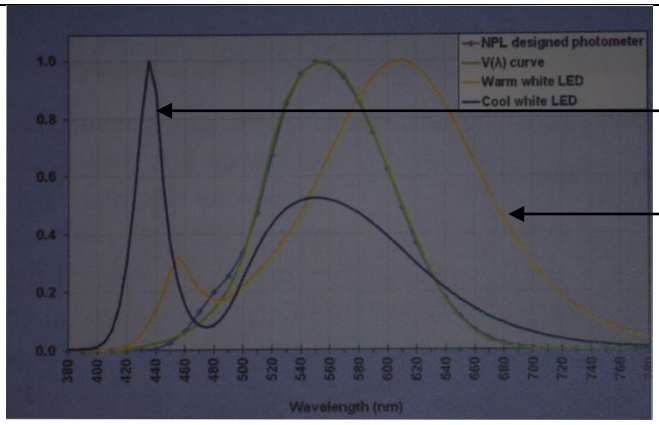
About 30% radiation below 500nm

CDM-T cool white CCT = 4200K, Ra = 96

About 50% radiation below 500nm



Low pressure mercury (compact fluorescent) (CFL)
Wide range of colour effects in tri-phosphor - Warm white, cool white, north light and many others



LED Recent Research
by Dr Paul Miller NPL

Cool White Spectral Distribution
6,000K - black curve

Warm White Spectral Distribution
3,200K - yellow curve

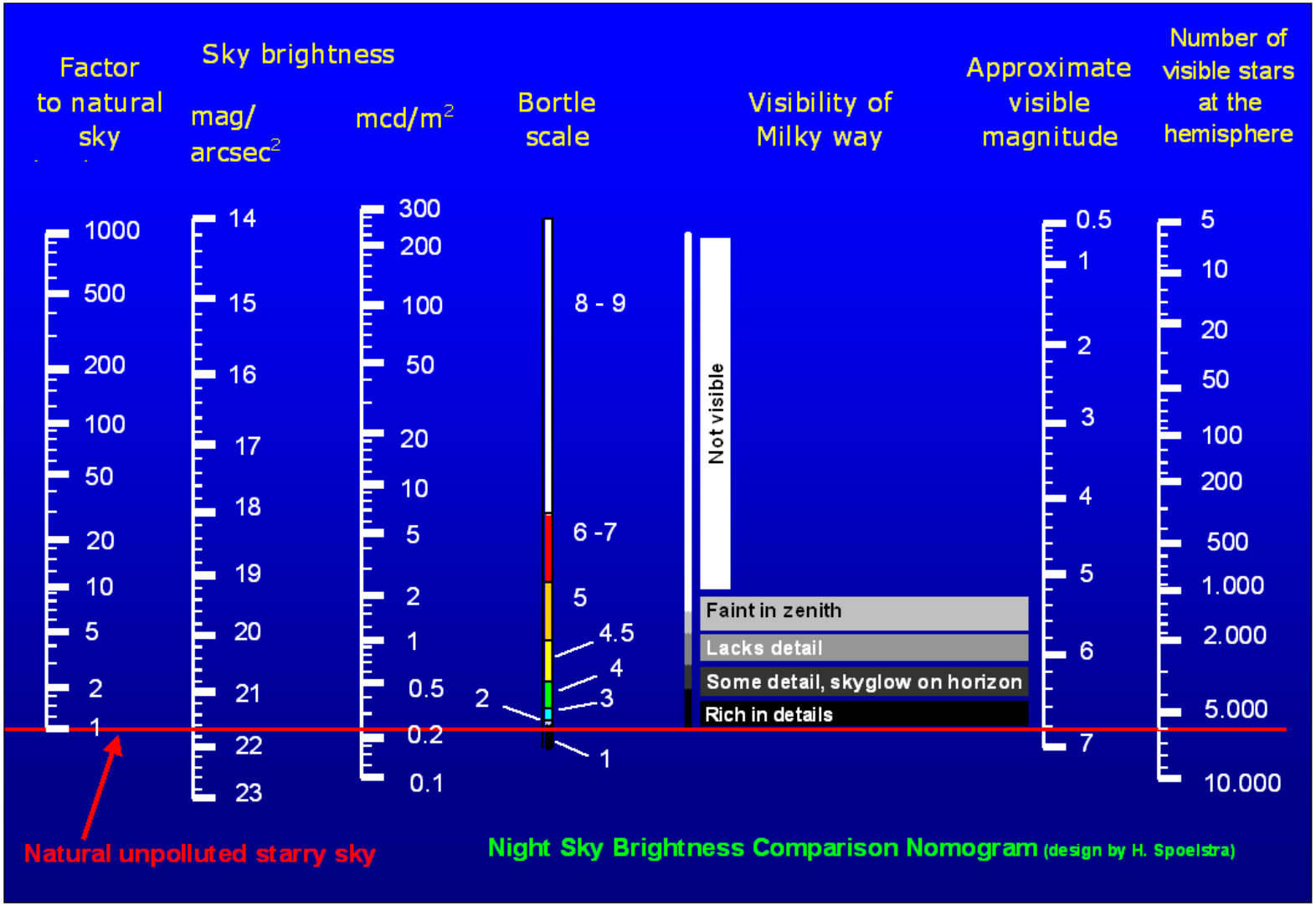
3 colour temperatures available

LMP Note: September'13 Data
Use Warm or Neutral White in residential side streets, conservation areas and in IDA Dark Sky areas.

Exclude the use of Cool White in IDA Dark Sky Places

Warm White about 3,200K
Neutral White about 4,500K
Cool White about 6,000K

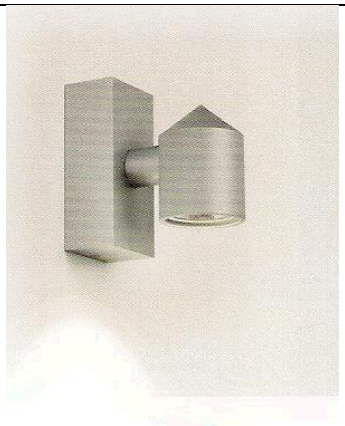
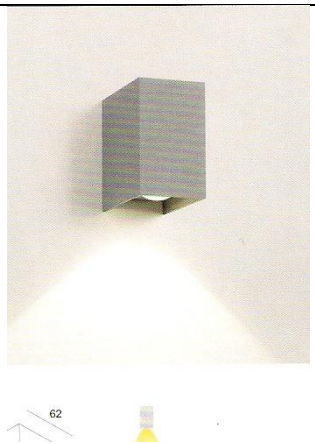
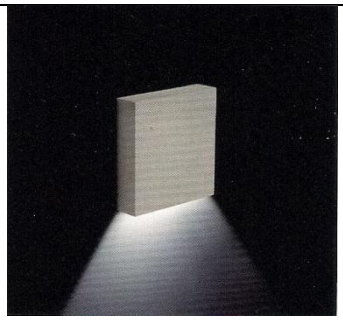
Appendix B – Sky Brightness Nomogram (by kind permission of Heck Spoelstra)

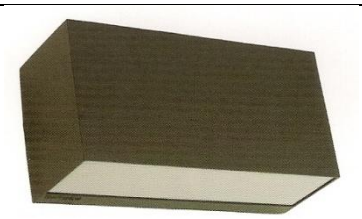


Appendix C

Domestic External Lighting Units

Suitable for exacting needs of Core Zone / E0-50 / E0-250 Retro-fits

 Deltalight Dox	 Deltalight Mono	 Deltalight Visionair
 Deltalight Nox	 Deltalight Lookout	contact Deltalight 94 Webber Street London SE1 0ON www.deltalight.co.uk
 Norlys Halden Also in - Konst Smide	 Norlys Koster A	 Norlys Narvic

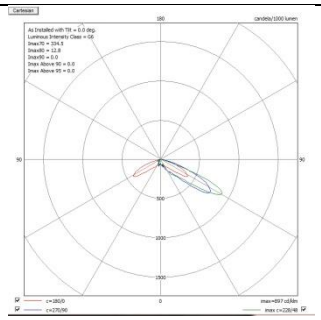
 Norlys Asker		Norlys & Lutec see Elstead Lighting Elstead House Mill Lane Alton Hampshire GU34 2QJ www.elstead-lighting.co.uk
 liteCraft Stainless Steel Down-light	 liteCraft Dacu 40 watt & LED	 liteCraft Savona (shielded version)
	Unknown Maker	liteCraft Showroom Seaward Street Kinning Park Glasgow G41 1HJ www.liteCraft.co.uk
	Zumtobel - Bega 2489 Triangular Bulkhead 18w PLC 3000^{0}K	
	B&Q	

Appendix D

Luminaire Profile Examples for Environmental Zone E1 / E2-0%
with typical intensity distribution of light emerging near the horizontal axis

GE – ALE - 4000K LED

Double ASY4/126/CCT/AT +4/139 +4/152 +4/165 +4/178 +4/190



Also
Double SS5/101/CCT/AT +5/126 +5/152 +5/178 +5/202
Single ASY4/50/CCT/AT +4/63 +4/76 +4/89 + 4/101

luminaire elevated 0^0

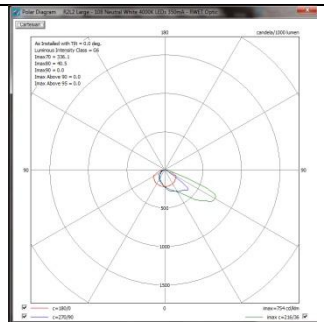
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	12.8
70^0	334.5

√

G6 compliant

Warning
No 5,700K LEDs in dark sky places

Thorn R2L2 LED
Neutral White
Large, Medium and Small versions have G6 options



108 luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	40.5
70^0	336.1

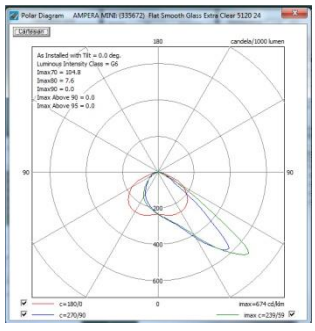
√

G6 compliant

Urbis Ampera

Mini 335672 8-24 LED = G6

Midi 336052 32-64 LED = G6 + Midi Zebra
Maxi 341042 80-128 LED= G6 + Maxi Zebra



24 luminaire elevated 0^0

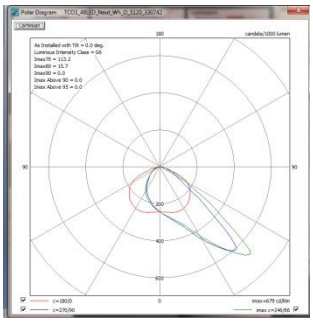
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	7.6
70^0	104.8

√

G6 compliant

Urbis Teceo 1
Flat Glass 5120 16-48 LED

Neutral White



Also Teceo 2
Flat Glass 5120 56-114 LED in Neutral White = G6

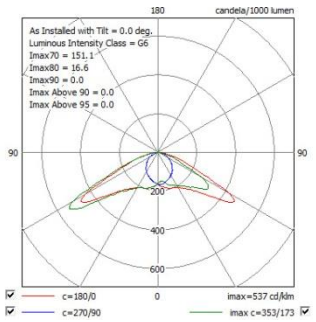
48 luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	15.7
70^0	113.2

√

G6 compliant

WE-EF
RFL530 TW/E
(on IDA approved list + VFL + PFL and RFS)
45w Cosmo



luminaire elevated 0^0

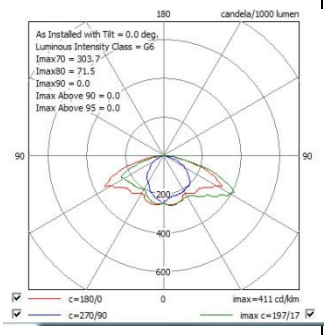
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	16.6
70^0	151

√

45w = G6 compliant

I-tables no longer in Lighting Reality update

Phosco
P850 200 mA LED



237w luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	35.4
70^0	349.6

√

87w-237w G6 compliant
Neutral white LED

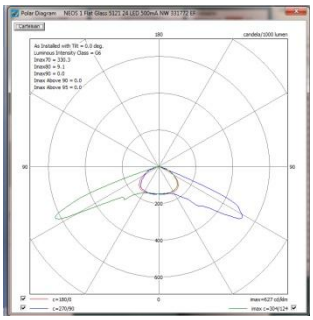
Phosco
P851 -12-M-STD-G6 range LED

31w-145w G6 compliant
Neutral white LED

145w luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0

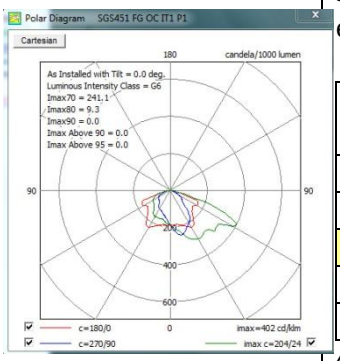
√

		80⁰ 21.7 70⁰ 256.4
Phosco **P852 -12-M-STD-NW-B range LED** **No G6 luminaires in this range** **Not recommended in Dark Sky Place**		39w luminaire elevated 0⁰ I max / Cd/klm Above 95⁰ 0 Above 90⁰ 0 90⁰ 0 80⁰ 61.8 70⁰ 488.2 14w-39w G4 compliant Neutral white LED
 Urbis Neos Flat Glass 5121 16-24 LED Neutral White		24 luminaire elevated 0⁰ I max / Cd/klm Above 95⁰ 0 Above 90⁰ 0 90⁰ 0 80⁰ 9.1 70⁰ 330.3 G6 compliant √
	Light Emitting Diodes Flat Glass Ruud / CU Phosco Ledway Road 30 x LED's @ 3000⁰K or 50 x LED's @ 4000⁰K Caution 6000⁰K also available	luminaire elevated 0⁰ I max / Cd/klm Above 95⁰ 0 Above 90⁰ 0 90⁰ 0 80⁰ 71 70⁰ 287 G6 compliant √
	**SILL Lighting** 453 CityLiter 26w Pll and 35w CDM	luminaire elevated 0⁰ I max / Cd/klm Above 95⁰ 0 Above 90⁰ 0 90⁰ 0 80⁰ 8 70⁰ 84 √

Philips - Mini Iridium
45w Cosmopolis
Warning:- Pole Top mounting elevates lantern 10^0. **Must** be side entry on 0^0 bracket

No BGS451 LEDs are G6
Typical G3 but G6 @ 90 and above

BGP352 range includes G6 mixed in with G3 and G4 variations

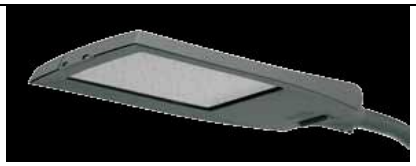


SGS451 FG luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	10
70^0	246

√

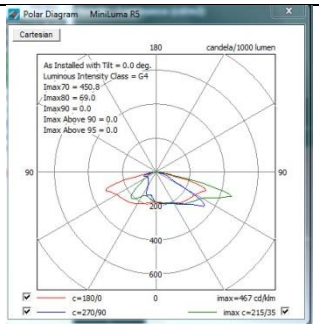
45w = G6 compliant
At 5^0 tilt output = G5



Philips/WRTL - Mini Luma

R6 Optic

Note
I_{70} maximum
for G6 = 350 cd/1000 lm

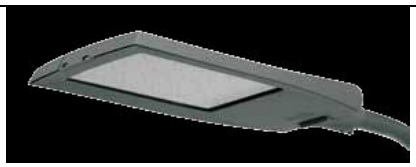


luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	71
70^0	384

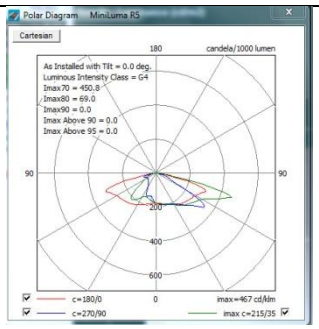
√

Typically G4
but G6 at 80 and above



Philips/WRTL - Mini Luma

R5 optic



luminaire elevated 0^0

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	69
70^0	451

√

Typically G4
but G6 at 80 and above

G4 optic (warning also G2 version)

Light Emitting Diodes
Flat Glass

Urbis
Remus
16, 24, 32 or 48 LED's

3500^{0}K or 4250^0 K

Caution
6000^{0}K also available

luminaire elevated 0^0

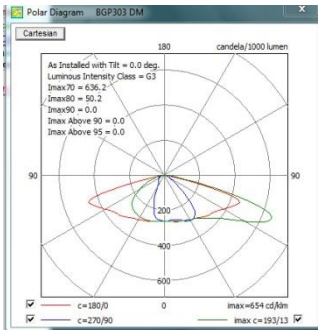
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	89
70^0	447

√

Typically G4
but G6 at 80 and above

Philips Clearway
LED 23/740

Note
I_{70} maximum
for G4 = 500 cd/1000 lm



luminaire elevated 0^0

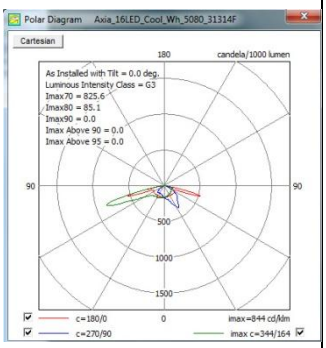
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	50
70^0	636

√

Typically G3
but G6 at 80 and above

Urbis - Axia
3500^{0}K or 4250^0 K
16, 24, 32 or 48 LED's

No true G6 in range



luminaire elevated 0^0

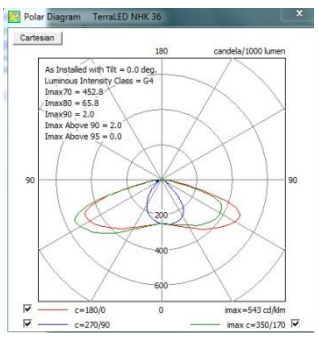
I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	85
70^0	825

√

Typically G3
but G6 at 80 and above

OrangeTEC

TerraLED

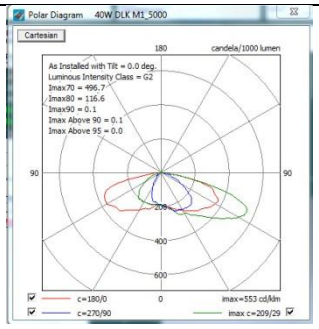


I max	Cd/ klm
Above 95^0	0
Above 90^0	2
90^0	2
80^0	65.8
70^0	452.8

G4 Compliant

OrangeTEC

Aria



I max	Cd/ klm
Above 95^0	0
Above 90^0	0.1
90^0	0.1
80^0	116
70^0	496

G2 Compliant

Thorn Lighting

Plazora Wall Light

26w TC-D fluorescent

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	8
70^0	50

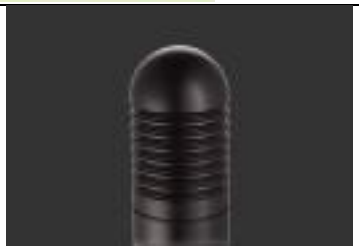
√

Sugg Lighting
And others

(white paint on louvers reflects upward light)

Up to 8% ULR and not suitable in Dark Sky Places

I max	Cd/ klm
Above 95^0	1
Above 90^0	7
90^0	7
80^0	22
70^0	35



0% ULR

Thorlux Probe

57w TC-T
Compact fluorescent

4,300 lumens

7-10 days delivery

Glare control = G3

I max	Cd/ klm
Above 95^0	0.2
Above 90^0	0.4
90^0	0.4
80^0	8.1
70^0	11.5

Almost G6

0% ULR

Urbis Isla

35watt CDM
or 42watt CFL

G6 optic (warning G2 optic also available)

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	31
70^0	274

√

The following examples do not fully comply with zero intensity at and above the horizontal but have been selected from many others as being the closest to "Fully Shielded" conditions and need to be located near other natural shields like buildings or trees.

JW Ltd Gloucester
G1/96 Philips Fortino optic

45w LED unit

Vertical lamps and refractors are not compliant with G6 or E1 objectives.

I max	Cd/ klm
Above 95^0	0
Above 90^0	0.3
90^0	0.3
80^0	33
70^0	93

Sugg Rochester and Tunbridge

50watt SON/T = G4 compliant with cgp stb optic

80w MBF/U = G5 compliant with cgp stb optic

I max	Cd/ klm
Above 95^0	0
Above 90^0	8
90^0	8
80^0	78
70^0	480

U_h = 0.0
U_l = 0.2 total ULOR = 2%

Sugg Lighting

Large Grosvenor

50w SON/T

Optic and lamp located in lantern top section to act as "fully shielded" but as in all heritage equipment the glass refracts some light upwards

I max	Cd/ klm
Above 95^0	0
Above 90^0	17
90^0	17
80^0	83
70^0	206

Urbis St. Giles

50watt SON/T

G3 compliant with SGS Clear P/1200/095/-38.5/ 911381

I max	Cd/ klm
Above 95^0	10
Above 90^0	7.7
90^0	7.7
80^0	23
70^0	148

DW Windsor

Garda
LED Hand Rail

I max	Cd/ klm
Above 95^0	4
Above 90^0	10
90^0	10
80^0	66
70^0	165

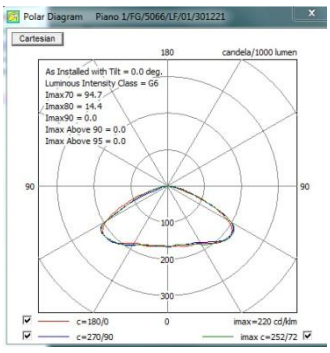
Emergency Exit Lighting Unit (mounted horizontally not as illustration)

Raylux 25

8 x LED's and complete with wall mounting bracket

Unit to be mounted pointing down for G6 compliance

Currently undergoing photometric tests to prove zero intensity at and above horizontal



luminaire elevated 0^0

Urbis
Piano 1 No longer available ?
3200K

Caution
6000^0K also available but
not approved in dark sky place

I max	Cd/ klm
Above 95^0	0
Above 90^0	0
90^0	0
80^0	14
70^0	95

√

G6 compliant

rayLUX 25

DIRECTIONAL WHITE-LIGHT

High Performance White-Light LED illuminators provide class leading performance, long life, energy efficiency and zero maintenance. They incorporate the very latest surface mount LED's to deliver excellent optical output and outstanding reliability, providing even illumination and excellent night time images for surveillance cameras and general area lighting.

The RAYLUX 25 provides a world class 'White-Light' output of 110lm/W at the LED source, and an independently tested luminaire output of 800 lm at 15lm/w.

Each unit is fitted with Active LED Life Control to carefully control LED output, delivering consistent illumination power and a projected working life of 10 years.

RAYLUX illuminators are supplied with bracket and power supply. Control features on the power supply include adjustable power output, photocell and telemetry control. RAYLUX 25 is designed for low light installations up to 20m (66ft).

RAYLUX 25 is also available with low voltage PSU.

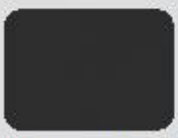
POWERFUL
- Quick Start
- PLATINUM LED technology
- High Power - Low Running Costs

FLEXIBLE
- Various Angles (30, 50 or 120°)
- Fully Controllable Power Supply
- Optional Low Voltage PSU

RELIABLE
- 10 year life
- Active LED Life Control
- Vandal resistant

CONTROLLED
- Excellent Colour Rendition
- Even Output Illumination
- Low Running Costs

WHITE-LIGHT IN USE:



White-Light off

White-Light on

Version 3.2

APPLICATIONS

rayTEC

General Domestic Lighting Equipment Profiles

Through this leaflet we hope to provide you with examples of well designed equipment which you may wish to consider when purchasing new lighting units. The leaflet also contains examples of poor design relative to the exacting demands of light control within Dark Sky Places.

Unless otherwise noted the equipment illustrated is available from local DIY Stores.

Good – Reflector shaped to direct light down. Boxed as dark sky friendly and has PIR sensor separate from the lamp unit pointing. For rural setting look for unit with a 150 watt lamp or less. Also provides reduced illumination dusk to dawn for courtesy and full power on presence detection.

Poor – Lamp reflector and PIR detector point in same elevation and rotational direction. 300 / 500 watts Tungsten Halogen lamps provide too much light for use in rural settings.

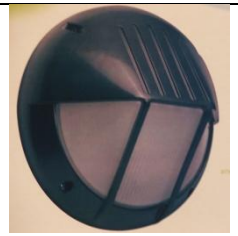
Good – Can direct light in 2 directions and lamps are less than 100 watts. Limit elevation angle to less than 45 degrees. Various other similar styles with integral PIR detector on mounting. 60w capsule with dimming for courtesy or LED lamps

Good – (above and below) 70w or 150w metal halide lamp. Must be installed with glass window **horizontal – and not as illustrated**. When the lamp is located at the bottom of the reflector the main beam will emerge from the glass window at about 45 degrees. Known technically as a double asymmetric light distribution.

Very Good – (SILL 453 CityLiter) Designed to be mounted horizontally and available in a range of low wattage lamps. Luminaire has IDA Dark Sky Friendly Fixture Award.
Fluorescent range + 35/70w metal halide

Poor – Low wattage light source but projects light upwards when mounted as shown and needs to be near horizontal to limit sky glow. (**Bracket does not allow horizontal fixing**)
18 watt PL-C = 1,200 lm

Poor – No light control



Fair – Upward light limited but lamp must be less than 600 lm.

Poor – No light control

Good – Porch light with downward light

Poor – Bollard with no light control and produces glare

Good – External louvers limit upward light and reduces glare. Lamp must be less than 600 lm

The output of lamps will shortly be valued in lumens rather than watts as at present. The table below provides interim user guidance when comparing lamp watts and lumens.

Lamp type & Watts		**Lamp Lumens (lm)**
Clear Bulb GLS	40w	420

Candle Lamp clear 40w	400
Candle Lamp LED 9w	405
Superlux Krypton 40w	455
Halogen energy saver 28w	370
Halogen linear 60w	840
12v Tungsten Halogen 42w	624
T2 linear fluorescent 8w	540
T5 linear fluorescent 8w	385
Compact Fluorescent Elegance globe 9w	405
Elegance candle 9w	405
Elegance spiral 9w	450
2D compact fluorescent 10w	650
3 loop compact fluor't 13w	900
1 loop compact fluor't 11w	900
LED Opal globe 15w	664

In order to protect the dark night sky it is proposed to limit the lamp output on existing poor or no light-controlled luminaires to **500** lumens in dark sky parks and reserves with **3,000** lumens in dark sky communities.

Illustration	*Lamp Name*	*Lamp Type*	*Nominal Watts*	*Output Lumens*
	Standarrd, clear bulb	Incandescent GLS	15 w 25 w 40 w 60 w 100 w	90 220 420 710 1,330
	Standard, pearl frosted bulb	Incandescent GLS	15 w 25 w 40 w 60 w 100 w	90 220 415 700 935
	LED equivalent in Edison Screw or Bayonet Cap	2,700 K Colour temperature	6.5 w 9.5 w 13 w 16 w	470 806 1,055 1,300
	Halolux Halogen energy saver in Edison Screw or Bayonet Cap	Incandescent Tungsten Halogen	28 w 42 w 45 w 52 w 70 w	370 625 710 835 1,180
	Candle, clear bulb	Incandescent Tungsten	25 w 40 w 60 w	220 400 660
	Candle, opal bulb	Incandescent Tungsten	25 w 40 w 60 w	190 390 640
	Twisted Candle, clear bulb	Incandescent Tungsten	15 w 25 w 40 w 60 w	90 200 400 660

Illustration	*Lamp Name*	*Lamp Type*	*Nominal Watts*	*Output Lumens*
	Twisted Candle, opal bulb	Incandescent Tungsten LED equivalent	15 w 25 w 40 w 60 w 3 w	90 200 400 660 245
	GE Candle Lamp (B&Q)	Incandescent Tungsten Incandescent Tungsten Halogen	18 w 30 w 45 w 18 w 28 w 42 w	170 415 710 205 370 625
	Round, clear bulb	Incandescent Tungsten	25 w 40 w 60 w	200 400 660
	Round, opal bulb	Incandescent Tungsten	25 w 40 w 60 w	200 400 660
	Superlux Krypton mushroom, opal Standard Superlux Krypton mushroom, opal And burning position	Incandescent Tungsten	25 w 40 w 60 w 75 w 25 w 40 w 60 w	240 455 760 1,000 160 300 530
	Haloline linear	Incandescent Tungsten Halogen	60 w 80 w 100 w	840 1,380 1,900

			120 w 130 w 230 w	2,216 2,440 4,650

Illustration	*Lamp Name*	*Lamp Type*	*Nominal Watts*	*Output Lumens*
	Halostar 12V	Incandescent Tungsten Halogen	G4 10w G4 14w G4 20w G4 25w G9 25w G9 18w G9 28w G9 30w G9 42w G9 45w	100 215 240 470 255 204 370 415 624 710
	LED Parathom clear globe	Solid State Light Emitting Diode	1.6 w 2 w 3 w	70 100 165
	Master LED opal globe	Solid State Light Emitting Diode	6 w 7.5 w 12 w	337 470 650
	Master LED reflector	Solid State Light Emitting Diode	4 w 7 w GU10 4w	110 230 200
	Lumilux T2 tubular	Discharge Linear Fluorescent	6 w 8 w 11 w 13 w	330 540 750 940

		T5 Tubular	4 w 6 w 8 w 13 w	130 270 385 830
		T8 Tubular	10 w 15 w	650 950

Illustration	*Lamp Name*	*Lamp Type*	*Nominal Watts*	*Output Lumens*
	Biax Extra Mini	Discharge Compact Fluorescent	9 w 11 w 15 w	480 600 900
	Elegance Globe	Discharge Compact Fluorescent	7 w 9 w 11 w 15 w 20 w	286 405 610 830 1,152
	DIALL Globe (B&Q)	Discharge Compact Fluorescent	13 w 15 w 23 w 30 w	664 820 1,400
	Elegance Candle	LED Discharge Compact Fluorescent	3 w 5 w 7 w 9 w	245 200 286 405
	Spiral	Discharge Compact Fluorescent	9 w 13 w 15 w 20 w 23 w 35 w	450 741 970 1,230 1,450 2,285
	2D Square	Discharge	16/14 w	1,100

		Compact Fluorescent	21/19 w 28 w 38/34 w	1,375 2,150 3,020
	Circular	Discharge Compact Fluorescent	22 w 32 w 40 w	1,000 2,250 3,100

Illustration	***Lamp Name***	***Lamp Type***	***Nominal Watts***	***Output Lumens***
	Biax S/E	Discharge Compact Fluorescent	5W 7W 9W 11W	265 425 600 900
	Biax D	Discharge Compact Fluorescent	10W 11W 13w	600 610 900
	Biax T	Discharge Compact Fluorescent	13W 15W 18/20W 42W	900 845 1,200 3,200

Appendix G
Property Self-Audit Guidelines – The Next Step for Improvement

Of particular interest in the lighting audit was the high percentage of security style floodlights, many of them with the glass almost vertical. The application for a dark sky status would benefit greatly if more "security" style floodlights were tilted down, preferably horizontal.

Are you ready to help improve the dark night time sky conditions?
If so survey your property externally (all buildings and any free-standing lighting eg. on poles in exercise yards or ménage areas)

Tungsten Halogen Floodlights

Preferred Step

Replace with new fitting having good light control & meeting the Lighting Management Plan requirements

or ***Option 1***

Tilt down until glass is horizontal and thereby meeting the requirements of a "fully shielded" luminaire.

Reduce lamp size if possible (500watts to 300watts or 150watts to 100watts).

or ***Option 2***

Tilt down as far as fitting allows (integral sensor units sometimes limits the downward angle).

Fabricate shielding from aluminium or similar material and fix securely in place.

Ensure that shielding as fixed, allows no light at or above the horizontal axis.

Reduce lamp size if possible.

Remember:-

SWITCH OFF - AFTER YOUR WORK IS FINISHED
NO TASK – NO LIGHTING

For all other fittings which are **not "fully shielded" or "fully cut-off"**, consider implementing changes or upgrades as follows:-

1) No or very minimal Light Control

Preferred

Measure the building footprint and consider replacing these types of light unit with new fitting(s) having good light control, preferably "fully cut-off" like the examples on the following page and thereby meeting the Lighting Master Plan (LMP) requirements.
Try not to exceed the total lumen limit in the table below for your size of property.

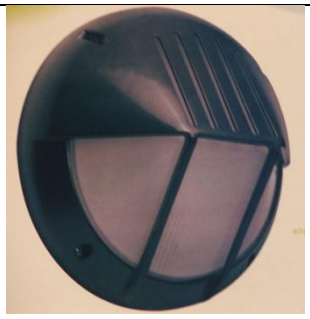
	Environmental Zone				
	E0-50 / E0-250 and E1		E2	E3***	E4***
Total Lumens for domestic Exterior Lighting	750 lm plus 4.5 lm / m^2 of site structures*		2250 lm plus 4.5 lm / m^2 of site structures*	4500 lm plus 4.5 lm / m^2 of site structures*	6000 lm plus 4.5 lm / m^2 of site structures*
Fully cut-off luminaires each lamp lumen maximum	1200 lm		1650 lm	2400 lm	3200 lm
Part cut-off luminaires each lamp lumen maximum	E0's none	E1 500 lm	1200 lm	1650 lm	2400 lm
No light control luminaires each lamp lumen maximum	E0's none	E1 500 lm**	600 lm**	750 lm	750 lm
© LCADS Ltd 2013					

Table - Total lumen limit and individual lamp lumen limit per property

* Site structures is the sum of the land area of residential buildings, habitable structures, garages, recreational buildings and storage structures on each property plot.

***** Environmental zones E3 and E4 exist but do not relate to any conditions in National Scenic Areas, Regional Scenic Areas, National Parks, Starlight Reserves or Dark Sky Communities.**

A full list of domestic lamp types, their wattage and their lumen outputs are shown in the previous appendix as reference data. However, lamp manufacturers are continually improving lamp efficiency and some lamp lumen outputs may change through time.

 Fully cut-off example	 Fully cut-off example	 Fully cut-off example
 Only part shielded so limit lamp size as per table 3.1	 Only part shielded so limit lamp size as per table 3.1	 Only part shielded so limit lamp size as per table 3.1

or ***Option 1***

Shield to fully comply with LMP requirements.

Fabricate shielding from aluminium or similar material and fix securely in place.

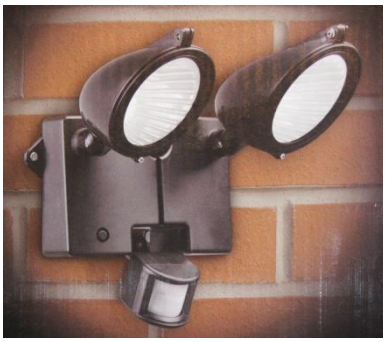
Ensure shielding as fixed, allows no light at or above the horizontal axis.

or ***Option 2***

If high power lamp, replace lamp with one having less than 500 lumen output (see tables in Appendix).

Consider shielding as well.

2) Partly Cut-off Fittings


Keep luminaire tilted down to lowest limit

Preferred

Adjust tilt angle down to meet LMP requirements.

or ***Option 1***

Tilt down if adjustable and

Provide additional shielding to comply with LMP requirements.

Fabricate shielding or cowl from aluminium or similar material and fix securely in place.

Ensure that shielding / cowl as fixed, allows no light at or above the horizontal axis.

or ***Option 2***

Consider replacing with new fitting having improved light control & meeting LMP requirements

or ***Option 3***

If high power lamp, replace lamp with one having less than 500 lumen output (see tables in Appendix)

Consider tilt reduction as well, if possible.

Consider shielding as well.

For all external lighting:-

- Check switching times are sensible / consider time limitation as appropriate.
- PIR detectors are properly aimed to avoid nuisance switching.
- Consider installing a push button switch with short time delay facility.


Dark Sky Park / Reserve / Community
Lighting Design Brief
for all New or Refurbished
Exterior Lighting Installations
in
Snowdonia National Park

Design Brief
For
External Lighting Design Planning Proposals

Forward - Controlling "Light Pollution"

In March 2012 the UK Government introduced the control of "light pollution" through planning procedures in their National Planning Policy Framework. Although the document applies to the English planning framework the principles outlined in paragraph 125 could be equally applied across the UK and Europe as a base of good planning practice. The paragraph states "***By encouraging good design, planning policies and decisions should limit the impact of light pollution from artificial light on local amenity, intrinsically dark landscapes and nature conservation***."

Additionally an associated publication, National Planning Practice Guidance (2014), provides municipal planning authorities with a defined link between planning and lighting see http://planningguidance.planningportal.gov.uk/blog/guidance/light-pollution/

Of prime importance is guidance for all planning authorities to set up their own night time environmental zones applicable to all new planning design work. In areas where there is a Dark Sky Award this task has already been fully outlined as a "Lighting Ordnance" in the Lighting Master Plan associated with each award. In all National Parks the Park Authority takes on all planning matters within its boundary.

On a worldwide base the International Dark Sky Association (IDA), in Arizona, created awards for the quality of sky darkness for three different “Places” namely, a “Park”, a “Reserve” and a “Community” to suit three different types of inhabited areas. (for IDA definitions see www.darksky.org).

The management of all external lighting in an IDA designated Dark Sky Place is contained in a Lighting Master Plan (LMP) specifically written for each Dark Sky Place. This Lighting Design Brief provides all the supporting technical data relating to the design of lighting which is not contained within the generality of any simplified Supplementary Planning Guidance Notes which often only provides generalised statements to maintain and enhance dark sky attributes. This brief is based on extracts from the LMP upon which the design of all new or refurbished external lighting, within and surrounding the Dark Sky Place, must be based.

Design Procedure Part 1 - Confirm Night Time Environmental Zone:-

General Zone Abbreviations:-

E0's: No Light Source perception - eg Dark Sky Core

E1's: Intrinsically dark Areas - eg Dark Sky Buffer Zone, Area of Outstanding Natural Beauty and National Parks

E2's: Low district brightness - eg Dark Sky External Zone - or Dark Sky Community locations

E3 and E4 (in CIE150:2005) do not relate to conditions expected in or close to a Dark Sky designated award area

For Environmental Zone Roadmap see page 3.

Zone Abbreviation Detail:-

E0's Core - A designated central area(s) within the Dark Sky Place and sub- divided for lighting as follows:-

E0-0	**Un-inhabited Core (no light permitted) eg Nature Reserve, SSSIs**
E0-50	**Inhabited Rural Settlement groups in Park or Reserve**
E0-250	**Remote Rural Property in Park or Reserve**
E0-SL	**Street Lighting in Park or Reserve**

E1's Buffer Zone - Majority of Place around the Core Zone, if Core is designated, and sub-divided for lighting as follows:-

E1-CIE150	**Generality of all rural parts of National Park and 10 mile surround including all small towns with new LED street lighting**
E1 in E0	**In Park where there is no Core designated (eg Northumberland)**

E2's

E2-0%	**Dark Sky Town Community (eg Mofat)**
E2-1%	**Dark Sky Town Community hub with CCTV**
E2-CIE 150	**Communities beyond Dark Sky Place boundary**

When carrying out a night time visual impact assessment some parts of the area may appear to be medium or high district brightness (E3 or E4) eg Dolgellau, Bala, Blaenau Festiniog or other town centres through earlier, more relaxed light control requirements.
All new lighting design work should be aimed at **reducing ambient brightness at every possible opportunity**.

An upward light ratio of **0%** should be the target throughout all Dark Sky designated areas and generally throughout all the rural parts of the region but may have a 1% relaxation in the central hub of Dark Sky Communities.

Environmental Zone E3 and E4 do not relate to any part within, or adjacent to, the dark sky place boundary and stray light limitations should be within the natural setting of the new development surrounds.

Environmental Zone Roadmap

E0-50 Community in **E0-250** area eg Llidiardau

E1 Community in future E0 area eg Rhyd Uchaf

E2-0% / E2-1% (eg Dolgellau)

5 mile external transition
Dark Sky Place Protection

Design Procedure Part 2A

Select lighting equipment and / or develop a lighting design, based on the following:-

For all domestic new build or refurbishment applications

Table A (3.7 in main document) - Permitted Total Lumen Limit for each residence

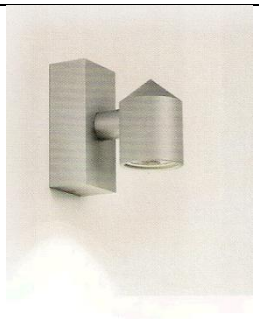
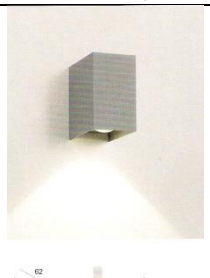
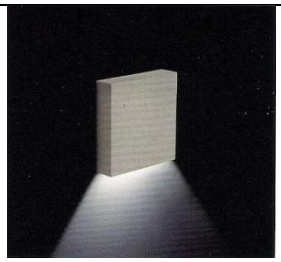
	Environmental Zone				
	E0	E1	E2	E3	E4
Total Lumens for domestic Exterior Lighting	750 lm plus 4.5 lm / m^2 of site structures*	750 lm plus 4.5 lm / m^2 of site structures*	2250 lm plus 4.5 lm / m^2 of site structures*		
Fully cut-off luminaires each lamp lumen maximum	1200 lm	1200 lm	1650 lm		
Part cut-off luminaires each lamp lumen maximum	none	500 lm	1200 lm		
No light control luminaires each lamp lumen maximum	none	500 lm**	600 lm		

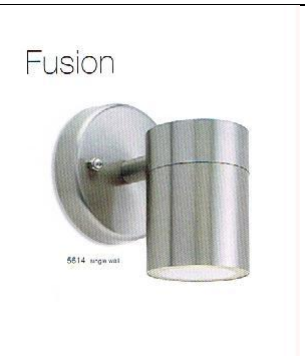
* Site structures is the sum of the land area of residential buildings, habitable structures, garages, recreational buildings and storage structures on each property plot.
** The maximum watts or lumens for each lamp in this section relates to replacing lamps in existing lighting units only.

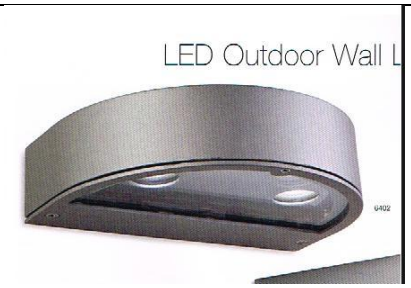
No new luminaires with little or no light control are permitted.

Lamp lumens are now indicated on the packaging of lamps instead of wattage. Some lumen / wattage equivalents and a worked example is indicated in the main document.

Typical Domestic External Lighting Units
Suitable for exacting needs of Core/ Buffer Zone / E0-50 / E0-250 Retro-fits

 Deltalight Dox	 Deltalight Mono	 Deltalight Visionair
 Deltalight Nox	 Deltalight Lookout	contact Deltalight 94 Webber Street London SE1 0ON www.deltalight.co.uk

 Norlys Halden Also in - Konst Smide	 Norlys Koster A	 Norlys Asker see Elstead Lighting Elstead House Mill Lane, Alton, Hampshire GU34 2QJ
 liteCraft Stainless Steel Down-light	 liteCraft Dacu 40 watt & LED	 liteCraft Savona (shielded version)
	 Zumtobel - Bega 2489 Triangular Bulkhead	liteCraft Showroom Seaward Street Kinning Park Glasgow G41 1HJ www.liteCraft.co.uk
 First Light - Delta LED/ 5watt 455mm and 805mm post height	 First Light - York Wall Light	 First Light -Fusion

 First Light - 6402	 First Light - Vegas	Contact First Light Products 22 Erica Road Stacey Bushes Milton Keynes MK12 6HS www.firstlight-products.co.uk

Design Procedure Part 2B
For all commercial development applications

Use relevant British Standard to select task illuminance. Table B is only included as a general guidance and is not exhaustive of various other tasks which could take place in or around the Dark Sky Place.

Table B (3.3 in main document)
Illuminance for typical tasks within Dark Sky Place

Ref No.	Type of area, task or activity	Eav lux	Uo	GR_L	R_a	Remarks
	Farms					
5.5.1	Farm Yard	20	0.10	55	20	
5.5.1	Equipment Shed (Open)	50	0.20	55	20	
5.5.3	Animals sorting pen	50	0.20	50	40	
	Farmland Sport					
	Equestrian (outdoor event)	100	0.50	55	20	
	Industrial sites and Storage					
5.7.1	Short term handling of large units and raw material, loading and unloading of solid bulk goods	20	0.25	55	20	
5.7.2	Continuous handling of large units and raw material, loading and unloading of freight, lifting and descending location for cranes	50	0.40	50	20	
5.9.1	**Parking Areas – See Public Lighting Roadmap in Table J (page 13)**					
	Simple Summary for safety and security					
	Very low risk	5	0.25	55	20	
	Low Risk	10	0.40	50	20	
	Medium Risk	20	0.40	50	20	
	High Risk	50	0.4	45	20	

Key to table abbreviations
Eav = Maintained average illuminance, Uo = Overall uniformity, R_a = minimum colour rendering index, GR_L = Glare Rating limit (for internal work visibility benefit and not a visibility measure from outside the site)

Illuminance recommendations are based on steps which are generally perceptible as shown in Table C. This table also shows the illuminance step difference between low colour rendering lamps, as in table B, and high colour rendering lamps.

Table C (3.5 main document)
Illuminance comparisons based on colour rendering index (R_a)

Colour Rendering Index	Task Maintained Average Illuminance Steps (lux)												
R_a < 60	2	3	5	7.5	10	15	20	30	50	75	100	200	300
R_a > 60		2	3	5	7.5	10	15	20	30	50	75	100	200

Ra < 60 poor colour rendering, eg. ‘orange’ or ‘pinkish’ SOX & SON sodium street lights etc.

Ra > 60 broader spectrum ‘white’ light e.g. most fluorescent, compact fluorescent, tungsten / tungsten halogen lamps & some mercury discharge (CDM & Cosmopolis) and LED < 4,000^{0}K light sources.

Table D (part of table 2.6 main document)

Intensity Distribution Recommendations in Core Zone(s) (E0)

Dark Sky Requirements	Glare Class	Maximum luminous intensity in cd/klm				Non technical description of luminaire light control in installed condition
		at 70^{0} az	at 80^{0} az	at 90^{0} az	above 95^{0} az	
Core Zone	G6*	350	100	0	0	Horizontal flat glass Fully cut-off installation in environmental zone E0 and source colour temperature about 3,000^{0}K

Note* Intensity relaxation may be appropriate at 70^{0} and 80^{0} depending on luminaire availability but the **values of zero intensity at 90^{0}, 95^{0} and above are crucial**.

Blue rich colour temperature (5,000-6000^{0}K) light sources are not permitted in Dark Sky Places (see nature conservation practice)**.**

Intensity distribution recommendations apply to the luminaire's installed angle of inclination (tilt) which can be tested in UK industry standard design calculation software.

Stray light control recommendations in Core Zone(s):

No stray light is permitted within the E0 Core Zone

Values for Upward light, Light intrusion into windows and source intensity are all zero.
No decorative external lighting (floodlighting etc.), is permitted.

Assessment Note 1: Measurement or calculation of light intrusion should be in the vertical plane and parallel with the window pane in its centre.

Assessment Note 2: Measurement or calculation of the source intensity should be based on a 1.5 metre high visual receptor placed at any location on the property boundary or 50/250 meters (see Table F) beyond the new light source, whichever is closer.

Table E (2.6 main document)

Intensity Distribution Recommendations within E1 sections of the Place (ie excluding Core Zone)

Zone Dark Sky Requirements	Glare Class	Maximum luminous intensity in cd/klm				Non technical description of luminaire light control in installed condition
		at $70^{0\ az}$	at $80^{0\ az}$	at $90^{0\ az}$	above $95^{0\ az}$	
Between Core Zone and nearest population cluster > 1,000	G6*	350	100	0	0	Fully cut-off installation in environmental zone E1
Residential buffer between town centre and rural remainder (or centre of town with < 1,000)	G5 - LCADS derivative	350	100	5	0	Cut-off installation
Town Centre with population > 1,000 (excluding heritage style streets)	G4	500	100	10	0	Part Cut-off installation
Heritage bowl style	G4	500	100	10	0	
Heritage gas style	G4+	500	100	20	0	
External for 5 miles beyond Park boundary (lamps < 20,000 lumens)	G3	.	100	20	2.5%	Semi-Cut-off installation in environmental zone E2
All luminaires with lamps greater than 20,000 lumens between Core Zone boundary and Region boundary	G6**	350	100	0	0	Fully cut-off installation regardless of night time environmental zone

Note ^{az} Table 2.3 restrictions apply to the luminaire's installed angle of inclination (azimuth) which can be tested in UK industry standard design calculation software.

Note* Intensity relaxation may be appropriate at 70^0 and 80^0 depending on luminaire availability but the **values of zero intensity at 90^0, 95^0 and above are crucial**.

Note** Requires discussions with adjacent land owners and local authorities to adopt similar controls in their individual environmental policy plan.

In addition to the intensity controls presented in table E further light limitation recommendations are contained in Table F, following, to mitigate any obtrusive light in an E1 Environmental Zone and the two tables should be considered in tandem at the design stage for all new exterior lighting.

Table F (2.3 main document): **Obtrusive Light Marker Points**
Summary of Light Limitation Tables used for Design Objectives

CIE Zone E0 variations							
Night Time Environmental Zone	Sky Glow Upward Light Ratio %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)	Assessment Point Illuminance
		Pre-10pm	Post-10pm	Pre-10pm	Post-10pm	Pre & Post - 10pm	Ev or Eh (lux)
E0-0	No New External Lighting Units Permitted						
E0-50	0	0	0	0*	0*	0	0.25
E0-250	0	0	0	0**	0**	0	0.10
E0-SL***	0	0.25	0.1	0	0	0	-
© LCADS Ltd 2014							(IESNA = 0.5 lux)

CIE Zone E1- Dark Sky Park Adaptation							
Night Time Environmental Zone	Sky Glow Upward Light Ratio %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)	Property Boundary Illuminance
		Pre-10pm	Post-10pm	Pre-10pm	Post-10pm	Pre-10pm	Ev or Eh (lux)
E1 in E0 area	0	0.5	0.25	1,000	0	0	0.50
E1 (CIE-150)	0	2	0	2,500	0	0	-
© LCADS Ltd 2014							(IESNA = 1.0 lux)

CIE Zone E2- Dark Sky Community Adaptation							
Night Time Environmental Zone	Sky Glow Upward Light Ratio %	Light Intrusion (into windows) $E_{vertical}$ (lux)		Source Intensity I (cd)		Maximum Luminance L (cd/m^2)	Property Boundary Illuminance
		Pre-10pm	Post-10pm	Pre-10pm	Post-10pm	Pre-10pm	Ev or Eh (lux)
E2-0% (Residential)	0	2.5	1	2,500	0	0	1.0
E2-1% (Town Centre)	1	5	1	2,500	500	3	3.0
E2-2.5% (CIE-150)	2.5	5	1	7,500	500	5	(IESNA = 3.0 lux)
© LCADS Ltd 2014							

Design Procedure Part 3A: For all Small Scale lighting proposals e.g. domestic property with light sources less than 500 lumens

Details for low intensity lighting proposals shall include where on site each light is located, what height each light is to be positioned, the type of light frame or bracket for each light, the orientation/direction of each light and the strength of each light in lumens is proposed.

Design Procedure Part 3B: For all Medium and Large Scale lighting proposals e.g. commercial development applications eg factory development or sports facility

All planning applications, with the exception of a singular new-build or modernised home, should contain an night time environmental impact based on recommendations given in the Institution of Lighting Professionals Technical Report PLG04 'Guidance on Undertaking Environmental Lighting Impact Assessments , 2013

Table G
Lighting Impact Assessment - Outline

Baseline Descriptions

Baseline Assessment Procedures
- **Day time visit**
- **Night time visit**
- **Viewpoint Scheduling**
- **Baseline Assessment Layout**
- **Location Plan**
- **Brief Description**
- **Viewpoint Pages**
- **Baseline Summary**

Proposed Development – Lighting Design
- **Design – General**
- **Preliminary Assessment**
- **Provisional Design**
- **Final Design**
- **Maintenance Factors**

The LMP for each Dark Sky Place encourages Development Control Committees, both within the Place and adjacent Local Authorities, to insist on a thorough design process by the developer before submitting proposals.

"Controlling Light pollution and Reducing Lighting energy consumption" contains a 20 point check list typical of the data required for a large scale lighting impact assessment when it forms part of a larger Environmental Statement. Reference to the full document www.scotland.gov.uk/Publications/2007/03/14164512/0 will provide the reasoning behind a 20 bullet point checklist.

An abbreviated 12 point summary checklist of the design methodology is shown in the LMP and is typical of the detail required for medium scale proposals where there is a stand-alone lighting impact assessment report.

Table H
External Lighting Design Practice

- Survey of surrounding area environment
- Identification of critical viewpoints or receptors
- Analysis of task lighting level recommendations and game level if sports lighting application
- Establish environmental light control limits
- New lighting design quality objectives
- Calculated measurement of
  - Task working area(s)
  - Overspill area(s)
- Obtrusive light calculation of Property intrusion
  - Viewed source intensities
  - Direct upward light output ratios
- Compare design achievement with baseline values
- Schedule of luminaire types, mounting height and aiming angles
- Schedule of energy usage and lumens per square metre
- Schedule of luminaire profiles
- Layout plan with beam orientation indication and site relationship with surrounding residential and commercial properties

Although only 12 points are included in Table H these should be treated as an absolute minimum requirement and there is no reason why the full 20 point plan is not set as a standard design objective as will be the case in applications for large scale lighting proposals regardless of being part of an Environmental Impact Statement.

Table J: Lighting Impact Assessment Provision Matrix

	Protected Core	**Buffer or Community**	**5 mile Transition Zone**	**Beyond the Dark Sky Place**
Small Scale eg House or Group of up to 6 houses	part LIA recommended Minimal details essential	Minimal details essential	Minimal details recommended	No details required if light source is less than 3,000 lumens - otherwise part LIA recommended
Medium Scale eg Farm re-development	Full LIA essential	Full LIA essential	Part LIA essential Full LIA recommended	Source greater than 3,000 lumens full LIA recommended if not in EIA
Large Scale eg Sports field Sports complex Trade / Commerce Distribution centre	Not permitted	Full LIA essential	Full LIA essential	Source greater than 3,000 lumens Full LIA essential if not in EIA

3.2 Requirements for Traffic and Residential Area Lighting

Selection Matrix Starter

Main User Type	Typical Speed of Main User	Excluded UserType	Situation Set
Pedestrian & Cyclist	Walking Speed	Motors, Slow Vehicles & Motor Cycles	Remote Path - Set 8 "Shops" - Set 7
Vehicle conftict and shop users	10-30 MPH		"Streets" - Set 7 Car Parks - Set 6
Residential vehicles, Cycles & Pedestrians	10-30 MPH	Heavy goods vehicles	Set 5
Motorised traffic & Slow vehicles	20-40 MPH		Minor / Rural- Set 4 Secondary - Set 3
Motorised Traffic	30-70 MPH	None	Set 2
Motorway Regulations	70+	Slow vehicles, cycles & pedestrians	Set 1

Set 1 - Luminance Design Objectives

Typical Network:- Motorway&Motorway Link Roads

Traffic Flow ADT		<40,000					>40,000				
		Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR
Complex Interchange		2.0	0.4	0.7	10%	0.5	2.0	0.4	0.7	10%	0.5
Junction Spacing	<= 3Km	1.5	0.4	0.7	10%	0.5	2.0	0.4	0.7	10%	0.5
	> 3Km	1.5	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5
Hard Shoulder		0.75	0.4	0.6	10%	0.5	0.75	0.4	0.7	10%	0.5

Set 2 - Luminance Design Objectives

Typical Network:- Strategic Routes, Trunk and some Principal "A" roads
Main Distributor Routes or
Routes between Strategic routes with peak time parking restrictions

Traffic Flow ADT		<15,000					>15,000					*>25,000*				
		Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR
Single Carriage-way	Normally	1.0	0.4	0.7	15%	0.5	1.5	0.4	0.7	10%	0.5	*2.0*	*0.4*	*0.7*	*10%*	*0.5*
	>10,000 & E3 or E4	1.5	0.4	0.7	10%	0.5						*Above only with on street parking, otherwise as below*				
Dual Carriageway		1.0	0.4	0.7	15%	0.5	1.5	0.4	0.7	10%	0.5	*1.5*	*0.4*	*0.7*	*10%*	*0.5*

Set 3 - Luminance Design Objectives

Typical Network:- Secondary Distributor ("A,B & C" Classified)
Unclassified Urban Bus Routes
Urban Collector Road

Traffic Flow ADT	Low District Brightness					Medium District (E3)					High District Bright. E4				
	Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR
< 7,000	0.75	0.4	0.6	10%	0.5	1.0	0.4	0.5	15%	0.5	1.0	0.4	0.7	15%	0.5
7,000 - 15,000	1.0	0.4	0.6	10%	0.5	1.0	0.4	0.6	15%	0.5	1.5	0.4	0.7	10%	0.5
> 15,000	1.0	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5	1.5	0.4	0.7	10%	0.5
> 25,000	*1.5*	*0.4*	*0.7*	*10%*	*0.5*	*1.5*	*0.4*	*0.7*	*10%*	*0.5*	*2.0*	*0.4*	*0.7*	*10%*	*0.5*

Set 4 - Luminance Design Objectives

Typical Network:- Local Rural Roads & Rural Bus Routes = 40MPH or less
Residential or Industrial Interconnecting Roads
Minor single carriageway & Link Roads between Secondary Distributors

	Traffic Flow ADT	Low District Brightness					Medium District (E3)				
		Lav	Uo	Ul	TI	SR	Lav	Uo	Ul	TI	SR
No	**< 7,000**	0.5	0.4	0.4	10%	0.5	0.75	0.4	0.5	15%	0.5
Parking	**<7,000 + high cycle**	0.75	0.4	0.5	10%	0.5	0.75	0.4	0.6	15%	0.5
Parking	**< 7,000**	0.75	0.4	0.5	10%	0.5	0.75	0.4	0.6	15%	0.5
	7,000 to 9,000	0.75	0.4	0.5	10%	0.5	*1.0*	*0.4*	*0.5*	*15%*	*0.5*
> 9,000 use Set 3											

Set 8 - illuminance Design Objectives

Typical Network:- Footpath, cycle way and non-town centre pedestrian area

Pedestrian Flow		Normal			High		
Environmental Zone		E1/2	E3	E4	E1/2	E3	E4
Normal Crime	Eav	2	3	5	3	5	7.5
	Emin	0.6	0.6	1	0.6	1	1.5
High Crime	Eav	7.5	10	15	10	15	20
	Emin	1.5	3	5	3	5	8

Pedestrian Flow Measurement from IESNA in 1st hour of darkness
Low = 10 or less
Medium = 11 to 100
High = over 100

Where a light source with Ra>60 is used, the lighting level can be reduced by 1 class except 2 lux should not be reduced further.

Set 7 - illuminance Design Objective

Typically:- City & Town Centre Shopping Streets

Pedestrian / traffic flow		Medium		High	
Environmental Zone		E3	E4	E3	E4
Pedestrian Only	Eav	15	20	20	30
	Uo	0.4	0.4	0.4	0.4
Mixed on separate surface	Eav	20	30	30	30
	Uo	0.4	0.4	0.4	0.4
Mixed on shared surface	Eav	20	30	30	30
	Uo	0.4	0.4	0.4	0.4

Set 6 - illuminance Design Objectives

Typical Network:- Car Parks & Motorway Rest Area

	Zone	Eav	Uo	GRL
Major shopping centre, sports & major multi purpose building complex		20	0.25	50
Small town shops, Department store office building, small sports complex		10	0.25	50
Village shops, schools, churches, terraced and apartment houses		5	0.25	50
See BSEN12464-2:2007 for other external work task illuminance				

Set 5 - illuminance Design Objectives

Typical Network:- Local Access Roads & roads serving limited number of properties
Urban Residential Loop Roads

Residential Traffic		Low traffic flow with pedestrians and cyclists				Normal traffic flow with pedestrians and cyclists				Normal traffic flow with pedestrians and cyclists			
Env. Zone		E1/E2		E3/E4		E1/E2		E3/E4		E1/E2		E3/E4	
Crime rate	Ra value	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin	Eav	Emin
Low	<60	3	0.6	5	1	5	1	7.5	1.5	7.5	1.5	10	3
	>60	2	0.6	3	0.6	3	0.6	5	1	5	1	7.5	1.5
Med	<60	5	1	7.5	1.5	7.5	1.5	10	3			15	5
	>60	3	0.6	5	1	5	1	7.5	1.5			10	3
High	<60	10	3	10	3	10	3	15	5			15	5
	>60	7.5	1.5	7.5	1.5	7.5	1.5	10	3			10	3

LIGHTING DESIGN ROADMAP - Devised and Designed by
LCADS Ltd, Moffat : Tel 01683 220 299
Values in RED italics are additional CEN values to BSEN 5489 Recommendations